Introduction

Changing the way time is used in an educational setting has a great impact on the everyday activities of the school. One such activity affected by how class time is used is teaching methodology (Calvery, Sheets, & Bell, 1999; Hamdy & Urich, 1998; Hottenstein & Malatests, 1993; Winn, Menlove, & Zsiray, 1997). How teachers use their allotted time within the classroom to engage student learning has been a topic of interest within the educational arena for a long time. With the publication of *America 2000: An Education Strategy* (1991) a series of studies examined the use of time in the classroom (Brett, 1996; Carroll, 1994; Hamdy & Urich, 1998; Hottenstein, 1998; Lofty, 2000; National Research Council, 1996, Pitman & Romberg, 2000). These authors examined the broad issues of how time affects learning within the context of a traditional school climate where students and teachers participated in a seven-period day with each period lasting between 35 and 55 minutes. In general, these studies concluded that with the need to provide students with more active learning opportunities in order to meet the mandated increases in graduation requirements, school leaders needed to examine different scheduling patterns. These studies also recommended a more flexible time schedule to better serve the educational needs of students and that "teachers must use a variety of teaching strategies to keep students motivated and on task" (Hamdy & Urich, p. 80).

"Teach, test, and hope for the best" (Robbins, Gregory, & Herndon, 2000, p.31) appears to be the catch phrase when it comes to teaching in the modern classroom. With an increased amount of material to cover, high stakes testing, and the fragmentation of curriculum in such a way as to make it deliverable only in piecemeal form, connections are lost, explorations are missed, and students are left alone to make sense of their classroom experiences (Robbins, Gregory, & Herndon, 2000).

Current researchers have not only looked into the use of time, but how teachers' beliefs and perceptions influence how they design their lessons, evaluate their students, and pedagogical issues (Beck, Czerniak, & Lumpe, 2000; Cochran, 1997; Lumpe, Haney, & Czerniak, 2000; Sanchez & Valvaracel, 1999). Cronin-Jones (1991) conducted a study to find out how teacher beliefs and perceptions influenced the success of the implementation of curriculum packages. She used a grounded theory approach to her case study of two middle school teachers. Each teacher was observed as they implemented 20 life science curriculum packages and from the analysis of field notes and interview transcripts, via a constant comparative protocol, she discovered four major categories regarding the belief structures of both teachers. These structures include:

1. How students learn.
2. The role of the classroom teacher.
3. The ability levels of students.
4. The relative importance of content topics.

This research is important because it establishes the construct of how belief structures influence the teaching strategies of educators under the block schedule. Both of the participants in her study believed that the most important student outcome was the acquisition of factual content. This belief was influenced by their attitude toward the content that they were teaching, the overall curriculum, and by how they implemented the instruction. In other words, the strategies used by the teachers were influenced by their belief structures. Belief structures, according to Czerniak, Lumpe, and Haney (1999), are convictions, philosophies, tenets, or opinions developed by teachers in the course of their studies or professional careers. "Disconcertingly, the beliefs of teachers are not necessarily consistent with best practices" (Czerniak, Lumpe, & Haney, 1999, p.125) and consequently problems may arise if the classroom teacher's beliefs are in conflict with the current educational reform(s).

Teacher beliefs are strongly related to the teachers' own epistemological framework. Beck, Czerniak, and Lumpe (2000) performed an exploratory study of teachers' beliefs and the implementation of constructivism in their classrooms. More specifically, the researchers looked at the implementation of five holistic subcomponents of constructivism: personal relevance, critical voice, scientific uncertainty, shared control, and student negotiation. They found that teachers believed that teaching for personal relevance in the classroom can motivate students, increase interest, and involve students in their own learning. Teachers were concerned about the amount of time it takes to prepare and implement a lesson based upon personal relevance. They also believed that teaching scientific uncertainty helps students understand the limitations and imperfections of science. The establishment of a social climate that allows students to question not only the content, but the teacher's pedagogy, a *critical voice*, was also deemed important in order for scientific understanding to occur. The teachers studied believed that teaching for shared control in the classroom can help students to take a vested interest in and ownership of their learning. Student negotiation, where students explain and describe their newly acquired ideas with other students, was seen as an important aspect of teaching and learning. The strategies used by the classroom teacher that allow for personal relevance, critical voice, scientific uncertainty, shared control, and student negotiation will reflect the teacher's own epistemological framework (Beck, Czerniak, & Lumpe, 2000). Inquiry based strategies, conceptual change strategies, and cooperative learning strategies are all current trends in science education.

Teaching strategies, such as inquiry-based learning, have been placed as the centerpiece within the National Science Education Standards (NSES). These strategies may be construed as coming from a cognitive or social constructivist epistemology (Rodriquez, 1997). This is because according to the NSES the central strategy for teaching science is based upon authentic questions generated from student experiences. The researcher will describe how science teachers, under the block schedule, are designing strategies that incorporate their own belief structures. Keys and Bryan (2001) believe that more research needs to be conducted at the high school level that shows a relationship between teaching strategies and teacher beliefs. "Research on the roles and knowledge of teachers in implementing inquiry in the classroom will have a broad impact on science education because such studies will reflect what may be realistically accomplished" (Keys & Bryan, 2001, p. 642).

Rationale for this Study

The connection between teaching strategies and time. The epistemologies behind the teaching strategies in science education are centered around constructivism (Hewson & Hewson, 1988), conceptual change theory (Glasson & Lalik, 1993; Stofflet & Stoddard, 1994), and inquiry based learning (Powell, 1994; Wildy & Wallace, 1995). "Although the brain is a pattern-seeking organ, learners find it much easier to make connections if the process is facilitated by an instructor who poses questions that beg exploration and who facilitate links between and among disciplines and processes"

(Robbins, Gregory, & Herndon, 2000, p. 33). To accomplish these teaching strategies, more class time is required (Moore, 1993; Salvaterra & Adams, 1996) “Extended periods can allow for this dialogue and exploration to occur” (Robbins, Gregory, & Herndon, p. 33).

National standards. The National Science Standards adopted an inquiry-based approach to teaching science. According to Keys and Bryan (2001) the actions taken by the science teacher in order to conform to the national standards will differ with respect to local government, teacher beliefs, student age and language proficiency. “Thus, the theoretical framework appropriate for conducting research on teacher beliefs, knowledge, and practice of inquiry is the use of cognitive constructivism and sociocultural frameworks” (Keys & Bryan, p. 632). Teachers will use many modes of inquiry within their teaching and learning strategies. These strategies will match their beliefs about learning (Keys & Bryan). Since the National Science Education Standards have adopted an inquiry-based approach to teaching strategies, and these strategies have a constructivist epistemology, research on teachers’ beliefs about strategies used within the classroom is important.

Rodriquez (1997) criticized the National Science Education Standards published by the National Research Council (NRC) for using a *discourse of invisibility* throughout the document. By this he means that the goals stated by the NRC do not directly address ethnic, socioeconomic, gender, and theoretical issues that affect science education.

According to Rodriquez (1997), “Readers are presented with sweeping recommendations for change, but are never given powerful arguments as to why they should abandon their usual teaching practices to embrace more student-centered and hands-on activities" (p.29). Rodriquez also pointed out that although not directly stated, constructivism is the underlying theoretical framework behind the document and is thus rendered *invisible*. The NSES does not provide the underpinnings for why the choice of *any* theoretical framework, as a professional model for science teachers, should be used over any other model. Yet, the NSES clearly supports pedagogies that are founded in constructivism.

Accountability. One of the overriding reasons that science teachers choose the strategies that they do may be influenced by the move toward accountability through the use of high stakes testing. Bacon (1995), a teacher, argued that there is a "mismatch between today's classroom experiences and curriculum, and traditional testing methods" (p.86). Any effort to measure the success of education must also take into account the responsibilities of other stakeholders such as parents, administrators, and local politicians within the entire community. "There is an assumption that a school can be so effective that it cancels out the influences of social disadvantage on students' academic achievement; and that all students, regardless of social origin, intellectual ability, or level of disability, can attain the same high level of academic achievement" (Bacon, 1995, p.86).

Smith and Fey (2000), wrote that high stakes testing produces top-down pedagogies that lead to inflated test scores. They wrote that we have yet to address the concerns teachers have about high stakes testing and accountability. "Teachers are not regarded as knowledgeable agents in the debate" (Smith & Fey, 2000, p. 343). Within the professional literature, teachers are regarded as either anonymous throughputs or obstacles to effective policy.

Limitations

The teachers are all associated with one rural school and their opinions about teaching strategies, learning, and block scheduling will not be representative of science teachers as a whole. Neither can this study's conclusions be extended to the teaching of science in general. There is a lack of transferability inherent in this study. Other limitations include the fact that the results of this study may be published and other employees at the high school will identify the participants. This may affect the way the participants respond to questions and how they teach within the classroom during the observation phase of the study. By simply participating in the study, the teachers may change what they do and how they do it.

Another limitation inherent within this study is the background of the researcher. I am a science teacher with 18 years experience, eight of those years teaching under the 4 x 4 block schedule. I bring to this study my own beliefs about teaching science and block scheduling, which are framed by a social constructivist and cognitive constructivist epistemology. I believe that knowledge is not directly transferable to the minds of students but is first passed through a lens constructed by social and cultural factors. I have been strongly influenced by the works of Gergen (1995), Doolittle and Camp (1999), and Doolittle and Hicks (2003). This background leads to specific biases that I have concerning how science should be taught.

The Conceptual Framework

According to Miles and Huberman (1994), a conceptual framework, "Explains, either graphically or in narrative form, the main things to be studied – the key factors, constructs or variables – and the presumed relationship among them" (p. 18). A graphic illustration of the conceptual framework of the proposed research is found in figure 1

This conceptual framework illustrates the relationship between the teaching strategies used by science teachers, how these strategies may be linked to their belief structures, and how block scheduling may influence how these strategies are implemented within the classroom.

Conceptual framework.

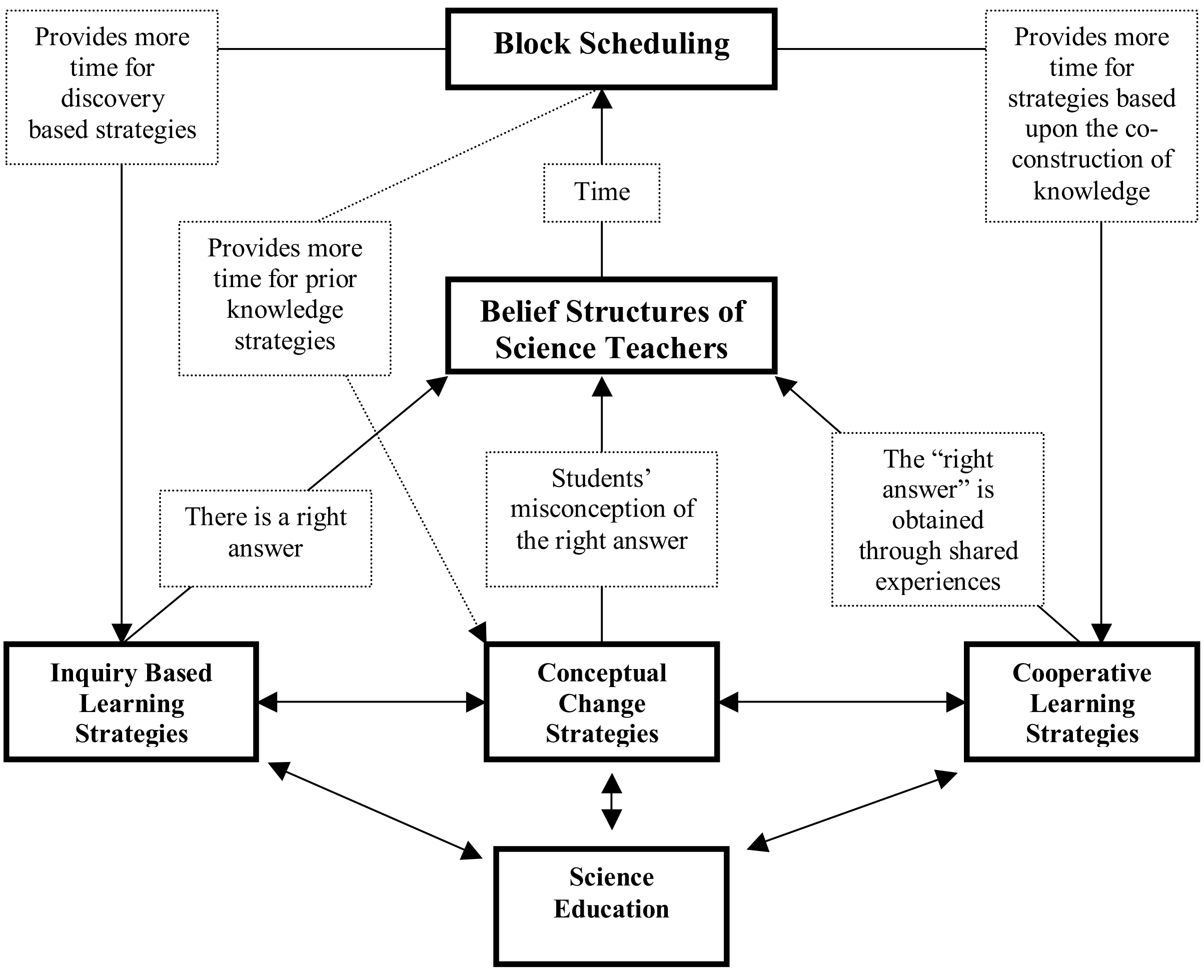


Figure 1. The conceptual framework connecting teaching strategies, belief structures of teachers, and block scheduling in science education.

Summary

Science teachers possess a variety of views about teaching and learning. These views develop from their own system of beliefs. As Aquirre, Haggerty, and Linden (1995) found in their study of prospective science teachers, almost half of the teachers studied believed that teaching was a matter of knowledge transfer from the teacher to the empty minds of children, while a third of the teachers believed that in order for learning to occur, new knowledge must be related to existing knowledge. Research conducted by Cronin-Jones (2001), Keys and Bryan (2001), and Lumpe, Haney, and Czerniak (2000) have shown that the belief structures developed by teachers influence the way that they teach.

Another major influence on teaching strategies used by the teacher is the use of class time. Cannady and Rettig (1995) alluded to the frustration teachers felt with the traditional class period as they moved away from the lecture teaching format. This frustration stemmed from their inability to incorporate different teaching strategies in such a short amount of time. Research on block scheduling (Brett, 1996; Bugaj, 1999; Hackman & Scmitt, 1997; Schultz, 2000) describes some of the advantages of block scheduling as: ideal for cooperative learning and inquiry-based teaching strategies; more time for hands on learning; and allows for more student-centered learning strategies. The reason teachers perceive block scheduling to be more advantageous than the traditional schedule is because it allows for more socially mediated learning strategies such as inquiry-based learning, cooperative learning, and conceptual change learning to be used within the classroom.

The National Science Standards have adopted an inquiry-based position of science teaching strategies. The strategies used by science teachers in order to conform to the national standards will differ with respect to the teachers' beliefs, among others, about teaching and learning (Keys & Bryan, 2001). The following points have been highlighted in this section:

- The national standards direct science teachers to incorporate more social constructivist teaching strategies such as inquiry-based learning into their teaching methods.
- Block scheduling is perceived as allowing more time for inquiry-based teaching strategies.
- Teaching strategies are strongly influenced by the beliefs held by teachers about teaching and learning.

Research questions. With these three statements as the foundation, the research questions are: What strategies do science teachers use to engage students under the 4 x 4 block schedule? How do science teachers understand their use of instructional strategies? The following section describes the current literature concerning constructivism, teacher beliefs, teaching strategies, and their relationships to science education.

Literature Review

Current reform movements such as Scope, Sequence and Coordination (National Science Teacher's Association, 1992), The National Research Council's National Standards for Science Education (1996) and America 2000: An Education Strategy (U.S. Department of Education, 1996), all recommend the use of inquiry-based instructional models. To help teachers develop curriculum and teaching strategies that incorporate these approaches, Taylor, Fraser and White (1994) recommended adopting a constructivist pedagogical framework that includes: personal relevance, scientific uncertainty, critical voice, shared control, and student negotiation. In order for teachers to incorporate these subcomponents into their teaching pedagogy, educators have had to discard some assumptions of the past. One such assumption is that the traditional 45-minute period is the best structure within the school day (Louden & Hounshell, 1998). It has been suggested (George, 1997; Louden & Hounshell, 1998; Veal & Flinders, 2001) that teacher-centered instruction takes less time than student-centered instruction. Block scheduling, with its extended class time, has been advanced as a conduit by which teachers can incorporate more student-centered, constructivist teaching strategies (Payne & Jordan, 1996; Robbins, Gregory, & Herndon, 2000; Shortt & Thayer, 1999).

Lemke (2001) discussed the implications of a sociocultural/constructivist perspective on science and on science education. His research, which investigated classroom interaction and the use of language as a socially and culturally contextualized system of resources, showed that constructivist approaches emphasize the role of "classroom communities and an understanding of the development of the unique social relationships and microcultures that characterize these communities" (p. 305). For the teacher/student and the researcher/discovery dynamic, this implies that the community of the classroom/laboratory is bound by shared experiences.

This document will review what is in the literature concerning constructivism, block scheduling, teachers' beliefs, teaching strategies, and science education.

The Constructivist Landscape

Tenets of constructivism. Constructivism is an epistemology. Constructivist theorists are not simply putting forth a theory about teaching, but are advancing a theory about learning acquisition, psychology and the theorists' own interpretations concerning the history of science and philosophy. Virginia Richardson (1997) wrote, constructivism is a descriptive theory that "suggests that individuals create their own new understandings, based upon the interaction of what they already know and believe, and the phenomena of ideas with which they come into contact" (p. 3). Along with this general description of constructivism, there are more specific ones that deal with specific content. For example, Jan Golinski (1998) describes constructivism in terms of scientific knowledge when he writes,

> The term [constructivism] draws attention to the central notion that scientific knowledge is a human creation, made with available material and cultural resources, rather than simply the revelation of a natural order that is pre-given and independent of human action. (p. 6)

According to Eric Bredo (2000), Immanual Kant was the principal originator of constructivist thought. Kant attempted to resolve the competing claims of the rationalist Descartes, who believed that knowledge is found within one's self, and the empiricist Locke, who believed that knowledge is synthesized from elementary sensory experiences.

Bredo (2000) wrote that in the view of Kant "we can never know the 'things in themselves' that cause perceptual experiences because even the phenomena of experience are shaped by mental relationships" (p. 129).

It is a difficult task to pin down a definition of constructivism. "Any conception of constructivism that fails to take into account the full variation and change in the way the term is used will itself be a humanly created construct" (Bredo, 2000, p. 128). The literature in cognitive psychology, science education, and educational philosophy is replete with examples of a description of constructivism, but is very limited as to a specific definition. The general epistemological framework of constructivism is that knowledge is constructed based upon experience (Gergen, 1995; John-Steiner & Mahn, 1996; Prawat & Floden, 1994). The interplay between new knowledge and how that new knowledge relates to experience is what differentiates and defines various forms of constructivism.

With these descriptions of constructivism in mind, authors such as Doolittle and Camp (1999) and Phillips (1995), break down the term constructivism and place each component on a continuum. The continuum ranges from the microdissection of constructivism by D. C. Phillips (1995) to the more typical categorization by Doolittle and Camp (1999) and Doolittle and Hicks (2003), which is based upon the three metaphors of cognitive psychology as defined by Mayer (1996): response strengthening, information processing, and knowledge construction (see Table 2).

Doolittle and Camp (1999) showed how constructivism can typically be broken down into the three major categories based upon specific constructivist tenets which were developed by Von Glasersfeld (1995) and modified by Doolittle and Camp (1999) and

Doolittle and Hicks (2003). The types of constructivism that appear on the continuum emphasize different tenets to some degree (see Table 1). These tenets flow from a radical constructivist epistemology to a social constructivist epistemology. The radical constructivist would emphasize tenets 1, 2 and 3 and de-emphasize tenet number 4. The social constructivist would emphasize all four of the tenets. The cognitive constructivist would emphasize tenets 1 and 2 but would consider the construction of knowledge as a "technical" process (Doolittle & Camp, 1999, p. 5).

Table 1.

The Four Tenets of Constructivsm

1. Knowledge is not passively accumulated, but rather, is the result of active cognizing by the individual;
2. Cognition is an adaptive process that functions to make the individual's behavior more viable, given a particular environment;
3. Cognition organizes and makes sense of one's experience, and is not a process to render an accurate representation of reality;
4. Knowing has roots in both biological/neurological construction, and social, cultural, and language-based interactions.

Note: Data taken from "Constructivism as a Theoretical Foundation for the Use of Technology in Social Studies," by P. E. Doolittle and D. Hicks, 2003, Theory and research in Social Education, 31(1), 76.

"To the constructivist, the learner plays an active role in the creation of knowledge.

with the realization that the knowledge created will vary in the degree of validity as an accurate representation of reality" (Doolitle & Hicks, 2003, p. 77). On one end of the constructivist continuum are those who believe that the knowledge created by the learner is a valid representation of reality. This is a form of constructivism called cognitive constructivism. On the other end of the continuum are those who believe that knowledge can never reflect an accurate or valid representation of reality because knowledge is either constructed from the interplay of many minds (i.e., social constructivism) or is entirely constructed by the individual, which is based upon the individual's experience (i.e. radical constructivism). What generally separates the different types of constructivist epistemology is, as Phillips (1995) wrote,

> [Cognitive constructivists] have been concerned with how the individual learner goes about the construction of knowledge in his or her own cognitive apparatus; for other constructivists [social and radical constructivists], however, the individual learner is of little interest, and what is the focus of concern is the construction of human knowledge in general. (p. 7)

The remainder of this section will discuss the types of epistemologies, their historical development, and how they relate to each other in general and to science education specifically. Since the National Science Standards have adopted inquiry-based learning strategies, which are derived from a social constructivist epistemology, it is important to this research that social constructivism be defined and be placed within the context of differing epistemologies.

The development of the constructivist epistemology. The roots of constructivist epistemology can be traced back to the early development of teaching and learning theories which have their beginnings under the auspices of the behaviorist paradigm (Skinner, 1950; Thorndike, 1932). According to Reynolds, Sinatra, and Jetton (1996), the dominant metaphor within the behaviorist paradigm is that of a switchboard on which connections are made and maintained. Mayer (1996) described behaviorism in terms of "response strengthening" (p. 152) and used the classic example of hungry cats from Thorndike (1911, 1965) to illustrate the idea that learning involves the strengthening and weakening of associations between stimuli and the corresponding response. Hungry cats placed into a box would serendipitously pull a string, which would open a door so that they could escape and eat. Eventually, the cats would use this method over others to make their escape. The implication of this experiment for education is clear: provide students with a stimulus that leads to a reward and they will learn. The problem with this particular brand of behaviorism is that it neglects the processes of understanding, reasoning and thinking (Bransford, Brown, & Cocking, 1999).

From the late 1950s to the present, the psychology of learning theory has shifted from the behavioral sciences to the cognitive sciences. The insights from this "cognitive revolution" (Anderson, Reder, & Simon, 1996, p. 5) have allowed for the development of new approaches and instructional techniques in education. These new approaches and techniques can be placed within the epistemological frameworks of information processing, cognitive constructivism, social constructivism, and radical constructivism. It is important for this research to define these epistemologies and the pedagogies that are associated with them because science education has moved from an information processing epistemology, through cognitive constructivism, then radical constructivism, and is now situated in the social constructivist camp (Fischer & Aufschnaiter, 1993 ; Hewson & Hewson, 1988) .

Cognitive constructivist epistemology. As the paradigm begins to shift from the traditional positivistic assumptions based upon the search for "truth" in education, learning theory began to "emphasize the external nature of knowledge" (Doolittle & Hicks, 2003, p. 80) and embraced the first two tenets of constructivism previously mentioned. To the cognitive constructivist, learning occurs when information is processed and an accurate representation of knowable reality is transmitted. Doolittle and Hicks (2003) write, "From a cognitive constructivist perspective, the goal of the lesson is for the students to build mental structures that mirror or correspond to the reality" of whatever is being taught (p. 81).

Cognitive constructivist pedagogy. Doolittle and Hicks (2003) relate the tenets of cognitive constructivism with the underlying principles associated with the construction of knowledge and then use these relationships to form strategies that a cognitive constructivist teacher may employ within the classroom (see Figure 1). Based upon these tenets and principles, a teacher who embraces a cognitive constructivist epistemology may incorporate strategies that include advanced organizers, concept mapping, teaching to transfer, elaborative practice, and algorithmic problem solving strategies. All of these focus on a process of learning acquisition that leads to mental models that accurately reflect the real world.

Table 2.

Relational Delineation of the Philosophical Tenets, Theoretical Principles, and Pedagogical Strategies of Constructivism.

TENET	PRINCIPLE	STRATEGY
#1: Knowledge is not passively accumulated, but rather is the result of active cognizing by the individual. #2. Cognition is an adaptive process that functions to make an individual's cognition and behavior more viable given a particular environment or goal. #3. Cognition organizes and makes sense of one's experience, and is not a process to render an accurate representation of an external reality. #4. Knowing has its roots in both biological/neurological construction and in social, cultural, and language-based interactions.	#1. The construction of knowledge and the making of meaning are individually and socially active processes. **Based on Tenet 1.** #2. The construction of knowledge involves the social mediation within cultural contexts. **Based on Tenet 1, 2, 3, & 4.** #3. The construction of knowledge is fostered by authentic and real-world environments. **Based on Tenet 2 & 3.** #4. The construction of knowledge takes place within the framework of the learner's prior knowledge and experience. **Based on Tenet 1 & 3.** #5. The construction of knowledge is integrated more deeply by engaging in multiple perspectives and representations of content, skill, and social realms. **Based on Tenets 1, 2, 3, & 4.** #6. The construction of knowledge is fostered by students becoming self-regulated, self-mediated, and self-aware. **Based on Tenet 1**.	#1. Teachers and students should use an inquiry-based approach to science education. **Based on Principles 1, 3, & 4**. (Inquiry-based learning) #2. Teachers should create authentic exercises which facilitate the process of student inquiry and action. **Based on Principles 1, 2, 3, & 4**. (Inquiry-based learning) #3. Teachers should foster local and global social interaction such that students attain multiple perspectives on people, issues, and events. **Based on Principles 1, 2, & 5**. (Inquiry-based learning) #4. Teachers should facilitate student knowledge construction by building on students' prior knowledge and interests. Based on **Principles1, 4, &, 6.** (Conceptual change learning) #5. Teachers should enhance the viability of student knowledge by providing timely and meaningful feedback. Based on Principles 1, 4, & 6. (Conceptual change learning and inquiry-based learning) #6. Teachers should cultivate students' academic independence by fostering autonomous, creative, and

		intellectual thinking. Based on Principles 1, 2, 3, 4, 5, & 6. (Conceptual change learning and inquiry-based learning)

Note: Data taken from "Constructivism as a Theoretical Foundation for the Use of Technology in Social Studies," by Peter Doolittle & David Hicks, 2003, *Theory & Research in Social Education*, 31(1), p. 103.

Radical constructivism epistemology. The "radical" part of radical constructivism lies in Von Glasersfeld's (1995) claim about knowledge. The epistemological differences between radical constructivism and all other forms of constructivism is that radical constructivism places its emphasis on the nature of knowledge with the construction of knowledge being secondary (Smith, 1997). The primary assumption made by radical constructivism is that "knowledge, no matter how it is defined, is in the heads of persons" (Von Glasersfeld, 1995, p. 1). Experience makes up our entire conscious world and is thus subjective. Although persons may have similar experiences, there is no way of knowing that these shared experiences are exactly the same.

Smith (1997) pointed out three premises that seem to underlie the coherence of radical constructivism. First, radical constructivism focuses on the individual as a receptor of experiences. It is the experience of the individual that forms the basis of "knowing, knowledge and communication" (p. 107). Second, there must be a separation between the knower and the existence of an ontological world. If the construction of knowledge is based upon the experiences of the individual, each individual will have a different view of the world. Finally, radical constructivism is a model of rational knowing and thus avoids the metaphysical and solipsism.

The traditional interpretation of the word *knowledge* is a "representation of some aspect of the physical world around us, and its truth status has been taken as a measure of how well the said knowledge corresponds to, or represents, an observer-independent world" (Hardy & Taylor, 1997, p. 137). This God's eye view of the universe, according to Von Glasersfeld (1991) is unattainable because knowledge is constructed from individual experience. Hardy and Smith (1997) summarized Von Glasersfeld's view on the relationship between knowledge and experience when they wrote,

> The learner constructs knowledge from his experience in an effort to impose order on and, hence, make sense of those experiences. Moreover, the sole function of knowledge is to allow one to impose such order on one's experiential flow. (p. 137)

To Hardy and Smith (1997) it is the failure of those who criticize radical constructivism to understand not only the difference between knowledge and experience as represented by Von Glasersfeld, but the context in which knowledge and experience reside within the individual. To the critic, knowledge is a truth tester that can be used to test whether what is being described about the universe represents reality.

Radical constructivist pedagogy. Since the foundation of radical constructivism is that while an external reality exists, it is unknowable, then the strategies adopted by a teacher who embraces this epistemology would center around stimulating the student to make his or her own investigations and discoveries. This understanding may not match the definitions within the textbook, but would make sense to the student based upon his or her own individual experiences.

K-W-L inquiry strategies would be used by the teacher along with providing other sources of information and brainstorming activities. The teacher would then ask the students to demonstrate what they have learned in the form of presentations, essays, or portfolios (Doolittle & Hicks, 2003). Hendry (1996) shows how radical constructivist principles are applied within the classroom (see Table 3).

Table 3

Application of Key Radical Constructivist Principles to Classroom Teaching

Key Principles of Constructivism	Application in Classroom Teaching and Learning
Knowledge exists in the minds of people only.	Knowledge does not exist on the blackboard, in books, floppy discs or the words of the teacher
The meaning or interpretations people give to things depend on their knowledge.	Students and teachers give meaning to instructional materials according to their existing knowledge and beliefs.
Knowledge is constructed from within in interrelation with the world.	Teachers or teaching do not change students' ideas. Change or construction occurs from within, through students' interrelation with the world.
Knowledge can never be certain.	Teachers can never be sure that the language they use to signify intended knowledge also signifies the same knowledge for students.

Note: Data taken from "Constructivism and Educational Practice," by G. D. Hendry, 1996, *Australian Journal of Education, 40(1), p. 25*

Continuing to move away from the knowledge as truth paradigms and toward the social constructivist paradigm, there are educational psychologists who believe that the brain is not like a computer because there are outside, sociological influences on learning (Cobb, 1994; Gergen, 1985; Prawat, 1993; Vygotsky, 1981). Nor is knowledge to be viewed as individualistic as it is within the radical constructivist paradigm (Hendry, 1996; Smith, 1997; Von Glassersfeld, 1995).

Social constructivism epistemology. Social constructivism centers around the idea that all meaning is socially constructed. Mead (1934) and Vygotsky (1981) thought that higher mental functioning is not attributable to individuals alone but has its origin in social life. To the social constructivist, learning is viewed as taking place through a dialectic (Bahktin, 1984). The dialectic acts as a filter, which is created by social and cultural factors. Outside influences are mediated by social and cultural influences and thus the learner constructs his or her own knowledge based upon the collective experiences of the social and cultural groups the individual resides in.

The four tenets of constructivism previously mentioned are the epistemological underpinnings of social constructivism. However, the social constructivists would downplay the mental construction of knowledge not because they do not believe it, but because they think it trivial (Doolittle & Camp, 1999). According to these tenets, it is the teacher, the student, and the social/cultural environment that influence the construction of knowledge. Students will construct their own interpretation of the truth based upon a shared experience and thus knowledge is not an individual construction as it is within the radical constructivist paradigm. Prawat and Floden (1994) wrote,

> Social constructivists are distinctive in their insistence that knowledge creation is a shared rather than an individual experience; they maintain that, to quote Goodman (1986), knowledge is developed 'by the dialectical interplay of many minds, not just one mind.' (p.37)

Truth, in this case, according to Doolittle and Camp (1999) "is neither the objective reality of cognitive constructivists nor the experiential reality of the radical constructivist, but rather is a socially constructed and agreed upon truth resulting from 'co-participation in cultural practice'. In order for the learner to deem new knowledge valid, the new knowledge must fit with the mental structures that were socially constructed by the learner from the interplay of many minds."

To the social constructivist, learning is not an individual accomplishment but is a result of social interactions. One of the important components of social learning is the development of language. Kenneth Gergen (1992) wrote, "The meaning of words and actions is not derived by comparing them against the subjectivity of their authors, but against the governing conventions of the communities in which we reside" (p. 22). To Gergen, social constructivism commences with language. If individuals transmit knowledge in the classroom primarily in the form of language (lectures, discussions, overhead projections), and if language is socially constructed, then there is no way to "vindicate the idea that language and thus knowledge paints an accurate picture of the world" (p. 24).

Starver (1998) established four integrated principles that are based upon a social constructivist epistemology as defined by Gergen (1998). These principles center around language-based social interactions. Their value to science pedagogy, according to

Starver, is that “language-based discussion, negotiation, and consensus building that takes place among students in cooperative learning are firmly grounded in constructivist principles” (p. 518). The epistemology of constructivism is expressed in the pedagogy of conceptual change theory. Conceptual change theory is the “most popular and wide spread interpretation of constructivism for practice in science education” (Bently, 1998, p. 242). The premise behind conceptual change theory is that misconceptions are deconstructed and replaced with valid scientific conception.

Social constructivist pedagogy. The social constructivist teacher would emphasize the interactions and social negotiations between the students themselves. The teacher would rely more on cooperative learning techniques such as posing questions to small groups and having them come up with an answer that is satisfactory to the group. Each small group is exposed to the same resources as all other groups and discusses the meanings and implications drawn from the resources. The teacher then guides the lesson based upon the input from the students.

Connecting radical constructivism with social constructivism in science education. Osborne (1996) examines social and radical constructivist epistemology in the context of science education. He does this because he states that they are the most clearly elaborated constructivist positions. Both social and radical constructivism are attempts to move away from the traditional epistemological base that uses the concept of knowledge as representative of reality. The difference lies in that ontological truth is replaced by the notion of viability to the individual learner in radical constructivism and by social interpretations in social constructivism. Osborne uses the example of the theory of gravity to distinguish between the two epistemologies. To the radical constructivist, a learner constructs a model of gravity that is viable in that the model fits the individual learner's experience. However, that model is not representative of absolute truth. To the social constructivist, the model constructed by the learner is influenced by social factors so that the representation does not belong to the individual but has been constructed from the interplay of many minds.

It is the concept of viability that prevents radical constructivism from slipping down the treacherous slope to the "anything-goes" philosophy of solipsism (Hardy & Taylor, 1997).

> Any mental construct that fails to satisfy the constraints of one's socio-physical environment is unviable and, once a construct is so characterized, it is discarded or altered, during the ensuing quest to create a viable construction. (p. 138)

Returning to the concept of gravity, any knowledge of gravity that the learner constructs, that satisfies his or her socio-physical environment is viable to that learner. The implication of this is that there are an infinite number of explanations for the concept of gravity. The one chosen by the individual is the one that is most viable and fits best with his or her own experiences.

To Osborne (1996) and Nola (1997) the epistemological position of radical constructivism cannot be justified within the scientific community. This prospectus purposefully avoids the relationship between constructivism and the pure sciences (Kuhn, 1970; Golinski, 1998) because it requires far more discussion than this document can hold and because the focus of this paper is the relationship between teaching strategies and teacher beliefs within the context of a socioconstructivist epistemology as adopted by the National Science Standards. In many cases in educational research, the construction of meaning by the scientist is equated to the construction of meaning by the science student (Nola, 1997). However, the problem of radical constructivism to the scientist is in the juxtaposition of the term *viability* and *validity*. Osborne writes, “The failure to recognize the important practice of science leads implicitly toward ontology where viability is equated with validity so that any viable theory is considered worthy of consideration” (p. 59). The problem of radical constructivism to the teacher/student dynamic is the slippery slope of relativism (Nola, 1997) wherein any answer to a question posed by a teacher is deemed correct because it fits within the experiences of the student.

Constructivist cautions. There are researchers and authors within the fields of cognitive psychology and education who think constructivism is, as Anderson, Reder, and Simon (1998) write, “A simplistic extremism capable of destroying any hope of progress in education” (p. 231). According to them “educational interventions involve changes on many dimensions, making it hard to assess what features are responsible for the learning outcomes” (p. 239). The many points that Anderson, Reder, and Simon (1992) make against radical constructivism and situated learning arise from cognitive psychologists’ (Cobb, Yackel & Wood, 1992) misinterpretations of Piaget, Vygotsky and Dewey.

The assimilation and accommodation components of Piaget’s work are also components to the representational view of which Anderson, Reder and Simon (1998) subscribe. “Assimilation incorporates experience passively into a representation already available to the child” (Anderson, Reder, and Simon, 1992, p. 234). A careful reading of Piaget suggests that a child will internalize knowledge when changes are made to mental structures and thus accommodation cannot proceed without assimilation: a tenet of the representational view. Their critique of the "progressive school" (Dewey, 1920) is that differences between graduates of progressive schools and those of traditional schools in terms of academic performance at a collegiate level have never been found. A very strong argument against the radical constructivist position that excessive practice will drive out understanding is made by Anderson, Reder and Simon (1992) when they write,

> Nothing flies more in the face of the last twenty years of research than the assertion that practice is bad. All evidence, from the laboratory and from extensive case study of professionals indicates that real competence only comes with extensive practice. (p. 241)

Peter W. Airasian and Mary E. Walsh (1998) raised the issue of caution when it comes to the "euphoria of constructivism" (p. 153). They wrote, "Critics of this perspective [constructivism] have pointed to the chaos that might be inherent in a multiplicity of potential meanings. It limits their recognition of the universal forms that bring order to an infinite variety of meanings" (p. 154). In *Beyond Constructivism*, Jonathan F. Osborne (1996) points out that constructivism suffers from a flawed epistemology which misrepresents the views and practices of science and scientists (p. 53). The flaw, according to Osborne, is in the constructivists' conceptions of science and the manner in which new knowledge is made. He wrote,

> The result is an instrumentalist epistemology and a misrepresentation of the nature of science through an overemphasis of the construction of the concepts, either personally or through discourse, and a failure to elaborate any methodology of theory adjudication. Notions of truth have simply been replaced by the concept of "viability." (p. 54)

The arguments made by Anderson, Reder, and Simon (1998) and by Osborne (1996) are against radical constructivism specifically. However, the authors tend to use the term *constructivism* loosely. They begin their critiques using the term radical constructivism but as the articles proceed, the term *radical* is often left out. However, their criticisms can be applied, with care, to other forms of constructivism.

Doolittle and Hicks (2003) caution against the theorists falling down the slippery slope from relativism to solipsism. Relativism, as defined by Doolittle and Hicks (2003), is the "General belief that knowledge is always dependent on the observations of an individual or social group" (p. 93) which is a tenet of social and radical constructivism. The adoption of this tenet could easily lead to solipsism, which is an extreme form of relativism and states that all knowledge is subjective. What grounds social and radical constructivism is the viability of the new knowledge as it relates to the individual's experiences.

Summary of constructivism. The major tenets of cognitive constructivism are that learning is the acquisition of mental representations that are formed through the creation and development of schemas and cognition is a series of mental processes. To the constructivists, what the person experiences is representative of what exists in the real world. To be deemed valid, the representation formed by the flow of information must bear some direct relationship with the initial input of information. (Prawat & Floden, 1994, p. 39). Using gravity to illustrate the cognitive constructivist epistemology, the knowledge that the learner gains about gravitational theory is reflective of how gravity truly functions within the universe. An individual's understanding of gravity is the true and only interpretation of gravity as a force. Individuals as learners can separate themselves from the real world and gain knowledge about the real world apart from any outside influences.

The social constructivist epistemology centers around the idea that people cannot remove themselves from the universe that they are studying. All knowledge is constructed by the minds of all participants within the culture and resources such as language mediate this knowledge. To the social constructivist, the concept of gravity held by the individual cannot be reflective of reality because the knowledge is filtered through sociological factors such as culture and language. The mental structures that are used to create the concept of gravity are a result of the social interactions of many minds.

Radical constructivism equates to social constructivism in that they share the view that knowledge cannot reflect ontological reality. Radical constructivism goes beyond social constructivism by replacing ontological reality with the concepts of viability and coherence, which are based upon the experiences of the individual learner. Thus, to the radical constructivist, the concept of gravity is influenced by those experiences held by the learner and this leads to a more viable interpretation of the concept. There are as many interpretations of the concept of gravity as there are individuals who deem that interpretation as viable.

Implications for the study. A review of the literature shows how attempts have been made to connect epistemology to pedagogy (Brooks & Brooks, 1993; Doolittle & Camp, 1999; Hendry, 1996). In these articles and studies attempts have been made to identify key principles of radical and social constructivism and link them to identifiable practices within the classroom.

The teaching strategies adopted by a teacher with a radical constructivist philosophy would allow the student to make his or her own investigations and discoveries so that what is learned makes sense to that student. The understanding achieved may not match the teacher's understanding, but would be internally coherent to the student.

Brooks and Brooks (1993), along with Doolittle and Hicks (2003), link principles of social constructivism to classroom applications. These applications revolve around the key social constructivist principle that learning should involve social negotiation and mediation. Student responses should drive teaching strategies and an open dialogue between the teacher and other members of the class should be encouraged. A teacher with a social constructivist philosophy may use strategies that emphasize the co-construction of meaning within a social activity. These activities could be cooperative learning groups, classroom discussions, and laboratory exercises that encourage the collection of data from other groups.

Block Scheduling

According to the *Alternative High School Scheduling: Student Achievement and Behavior Research Report*, (Metropolitan Educational Research Consortium, (MERC) 1997), the daily schedule that a school develops is used to organize curriculum, deliver instruction, and monitor student behavior. In 1910, the Carnegie Foundation first proposed the idea of the "Carnegie Unit." This unit became the structural component on which the school organized its school day (MERC, 1997, p.7). The Carnegie Unit is equal to 120 hours per subject and has become the standard time unit used to measure the worth of a high school credit. It is from the Carnegie Unit that schools developed the traditional everyday classroom schedules that have classes meeting four or five times per week, for 40 to 60-minutes, for 36 to 40 weeks per year.

In the late 1980s, after the publication of *A Nation At Risk* (1982) national reforms in education attempted to make the school day more efficient. These reforms led to the development of additional graduation requirements that were based on outcome-based education, alternative assessment, interdisciplinary teaching, site-based management, essential schools, Paeideia seminars, cooperative learning, and technology infusion. Block scheduling was proposed as a way to help facilitate these reforms. Table 4 summarizes the types of school day schedules that are in place in schools throughout the nation.

Table 4

Traditional School Day and Alternative School Day Schedules

Schedule	Schedule Type	Characteristics
Every day	Traditional six period day	Every day six period schedule, meets five times a week, 50-60 minutes daily, and 36-40 weeks per year. Teachers teach five classes daily for full year.
Short block	Traditional seven period day	Every day seven period schedule, meets five times per week, 40-51 minutes daily, and 36-40 weeks per year. Teachers teach five classes daily for a full year.
Alternating block	Alternating schedule	Alternating day seven period

	#1	schedule, meets 88-104 minutes daily, and 36-40 weeks per year. three classes meet on alternate days, two to three times per year and one (45-minute) class meets daily for a full year. Teachers teach three classes daily for a full year.
Alternating block	Alternating schedule # 2	Alternating day seven period schedule, meets 90-minutes daily, 36-40 weeks per year. Four classes meet on alternating days two to three times per week. One block is used as a study block. Teachers teach three classes daily for a full year.
Alternating block	Alternating schedule #3	Alternating day seven period schedule, meets 88-90 minutes daily, 36-40 weeks per year. Four classes meet on alternating days two times per week. On Fridays each of the classes meet for 40 minute periods. Teachers teach three classes daily on block days for a full year.
Everyday long		Every day schedule, four classes, meets 85-90 minutes daily, 18-20 weeks per year. A second set of four classes meet daily for the second semester. Teachers teach three classes daily each semester.

Note: Data taken from "Alternative High School Scheduling: Student Achievement and Behavior Research Report" *The Metropolitan Educational Research Consortium, 1995, p. 10.*

Cannady and Rettig (1995) also describe in detail the different types of block scheduling and ways to implement them. They point out that under the traditional school day of seven periods, each 45-minutes in duration, only about 60% of the school day is actually available for instruction. They write, "As many of them [teachers] moved away from the lecture teaching format, they became frustrated with the single period scheduled day" (p. 8). They become frustrated because the 45-minute class period limits the type of instructional strategy the teacher can employ.

Cannady and Rettig (1995) were the first to write a detailed analysis of block scheduling. What they wrote was not research, but was a description of the positive influences that block scheduling could have on curriculum, teaching strategies and student behavior. After the publication of Cannady and Rettig's work, other authors (Brett, 1996; Bugaj, 1999; Day, 1995; Hackman & Scmitt, 1997; Queen, 2000; Schultz, 2000; Winn, Menlove, & Zsiray, 1997) began to look at and discuss the merits of block scheduling. As did Cannady and Rettig, most described the advantages of the extended school period to be:

1. the introduction and reinforcement of a concept in one class period;
2. allowing the teacher to get to know his or her students better;
3. ideal for cooperative learning and other teaching strategies;
4. more time spent using technology;

5. more hands on activities;
6. greater opportunity to take electives;
7. fewer classes allow for less homework;
8. science classes can participate in more in-depth laboratory exercises;
9. accommodations for individual learning styles;
10. promotes student inquiry as a method for achieving greater understanding;
11. student-centered teaching and learning;
12. reduced percentage of class time used for administrative responsibilities;
13. extended planning time for teachers

The general disadvantages to block scheduling are: slower students may fall behind because more information is packed into a 90-minute class than a 45-minute class; student absenteeism; individual school programs that conflict with the block schedule such as the fine arts programs; student misbehavior in an extended class period; non-supportive administration; and teachers using 45-minute strategies in a 90-minute format.

According to Brett (1996) “A successful program depends upon the attitude of the teacher” (p. 78). The success or failure of any program comes down to the teacher’s approach to planning, content material, class assignments and homework policies (p. 79). These thoughts are echoed by Schultz (2000) when he writes, “It is the teacher’s imaginative pedagogy that develops the classroom experiences” (p. 30).

The research studies that have been conducted to evaluate block scheduling fall into the two main paradigms of research: qualitative and quantitative. In general, the quantitative studies looked at the relationship between block scheduling and academic achievement and the qualitative studies looked at the relationship between student and teacher attitudes and perceptions about block scheduling.

Block scheduling and academic achievement. The research that evaluates student achievement can be further divided into those studies that included school systems, either high schools within the state or the district, (Arnold, 2002; North Carolina State Department of Education, 1997; Office of Program Evaluation, 1996; Payne & Jordan, 1996; Pliska, Harmston, & Hackman, 2001; Texas Education Agency, 1999) or those studies that evaluated students as a group within a school system (Eineder & Bishop, 1997; Freeman & Maruyama, 1995; Hess, Wronkovitch, & Robinson, 1999; Lawrence & McPherson, 2000; Schroth & Dixon, 1996; Skrobaracek, et. al, 1997).

Student achievement was measured against state mandated end-of-course (EOC) exams, SAT/ACT exams, advanced placement (AP) exams, individual grade point averages (GPA), failure rates, course grades assigned by the classroom teacher, and course credits earned by individual students. Failure rates declined for students on intensive schedules (Kramer, 1997; Office of Program Evaluation, 1996; Rettig & Canady, 2001). However, there is evidence (Kramer, 1997; Freeman & Maruyama, 1995; Skrobarcek, et. al, 1997) that algebra I students have a higher failure rate on the block schedule than on the traditional one. Freshman, Sophomores, and Juniors earned more credits on the intensive schedule (North Carolina State Department of Education, 1997; Office of Program Evaluation, 1996), and the numbers of students achieving honor roll status increased on the block schedule (Eineder & Bishop, 1997; Office of Program Evaluation, 1996).

Individual student class grades increased under the block schedule (Eineder & Bishop, 1997; Freeman & Maruyama, 1995; Rettig & Canady, 2001; Texas Education Agency Office of Planning and Research, 1999) and there were mixed results as far as student achievement and standardized testing. Payne and Jordan (1996) studied 788 high school students in Georgia and compared the scores on the Georgia EOC exams with those students on intensive schedules (323) and those on the traditional schedule (465). The Georgia EOC exams are given in the subjects of English-language arts, math, and writing assessment. They found that 78% of first time test takers who were on the block schedule passed the exams with 67% of first time test takers on the traditional schedule passing the exams. Most other studies on block scheduling and achievement on standardized test scores (Eineder & Bishop, 1997; Kramer, 1996; Schroth & Dixon, 1996) showed no difference in mean test scores on standardized tests between those students on intensive schedules and those on traditional schedules. The one stand out study was performed by the North Carolina Department of Education (1997). When the EOC mean scores were adjusted for socio economic status (SES) and parent educational level (PEL), students on intensive schedules had significantly higher mean test scores than students on the traditional schedule.

Block scheduling and perceptions. The research that has been performed to evaluate the perceptions of those in education can be divided into three main groups: perceptions held by administrators (Black, 1998; Bugaj, 1999; Calvery, Sheets, & Bell, 1999; Hamdy & Urich, 1998; Stader & DeSpain, 1999), perceptions held by teachers (George, 1997; Hamdy & Urich, 1998; ; Salvaterra & Adams, Staunton, 1997; Stader & DeSpain, 1999; Veal & Flinders, 2001; Wison & Stokes, 1999), and perceptions held by students (Hurley, 1997; Salvaterra, Lare, Gnall, & Adams, 1999; Wilson & Stokes, 2000).

Principals and administrators overwhelmingly support block scheduling (Hamdy & Urich, 1998). According to Black (1998) intensive scheduling was adopted by principals as a solution to three problems: haphazard pull-out programs, school climate and discipline, and to help slower students who need more time to grasp a concept. Bugaj (1999) found that administrators support block scheduling more than teachers do and that teachers support block scheduling over the traditional schedule. However, more than half of all administrators surveyed indicated that other factors besides scheduling have more effect on student outcomes or performance and that, "These findings indicate that intensive scheduling had the greatest positive impact on those planning/programming items that are under the control of the school district" (p. 67).

Hamdy and Urich (1998) pointed out that the primary reason principals favored block scheduling was that it would "compel teachers to abandon the lecture method of instruction and utilize teaching strategies more compatible with individualized instruction" (p. 9). In a study that compared the perceptions of administrators with those of teachers, Stader and DeSpain (1999) reported that principals perceived an increase in the number of A's and B's but when compared to school records and broken down into subject areas, math and science courses showed a decrease in A's and B's with English and Social studies showing a large increase. Administrators perceived a substantial increase in the curricular scope while teachers perceived a decrease. Administrators as a whole rejected the idea of returning to a traditional schedule while teachers generally rejected the idea of returning to a traditional schedule.

Teachers perceived substantial increase in the variety of teaching strategies used by the classroom teacher (Veal & Flinders, 2001). Salvaterra and Adams (1996) reported that teachers perceived block scheduling enhanced the ability to incorporate more teaching strategies such as cooperative learning. Other studies that looked at teacher perceptions (Bugaj, 1999; George, 1997; Hamdy & Urich, 1998; Stokes & Wilson, 2000) concluded that teachers varied teaching strategies as well. These studies also showed that teachers felt that block scheduling allowed them to teach the content of their courses in a more in-depth fashion, allowed for more student-teacher interaction, and provided more time for student-centered instruction.

Calvery, Sheets and Bell (1999) showed that after one year on the block schedule, the students' positive attitude about intensive scheduling increased from 17% to 36%. However, only 14% of the students responding to the survey felt that their teachers changed or varied their instruction strategies. Hurley (1997) found that a majority of students from five high schools in North Carolina would not be in favor of returning to a traditional schedule. The advantages of block scheduling as perceived by students were higher grades, more in-depth coverage of subject matter, more individualized attention from teachers, less hectic atmosphere, having a fresh start each semester, early graduation, being able to re-take a class previously failed and remain within the graduating class, and less homework. Disadvantages of intensive scheduling were listed as teachers lecture too much, bad classes are really bad for 90 minutes, teachers not using diverse instructional strategies, and uneven schedules: one semester with hard classes followed by a semester with easy ones.

Summary of block scheduling. If academic achievement is defined within the boundaries of class grades, number of students on the honor roll, scores on standardized tests, student failure rates, grade point averages, and number of credits earned, then the best that we can say about block scheduling is that it does not harm the academic achievement of students. In most schools studied, block scheduling had been in use for between 1 and 4 years. The research shows that if school systems are implementing block scheduling with the hopes of increasing EOC, SAT, or ACT scores, they will be disappointed. However, if they are implementing block scheduling to increase student achievement in terms of how the system defines achievement, that is, class grades, number of earned credits, failure rates, and number of students on the honor rolls, then they will be satisfied.

Overall, administrators, teachers and students support block scheduling. The perceptions held by each group differ greatly as to how and why block scheduling succeeds. Administrators perceive a decrease in discipline issues outside the classroom. With fewer classes there are fewer class changes. Principals also perceive block scheduling as a means of compelling teachers to incorporate more and varied instructional strategies and move away from the lecture format. Teachers perceive block scheduling as a way to get to know their students better, allow for more varied instructional strategies such as cooperative learning, and to foster a more social atmosphere within the classroom. Students perceive block scheduling as a way to experience more in-depth coverage of course materials, increase class grades, and increase the number of course credits.

The common theme as perceived by all three groups is that block scheduling will allow for the classroom teacher to present a more varied instructional strategy to the students. The question is, are they? Responses to Likert scale questions like “Teachers have developed methods to keep students engaged and involved in several activities to make the increased time more effective and interesting” (Hamdy & Urich, 1998, p. 11), or “I am better able to vary my instructional practice” (Staunton, 1997, p. 75) allow the administrator and the teacher to express a positive outcome without explaining *how* they change or vary their instructional practice.

The research articles cited above illustrate some general findings as one searches the literature. The qualitative research (Benton-Kupper, 1999; Bugaj, 1999; George, 1997; Veal & Flinders, 2000; Wilson & Stokes, 2001) supports the idea that teachers, students and administrators have a positive perception of block scheduling while the quantitative research generally shows no or modest difference in academic achievement between those schools that are blocked and the traditionally scheduled schools (Lawrence & McPherson, 2000; Payne & Jordan, 1996; Wilson & Stokes, 1999).

In conclusion, the research available tends to break down into qualitative and quantitative interpretations about the effectiveness of block scheduling. There appears to be no significant statistical change in standardized scores on achievement tests (Lawrence & McPherson, 2000; Wilson & Stokes, 2000, MERC, 1997). However, when the analysis turns to perceptions, it is apparent that teachers, students and administrators find block scheduling to be a better learning environment.(Louden & Hounshell, 1998; Hurley, 1997; Wilson & Stokes, 1999; Veal & Flinders, 2001). More time is allotted for constructivist-type activities. This allows students more time to accomplish hands-on activities and to process information.

Implications for the study. “Extended class blocks permit teachers to use a variety of creative approaches to instruction while accommodating individual learning styles” (Hackman & Schmitt, 1997, p. 1). Some of the creative approaches suggested by Hackman and Schmitt (1997) are: think-pair-share, learning journals, guided notes, active questioning, and cooperative learning. These types of strategies, according to Robbins, Gregory and Herndon (2000), “Foster deep understanding of skills, concepts, and habits of mind, such as critical thinking and creative thinking” (p. 99) and are appropriate for the extended class block. Robbins, et al. (2000) identify strategies under what they call the “social family” (p. 64) which includes group investigations, role play, simulations, and cooperative learning groups. These strategies fit well with the social constructivist epistemology. Under the “personal family” (p. 64) of group, the authors list learning centered strategies, synectics (a strategy that relies heavily on metaphors), expanding personal horizons, and class meetings. These strategies fit well with the radical constructivist epistemology. Teaching strategies used by teachers reflect their own personal beliefs about learning. There are as many teaching strategies as there are beliefs about learning. However, science education has adopted teaching strategies based upon inquiry, conceptual change, and cooperative learning. These are social constructivist in nature.

Science Education

National science standards and epistemology. According to Hewson and Hewson (1988), and the National Research Council (1996), a large body of research in recent years has produced a general picture of science learning. This picture is a constructivist one: learners actively construct their own new knowledge. Two learning theories have emerged as the basis for implementing constructivist strategies within the science classroom: (a) conceptual change theory and (b) inquiry-based theory. This section will discuss both theories and how they relate to science education.

Conceptual change theory. Research, like that of Ritchie, Tobin, and Hook (1997) has shown that science learning is a constructive process and that the teacher must identify the prior knowledge held by the students and understand their viewpoints. They found that when middle school science teachers embraced a referent that excluded strategies that identified the students' prior knowledge or viewpoint, the interaction between student and teacher were "dominated by authority" (p. 223). In order for scientific understanding to occur, students need to change their minds in ways that incorporate the new knowledge with their own prior knowledge. This is conceptual change learning theory and social constructivists have criticized it. Conceptual change theory involves changing the scientific concepts with which students enter the classroom and replacing them with scientific conceptual schemes that are more acceptable. "Helping students to understand and use the conceptual schemes of science is complicated by the fact that students enter instruction with other, nonscientific conceptual schemes of their own" (Smith, Blakeslee, & Anderson, 1993, p. 112). William Cobern (1996) argues that conceptual change theory has a goal that is "wrong-headed" (p. 579). Science educators who believe in the conceptual change theory assume that the validity of scientific theories is *prima facie*. In other words, science educators believe that students will accept the new scientific knowledge over their own preconceived knowledge because science represents true knowledge. Since conceptual change theory assumes that the student will change his or her conceptions about science to more desirable ones, it is non-constructivist. This is non-constructivist because conceptual change theory assumes that the students' acquisition of new knowledge matches that of the teachers and that the new knowledge is correct. It assumes that there is only one correct concept, the scientific one, and that the student will replace his or her own concepts about science with the one(s) provided by the teacher.

Stofflet and Stoddard (1994) define conceptual change learning as learning that occurs when students' understanding about specific concepts is restructured in major ways and that the theoretical framework for this pedagogy is based upon Piagetian, or radical constructivism. The student will assimilate and accommodate new information so that an equilibrium is established between what was previously known by the student and the new information.

Hewson and Hewson (1988) conclude that research in science instruction which is based upon conceptual change ideas "make important contributions to an appropriate conception of teaching science, by identifying key points in instructional strategies which help students overcome their naïve, inappropriate conceptions" (p. 607). These strategies are: (a) using pretests to diagnose prior knowledge, (b) having students work in groups for the clarification of their own thoughts and to form a basis on which their conceptions are plausible and fruitful, (c) provide for a direct contrast between the student's view and the desired view so that the student is dissatisfied with his existing ideas, (d) provide immediate opportunities for the desired view to be used in explaining a phenomenon, (e) provide immediate opportunities for the student to apply his newly acquired understanding to different examples. Fischer and Aufschnaiter (1993) stated that their investigations lead to three conclusions or tendencies in the science educators' community:

1. It is evident that more than input to and output from a black box has to be taken into account when students are observed during instruction. One has to consider how students interact within a context of social demands (e.g., the expectations of the teacher and other students.)
2. At present, more and more scientists are convinced that students differ greatly from each other in their individual perceptions of the world.
3. Among many teachers and researchers, it is generally accepted that the human brain does not process information like a computer. The 'information' problem can be recognized as an important paradigm case regarding questions about perception and understanding. Consequently, a new kind of description of complex perception and thinking is absolutely necessary. (p. 154)

To Starver (1998), the value of these conclusions, along with social negotiations that are based upon language, to science pedagogy is that the "language-based discussion, negotiation, and consensus building that takes place among students in cooperative learning are firmly grounded in constructivist principles" (p. 518). Glasson and Lalik (1993) along with Stofflet and Stoddard (1994) showed that when science teachers are exposed to a constructivist teaching pedagogy such as conceptual change learning, they alter their teaching practices so as to allow students more opportunities to express their views about scientific concepts

Inquiry-based learning. In *A Neurocognitive Perspective on Current Learning Theory and Science Instructional Strategies*, Anderson (1997) states that "older dualistic views and those based solely on biological structural-functional analysis may be insufficient to explain an active role of the learner in information processing as included in modern learning theories" (p. 67). He also states,

> Learning science through hands-on and manipulative experiences, in conjunction with group learning processes, affords a rich matrix of information that encourages simultaneous as well as serial information processing. Attention to the many social, intellectual, phenomenological, and internally generated sources of information that accrue in group-oriented, laboratory-based learning experiences, encourages the learner to construct interpretations of experience that involve multiple pathways and build strengthened and enlarged networks of knowledge representation. (p. 79)

The importance of group work, manipulatives, and experience is that they lead to student generated discussion. Discussion, according to Hendry (1996) helps the student to interpret and evaluate the experiences of others. "A person's generation of diverse ideas increases the probability that his or her knowledge will become unsustainable. Thus, students' discussion and interrelation with a variety of materials will promote their construction of totally new knowledge" (Hendry, 1996, p. 29). The link between constructivist learning and inquiry-based learning is made by Eick and Reed (2002). They wrote, "Constructivist learning theory supports inquiry by placing the focus of learning on student ideas, questions, and understanding, and not teacher delivery of content" (p. 402). Inquiry learning strategies are used to promote not only the basic scientific laws and theories but also how scientists study the natural world and the nature of science.

The nature of science. While Starver and Anderson have written about constructivist theory and science education, other researchers (Gallagher, 1991; Glasson & Lalik, 1993; Munby, 1984; Powell, 1994; Shapiro, 1996; Stofflet & Stoddard, 1994; Wildy & Wallace, 1995) have devoted time to studying the perception of science teachers toward learning and scientific literacy. Lederman (1992) defines the nature of science (NOS) as, "The values and assumptions inherent to the development of scientific knowledge" (p. 331). In an exhaustive review of the empirical literature, both qualitative and quantitative, that has examined the NOS , Lederman (1992) has clarified what has been learned in the past 40 years of research. He divides the research related to NOS into four related, but distinct, lines of research: (a) assessment of the student conception of the nature of science; (b) development, use, and assessment of curricula designed to improve student conceptions of the nature of science; (c) assessment of, and attempts to improve, teachers' conception of the nature of science; (d) identification of the relationship among teachers conception, classroom practice, and students' conception. For this prospectus, the latter two lines of research will be the focus.

An important tool used by researchers to measure teachers' understanding of the nature of science is the Test on Understanding Science (TOUS) developed by Cooley and Klopfer in 1961. Using this instrument, along with others, Lederman (1992) concludes that the research in the past 30+ years has provided four significant findings concerning the NOS: Science teachers appear to have an inadequate conception of the NOS; efforts to improve teachers' conceptions of the NOS have achieved some success; academic background variables have not been significantly related to teachers' conceptions of the NOS; the relationship between teachers' conceptions of the NOS and classroom practice is not clear.

Science teachers' knowledge about the nature of science plays a key role in the formation of the image of science held by the general public (Gallhagher, 1991). Since the majority of science teachers are taught science under the positivistic philosophical perspective, as defined by Garrison (1986) and Brown (1977), secondary school science students leave the classroom with the perception that the goal of science is to "achieve an isomorphic relationship between human knowledge and the natural world" (Glasson & Lalik, 1993, p. 187). Not only are science teachers exposed to a positivistic prospective about the nature of science by their instructors, but they use textbooks that present scientific knowledge as "revealed truth" (Gallagher, 1991, p. 123). A positivistic philosophy according to Brown (1977) "maintains that only those knowledge claims which are founded directly on experience are genuine" (p. 21).

Early research (Anderson, 1950; Behnke, 1961, Miller, 1963) found that teachers perceived the laws and theories of science as "fixed and unchangeable" (p. 340). Other studies (Aguirre, Haggerty & Linder, 1990; King, 1991) have corroborated the earlier findings. Most individuals [preservice teachers] believed that science was a body of knowledge consisting of a collection of observations and explanations of propositions that have been proven to be correct. Subjects were evenly divided between the 'dispenser of knowledge' and 'guide/mediator of understanding' conceptions of science teaching. Approximately one-third of the preservice teachers characterized learning as the 'intake of knowledge.' (p. 344)

Lederman (1992) also looked at prior research that focused on the relationship between the teachers' conceptions of NOS and classroom practice. As a result of a series of investigations (Brickhouse, 1989; Duschl & Wright, 1989; Zeidler & Lederman, 1989), the presumed relationship between teachers' conceptions and instructional behaviors were demonstrated to be too simplistic relative to the "realities of the classroom" (p. 347). Duschl and Wright (1989) found through their research that there was no significant relationship between teachers' understanding of the nature of science and classroom practice. The study conducted by Hodson (1993) examined how a teacher's choice and design of learning experiences, especially laboratory procedures and practices, were reflective of their views concerning the nature of science. He found that that there were inconsistencies between the teacher's expressed views about how scientific knowledge is constructed and validated within the scientific community and their views about scientific knowledge implied by the teacher's choice of learning experiences. These inconsistencies were manifested in several ways. One teacher presented scientific knowledge to students in an authoritarian manner, which was in direct conflict with his own expressed views concerning the nature of science. Other teachers in the study kept sending mixed messages to the students. Some material was presented as absolute truth about the universe while other material was presented as being socially constructed/negotiated and culturally determined knowledge. According to Hodson (1993) the reason there is a persistent mismatch between the philosophical position of the classroom teacher and curriculum experiences is, "The failure to acknowledge the social construction of scientific knowledge in the design of laboratory activities" (p. 50). Current research on NOS, such as that of Nott and Wellington (1998) use what are termed critical instances to probe how teachers view the nature of science. They define a critical instance as an event "which makes the teacher decide on a course of action which involves some kind of explanation of the scientific enterprise" (p. 581). They found that with the use of these critical instances, researchers can indeed elicit the views and beliefs of teachers about the nature of science.

Science and personal beliefs about learning. In *From Field Science to Classroom Science: A Case Study of Constrained Emergence in a Second-Career Science Teacher*, Richard Powell (1994) wrotes, "Studies conducted with both beginning and experienced science teachers suggest that classroom instruction is linked to personal beliefs about science and about how students learn science" (p. 273). These personal beliefs can conflict. The subject in Powell's study had a personal belief about science that aligned with logical positivism. However, his belief about how students should learn science was based upon "experience centered activities" (p. 281). Wildy and Wallace (1995) also share this philosophy of learning:

> Learning occurs as students try to make sense of what is taught by trying to fit it with their own experience. To do this, though, teachers need to have a clear idea of what students already know and understand so that they can engage students in activities that help them construct new meanings (von Glasersfeld, 1992). From a constructivist perspective, then, science is not the search for truth; it is a process that helps make sense of the world. (p. 145)

Research conducted by Fisher and Aufschnaiter (1993) and by Ebenezer and Erickson (1996) used specific scientific concepts such as solubility and electricity to show a relationship between the science teacher's own epistemological philosophy and students' understanding of the concept. Ebenezer and Erickson (1996) conclude that there are many commonalties in students' conceptions that span age and sociocultural backgrounds and that, "In school, students are expected to abandon their perceptually sensitive models in favor of the more abstract models developed by scientists"(p. 195).

The relationship between the science teacher's knowledge, views on learning, and teaching strategies is complex. In *The Social Constructivist Movement in Modern Psychology,* Kenneth Gergen (1985) writes, "The mounting criticism of the positivist-empiricist conception of knowledge has severely damaged the traditional view that scientific theory serves to reflect or map reality in any direct or decontextualized manner" (p. 266). Much has been written about the relationship between the logical positivism of science and modern cognitive theory (Appelton & Asoko, 1996; Anderson, 1997; Letts, Bailey, & Scantlebury, 1997). Those who write on this subject could be classified as social constructivists with strong leanings toward cognitive constructivism, and to some degree the information processing educational philosophies. In fact, Grandy (1997) claims that metaphysical (radical) constructivism is "irrelevant to science education" and that cognitive constructivism has "strong empirical support and indicates important directions for changing science instruction" (p. 43).

Meaningful learning in science education involves the networking of established schemata within the brain (Anderson, 1996). These schemata act to modify incoming information to make it more compatible with the learner's prior knowledge (Reynolds, Sinatra, & Jetton, 1996, p.97). Using hands-on and manipulative experiences along with group learning provides the necessary venues for the acquisition of knowledge through drill and practice as well as providing for the many social, intellectual, phenomenological, and internally generated sources of information that are experienced in group-oriented, laboratory based exercises.

Those who have performed research within the classroom (Appleton & Asoko, 1996; Fischer & Aufschnaiter, 1993; Spraque & Dede, 1999) that focused on constructivism and science education showed that whether or not a teacher uses a constructivist approach to teaching depends upon the teacher's own referent. If the teacher thinks that content is more important than depth, lecturing will be the dominant form of delivery. However, if the teacher thinks that depth is more important, then a more constructivist approach will be used. Appleton and Asoko (1996) performed an interpretive case study in which they found, as did Tobin (1990), that "the most persuasive influence on classroom transactions was the teacher's beliefs about teaching and learning" (p.169).

In general, the research shows that constructivist philosophy and constructivist teaching strategies are consistent with the view that science education takes place through inquiry (Hendry, 1996). Although Hendry does not go into detail as to what he means by inquiry, Dettrick (1999) defines it as when "teachers design situations so that pupils are caused to employ procedures research scientists use to recognize problems, to ask questions, to apply investigational procedures, and to provide consistent descriptions, predictions, and explanations which are compatible with shared experience of the physical world" (p. 1). Dettrick (1999) goes on to make an important distinction between inquiry and discovery based teaching strategies. He defines the discovery approach as being able to "motivate students to learn science if they experience the same feelings scientists obtain from 'discovering' scientific knowledge" (p. 18). From these definitions, the inquiry approach fits best with constructivist epistemology because “discovery” assumes that the individual student’s understanding of the new knowledge matches the reality of the discovery. By this argument it is easy to see why the National Science Education Standards adopted an inquiry-based approach to science education. It is unfortunate, according to Rodriquez (1997), that the NRC did not take the time to develop the theoretical background necessary to convince science teachers.

Teaching strategies in science education. Science teachers are using varied sorts of teaching strategies that incorporate aspects of conceptual change theory (Glasson & Lalik, 1993; Smith, Blakeslee, & Anderson, 1993), inquiry based learning (Germann, 1991), and cooperative learning (Lord, 1994). According to Hartman and Glasgow (2002) learning is more meaningful when strategies used by the science teacher include organizational techniques that allow the students to know in advance what topics and sub-topics are going to be included in the lesson.

Hartman and Glasgow (2002) base their teaching strategies on Ausubel’s (1960) theory of knowledge structure. Ausubel (1960) wrote that meaningful learning occurs when teachers use advanced organizers, and abstract, general, and inclusive introductory material that provides a framework for students to incorporate and evaluate new information. From this, Hartman and Glasgow (2002) developed a series of instructional strategies linked directly to classroom practices. For example, a suggested instructional strategy mentioned is to show students an overview of the day’s content. They then give two examples of advanced organizers that could be used by the teacher. Another strategy that is given uses the conceptual change model to identify misconceptions generated by the textbook. Concept mapping, the use of peer tutoring, a learning cycle, and the use of state mandated national standards as benchmarks are other suggested learning strategies.

A study performed by Smith, Blakeslee, and Anderson (1993) showed how 7th grade life science teachers incorporated the strategies based upon the conceptual change model into their pedagogy. The model of conceptual change developed by Posner, Strike, Hewson, and Gertzog (1992) consists of four components that include: the student's dissatisfaction with his or her existing conceptions; new concepts must be minimally understood in order to explore the inherent possibilities in them; new concepts must appear initially plausible and capable of fitting with other knowledge and experiences; and that the new concept should suggest the possibility of a fruitful research program that has the potential to be extended to new areas of inquiry. Using this as the basis, Smith, Blakeslee, and Anderson (1993) developed a system designed to provide quantifiable data about teaching strategies that reflect the conceptual change model. These strategies were categorized based upon: questioning strategies used by the teacher, strategies used by the teacher to present information, strategies used to focus the students' attention on the conceptual content of the lesson, and strategies for using phenomena in laboratory work, demonstrations, or examples for discussion.

Thirteen 7th grade teachers taught units on photosynthesis, cellular respiration, and matter recycling in ecosystems. The thirteen teachers were divided into three groups. One group of four teachers attended a half-day workshop where they were exposed to conceptual change theory strategies. A second group of five teachers did not attend the workshop but used curriculum materials designed by the researchers that incorporated conceptual change strategies. The third group consisted of four teachers who attended the workshop and who used the curriculum materials provided by the researchers.

The results of the study conducted by Smith, Blakeslee, and Anderson (1993) showed that teachers varied widely with their use of conceptual change strategies. Those teachers that used the specially prepared materials provided by the researchers incorporated more conceptual change strategies within their pedagogy. This makes sense because the materials were designed for the use of these strategies. Along with the research performed by Smith, Blakeslee, and Anderson (2002), Lawrenz (1990) studied the relationship between teaching strategies and learning. She also showed that science teachers use a variety of instructional strategies. However, the distribution of time spent on various activities does not support the teacher's commitment to hands-on inquiry learning. There is a clear mismatch between the teacher's desire to provide more inquiry-based learning strategies and the actual class time devoted to the practice of these strategies.

The National Survey of Science and Mathematics Education: Trends from 1977 to 2000 (Smith, Banilower, McMahon, & Weiss, 2002) provides three sources of information concerning teaching strategies in science and mathematics education. The first source is a series of questions concerning instructional strategies that asked teachers to indicate the frequency with which they used specific strategies to complete a lesson plan. Teachers' responses were compared between the two years of 1993 and 2000 (see Table 1). The results from this survey indicate that not much has changed concerning the use of instructional strategies by teachers in the past ten years. The trend, however small, is toward more cooperative and hands-on type strategies.

Table 5

Frequency of Instructional Strategies Used by teachers in 1993 and 2000

% of teachers who:	1993	2000
reported using hands on/laboratory activities at least once per week.	67%	71%
had students listen and/or take notes.	93%	86%
had students work in groups.	74%	80%

Most recent classroom activity	1993	2000
Completion of textbook/worksheet problems.	62%	57%
Hands-on/laboratory activities.	44%	42%
In-class reading assignment.	39%	26%

The number of minutes spent on each activity	1993	2000
Class time spent on whole class lecture/discussion.	42%	40%
Class time spent on reading from books, completing worksheets, or other like activities.	17%	15%

Class time used for manipulatives and other hands-on activities.	21%	22%

Note: Data taken from "The national survey of science and mathematics education: Trends from 1977 to 2000, 2002, retrieved September 10, 2002, from http://2000survey.horizonresearch.com/reports/trends.php

Summary of science education. The National Science Education Standards have adopted an inquiry-based approach to science education which is constructivist in nature. A constructivist approach to teaching and learning provides a powerful model for describing how conceptual change and inquiry in learners can be promoted. The criticism of constructivism is in its inherent difficulty in translating an epistemology into a pedagogy (Campbell & Ramsden, 1996; Pekarek, Krockover, & Shepardson, 1996; Russell, 1993). There is research that shows what strategies teachers should be using in the classroom (Hartman & Glasgow, 2002; Lawrenz, 1990; Smith, Blakeslee, & Anderson, 1993) and there is research indicating what teachers are actually doing in the classroom (Smith, Banilower, McMahon, & Weiss, 2002). As reported by the National Survey of Science and Mathematics Education; Trends in 1977 to 2000 (2002) survey of teachers, there has been a reduction in some traditional types of activities such as students reading about science. However, science instruction in general and the strategies used by science teachers do not appear to have changed with any statistical significance in the past 7 years. According to Lederman's (1992) exhaustive review of research on the nature of science, science teachers views on the NOS are not reflected in the choice of classroom experiences that the teachers design or use. Teachers of 40 years ago perceived scientific knowledge as fixed and immutable, as do a significant number of teachers today (Duschl & Wright, 1989).

Implications for the study. The types of strategies used by the teacher and the time spent on each strategy makes a statement about how that teacher thinks students learn (Munby, 1984; Powell, 1994). “Teachers’ beliefs and principles are contextually significant to the implementation of innovations, be they curricular or instructional” (Munby, 1984, p. 28). Science education has embraced a constructivist philosophy concerning teaching and learning (Naylor & Keogh, 1999; Pines & West, 1997; Ritchie, Tobin, & Hook, 1997). Linked to this constructivist epistemology are teaching strategies such as cooperative learning, conceptual change learning, and inquiry learning. Studies have suggested that these strategies take more time to incorporate into a lesson than do more traditional activities (Cannady & Rettig, 1995; Hamdy & Urich, 1998). Block scheduling has been proposed as a way to provide more time so that the teacher can achieve more depth of content (Benton-Kupper, 1999; Hurley, 1997). This proposed study would examine the strategies used by science teachers to engage students within the block schedule and how these strategies reflect the teacher’s own philosophy of how students learn.

According to the survey conducted by Smith, Banilower, McMahon, and Weiss (2002) teaching strategies in science education have not changed much in the past seven years. During this time period, many schools have adopted block scheduling. It appears that with the adoption of block scheduling, teachers are not changing their teaching strategies. One reason for this may be the teachers’ own personal views about the nature of science. The choice of learning experiences, especially with the use of hands-on manipulatives, are reflective of the teachers own view of the nature of science (Hodson, 1993).

The "conduit" or "jug-and-mug" view of learning (Bentley, 1998) that has dominated science education for the past fifty years describes the teacher-student relationship as a sender-receiver dynamic. The logical positivistic philosophy (Brown, 1977; Garrison, 1998) of science education has been recently shown to be untenable. Bentley (1998) wrote, "Knower and known are clearly separated, that object knowledge is the product of scientific methods, and that theories are sharply distinct from facts, and facts from values" (p. 244).

Hodson (1993) showed how a teacher's choice and design of learning experiences were reflective of their views concerning the nature of science. He found that that there were inconsistencies between the teacher's expressed views about how scientific knowledge is constructed and validated within the scientific community and their views about scientific knowledge implied by the teacher's choice of learning experiences.

Teacher Beliefs

Factors that influence the beliefs of teachers. Much of what a teacher does within the confines of the classroom is influenced by his or her life experiences and beliefs (Brand & Glasson, 2003; Keys & Bryan, 2001; Pajares, 1992). Munby (1984) wrote, "Evidently, teachers' beliefs and principles are contextually significant to the implementation of innovations, be they curricular, instructional" (p. 28). Therefore, in order to understand how a teacher deals with innovations such as the incorporation of certain teaching strategies within a specific time frame, we must first understand the teacher's own beliefs about teaching and learning. According to Lumpe, Haney, and

Czerniak (2000), "Both prospective and in-service teachers develop their beliefs about teaching from years spent in the classroom as both teachers and students" (p. 276). Beliefs are thought to be the best indicators of future decisions and they are reflective of the knowledge, attitudes, and personal convictions held by teachers (Bendura, 1997; Koballa, 1992). The elements of a teacher's belief system may "significantly affect how teachers implement inquiry based instruction" (Keys & Bryan, 2001, p. 635).

According to Cronin-Jones (1991) the components of a teacher's belief system include beliefs about curriculum implementation, how students learn, the role of the teacher in the classroom, the ability levels of the students within the classroom, and the relative importance of the topics. Both of the participants in Cronin-Jones' case study believed that the most important student outcome was the acquisition of factual content. This belief was influenced by their attitude toward the content that they were teaching, the overall curriculum, and by how they implemented the instruction. Both participants believed that students learned best by the use of drill and practice techniques and that their role within the classroom was that of director as opposed to facilitator. Although Cronin-Jones does not attempt to get at the underlying root of why these two teachers believed what they did, such as life experiences, she does point out that, "Regardless of the potential usefulness of strategies such as small group work, if teachers do not believe such strategies are important or valid, they will not be implemented" (Cronin-Jones, 1991, p. 248).

Brand and Glasson (2003) go even further in their study of pre-service teachers and the development of belief systems as related to racial and ethnic identities. They define beliefs as, "Unconscious associations and inferences developed during early stages of life that determine our ideas about the world" (p.3). Their ethnographic study of three pre-service teachers from diverse ethnic and racial backgrounds identifies three themes that depict the influence of racial and ethnic subcultures on the beliefs of their participants. These themes are: (a) The early life experiences and racial and ethnic identity of the pre-service teachers influenced their beliefs about diversity; (b) life experiences and racial and ethnic identity influenced the choice of pedagogy and epistemology as they relate to diversity within the classroom; (c) experiences with diversity within the teacher education programs challenged the pre-service teachers' preexisting beliefs. The authors show how instructional practices are governed by the need to maintain control and familiarity, which are affected by deep-rooted beliefs that in turn are affected by life experiences. "Although inquiry instruction was modeled and valued in the methods classes, the three pre-service teachers in this study were more likely to teach within the framework of their own comfort levels" (Brand & Glasson, p. 33).

Holt-Reynolds (1992), a teacher educator, developed a practical theory about teaching content literacy to prospective secondary teachers. She made two assumptions concerning her ability to teach the course and the ability of the students to learn the content of the course: (a) the beliefs her students brought to the course and how, if left unexamined, would lead her students to reject the rationales underlying the pedagogies she wanted to teach; (b) the pedagogical strategies most likely to engage her students so that they could reframe their beliefs in order to find the content useful. Within this context, she addressed underlying beliefs about the teaching and learning of content area literacy and developed three belief structures that were most likely to influence how students learned in her classroom.

1. *Beliefs about learning and learners*. From past experience with this course, Holt-Reynolds predicted that many students would enter with beliefs that secondary students' learning was primarily a function of their motivation or interest.
2. *Beliefs about teachers' instructional roles*. Holt-Reynolds predicted that many prospective teachers would believe that if teachers are enthusiastic about the subject and showed students that they cared, then students would be more interested and work harder and therefore learn more.
3. *Beliefs about student activities*. Holt-Reynolds predicted that many prospective teachers would consider academic tasks and activities as less critical for learning than the oral or written text that presented the content to be learned. Activities other than listening to lectures or reading might be seen as "frills," nice things to do if there is time but not critical for learning. (Anderson & Holt-Reynolds, 1996, p.4)

Teacher beliefs about learning. The need for drill and practice may be an obstacle for inquiry-based instruction (Keys & Bryan, 2001). Teacher beliefs that center around the idea that science is a body of immutable knowledge and factual content will lead to teaching strategies that are at odds with the intended curriculum (Cronin-Jones, 1991). However, teachers with a more contemporary and accurate understanding of the nature of science will implement a more problem-based approach to science teaching (Brickhouse, 1990; Keys & Bryan). Instead of teaching a specific law, for example, a science teacher may use the concepts of the nature of science to show students where the law came from, how it was derived, and the what cultural influences may have affected its derivation.

Lumpe, Haney and Czierniak (1998) performed research that looked at the role of teacher beliefs regarding the implementation of cooperative learning strategies. As they point out, cooperative learning strategies are prominently mentioned in the National Science Education Standards and that "incompatible beliefs about science reform would seem certain to doom current educational policy efforts" because a teacher who does not share the same epistemology that surrounds the educational policy, may not implement that policy. The results of this study showed that teachers believed that cooperative learning strategies increased problem-solving techniques, helped teach leadership skills, how to compromise, how to communicate, how to share ideas, and how to be more responsible. The authors concluded that teachers believed that cooperative learning strategies could make science learning more interesting. They also found that teachers were concerned that cooperative learning could take too much time. "More research should be conducted regarding the influence of teacher beliefs on classroom practice" (Lumpe, Haney, & Czerniak, 1998, p. 130).

Haney, Czerniak, and Lumpe (1996) studied the relationship between teacher beliefs and the implementation of the four strands (i.e., inquiry, knowledge, condition, and application) of the Ohio Competency Based Science Model. They wrote that research shows that "teacher beliefs systems are significant factors in motivating a change in teaching behaviors and that previous reform efforts largely ignore the influential nature of teacher beliefs on changes in teaching practice (p. 974). The result of their study indicates that it is the teachers' attitudes and beliefs toward targeted behaviors that are most important in predicting the success of the behaviors.

Robert Orton (1996) explores how teacher beliefs about student learning might be justified in a way not connected to student performance. The alternative support or justification will arise from the discussion of teacher beliefs about student learning. These beliefs are not rooted in learning theories but deeply rooted in what has worked in the past, situations, particular instances, trial and error, and by 'muddling through.' These beliefs become justified if it helps the believer "cope or deal with his or her environment in a fruitful way" (p. 143). If the teacher believes that the knowledge of students must grow and develop and be justified in the same manner as the teachers, "Students will need to be engaged in tasks or activities where their beliefs about the subject matter can help them cope with their environment. This leads to the need for the teacher to teach in 'constructivist' ways" (Orton, p.143). Orton summarizes his article by writing that teacher beliefs about student learning will be justified by the degree to which his or her own activities and strategies encourage student learning. The implications of Orton's writings toward further research can be seen in his concluding remarks, "The explicit formulation of plausible ideas about student learning, in the ideal sense, would lead to a community of colleagues in which teachers are thinking and talking about their beliefs with interested individuals" (p. 144).

Implications for the study. National reports are calling for improvements in science teaching. According to Hewson, Kerby, and Cook (1995) science teaching is dependent upon teacher thinking and thus research on the thinking of experienced science teachers is needed to guide the practices of teacher certification and professional development programs. Powell (1994) points out that studies conducted with beginning and experienced science teachers suggest that the teaching strategies implemented by the teacher are strongly influenced by their beliefs about science and by their beliefs about how students learn. Keys and Bryan (2001) state that studies of teachers using inquiry-based approaches in diverse settings will be a valuable addition to the knowledge base about teaching and learning. They believe that there are three main areas of research based on an inquiry approach to teaching and learning: One includes studies similar to theirs relating to high school science teachers and their beliefs about learning; another area of research is the study of inquiry based approaches in more diverse settings; and the final area is concerned with inquiry approaches from the students' point of view.

Chapter 2 Summary

What is the relationship between a teacher's personal philosophy about learning, teaching methodologies, and the time allotted during the instructional day? The strategies used by the science teacher will reflect his or her own person beliefs about teaching and learning. All science teachers have a philosophy of science (Grandy, 1997). This philosophy may be unconscious and implicit, and may be based upon the "empiricist inductive scientific method, the immutability of scientific facts, and in scientific realism" that characterizes cognitive constructivism (p. 45). Or it may be based upon a more holistic, inquiry-based, constructivist epistemology as adopted by the National Science Education Standards. Whatever the teacher's philosophy of science is, to accept a pedagogy that is based upon a constructivist epistemology, the teacher must agree that students construct a representation of scientific theory that is based upon the student's individual experiences (i.e., radical constructivism) and/or that these personal experiences may take place within a social context (i.e., social constructivism).

The amount of class time may influence the science teachers' choice of instructional strategies. With the advent of the restructured school day, science teachers are being asked to incorporate more constructivist activities based upon inquiry into their teaching styles. Very little qualitative research is being done to see how these science teachers are adapting their own personal philosophies to the restructured time schedule. This is a particular dilemma to science teachers. Most science teachers received degrees in some form of pure science: biology, chemistry, Earth science, or physics. These disciplines have a positivistic, empiricist view on the nature of science (Stofflett & Stoddard, 1994). A student who is a science major is exposed to these philosophies overtly and covertly. Therefore, since the teacher has learned science under these circumstances, he or she tends to teach science with the same pedagogy. The following section will describe the research design behind the research questions which are: What strategies do science teachers use in the 4 x 4 block schedule and how do science teachers understand their use of instructional strategies?

Methodology

Purpose of the Study

The purpose of this research was to identify how science teachers incorporated teaching strategies within the time frame established by a 4 X 4 block schedule in order to investigate the link between their own understanding about teaching and learning and their pedagogy. Teaching strategies in science education center around constructivism (Hewson & Hewson, 1988), conceptual change theory (Glasson & Lalik, 1993; Stofflet & Stoddard, 1994), and inquiry-based learning (Powell, 1992; Wildy & Wallace, 1995). A review of the literature showed that key principles of radical and social constructivism are associated with identifiable practices within the classroom (Brooks & Brooks, 1993; Doolittle & Camp, 2003; Hendry, 1996).

One aspect these studies have not focused on is the importance of class time. Block scheduling has been advanced as a means to provide the classroom teacher with more time to incorporate a variety of teaching strategies that will accommodate different learning styles (Hackman & Schmitt , 1997). More specific to the science teacher is the use of experimental manipulatives such as laboratory exercises, cooperative learning groups, and think-pair-share strategies which "Affords a rich matrix of information that encourages simultaneous as well as serial information processing" (Anderson, 1997, p.79).

The use of a multiple case study as a qualitative research tool was used to identify the strategies associated with how three science teachers developed methodologies within the framework of block scheduling and how these methodologies and strategies reflected the teachers' own understanding about teaching and learning. The fundamental questions behind this research are:

- What strategies do science teachers use to engage students in the 4 x 4 block schedule?
- How do science teachers understand their use of instructional strategies?

Research Overview

Why the research is important. Block scheduling has been proposed as a means by which science teachers can incorporate more constructivist type teaching methods into their daily strategies (Hackman & Schmitt, 1997; Robbins, Gregory, & Herndon, 2000). If the term constructivism is used in the sense that "knowledge is constructed by the learners as they attempt to make sense of their experiences" (Richardson, 1997, vii), then a constructivist teacher allows the flow of information within the classroom to be multidirectional and provides opportunities for the learner to relate the new knowledge to prior experiences in a way that fits within the schema of the learner. This is the epistemological framework behind the National Science Education Standards adoption of inquiry-based strategies. Keys and Bryan (2001) wrote:

> We propose that more research is needed in the areas of teachers' beliefs, knowledge, and practices of inquiry-based science, as well as student learning. Because the efficacy of reform efforts rest largely with teachers, their voices need to be included in the design and implementation of inquiry-based curriculum. (p. 631)

The previous literature described how attempts have been made to connect pedagogy with epistemology. Science education specifically has moved from a positivist approach, through radical constructivism, to social constructivism (Hewson & Hewson, 1998; Starver, 1998). Brooks and Brooks (1993) along with Doolittle and Camp (1999) have linked principles of social constructivism to classroom practices. A social constructivist teacher views learning through the lens of social negotiations and mediation. A teacher with a social constructivist philosophy may use strategies that emphasize the co-construction of meaning within a social activity and would allow for the direction of the lesson to be guided by student responses.

As Lawrenz (1990) and Germann (1991) pointed out in their studies, there is a mismatch between the teacher's desire to provide more constructivist type learning activities and the actual time provided to accomplish them. Along these same lines, Letts, Bailey, and Scantlebury (1994) have shown that there is a wide variation between instructional strategies used by science teachers due to the conflict that exists between the "lecture based, operationalized, behavioral objectives associated with the old teaching paradigm and the socially negotiated transfer of knowledge that is associated with the newer constructivist paradigm" (p. 192).

The National Research Council (NRC) has adopted an inquiry-based approach to teaching and learning through the development of the National Science Education Standards (NSES). It is important to conduct research to find out if science teachers are adopting and adapting these strategies within their daily lesson plans and to document the influences that affect the teachers' decisions regarding the use of strategies.

How the research was conducted. The research was a qualitative, multiple case study, using a triangulation between interviews, observations and the collection of documents as the data sources. Three science teachers from a large rural high school were asked to participate. Each teacher was interviewed individually three times: once before the observation phase, once as the observation phase was underway, and once after the observation phase. During the observation phase of the study, each teacher was observed five times during a specific unit. Documents and other artifacts such as lesson plans, assessment and evaluation tools, and laboratory procedures were also collected and analyzed.

Research Design

Qualitative methods. Researchers use qualitative methods because they provide an in-depth description of programs, practices and settings. Qualitative research is multi-method in focus, involving an interpretive, naturalistic approach to subject matter, and uses an inductive approach that starts with specific observations of phenomena that allow categories of analysis to emerge from the study as it progresses. These emerging categories describe routine and problematic moments and meanings in individuals' lives (Denzin & Lincoln, 2000; Mertens, 1998).

The reasons for selecting a qualitative research methodology are threefold: (a) the researcher's views of the world, which can be either interpretive/constructivist or emancipatory; (b) the nature of the research question, which may focus on process, implementation, or the development of a program, or the participant's beliefs as to the nature of the problem he or she is addressing; (c) practical reasons associated with the nature of qualitative methods because many educational programs are based on humanistic values and there may be no other acceptable, valid, reliable, or appropriate quantitative method available (Mertens, 1998). Since this research focuses on how science teachers incorporated learning strategies and how these learning strategies reflected their own understanding, there was a reasonable fit between the research questions and a qualitative study methodology.

In this study, three forms of data collection were used: (1) In-depth, open-ended interviews which consisted of direct quotations from participants about their experiences, beliefs, and knowledge concerning the strategies they chose and their understanding of the strategies they chose; (2) direct observation which consisted of detailed descriptions of the teachers' activities and actions. Specifically, a description of the specific activity performed by the teacher, and how much time was spent on that activity was recorded; (3) written documents that included lesson plans, assignment sheets, assessments, laboratory hand-outs and activities, homework assignments, and other documents created and presented by the teacher were included as sources for document analysis. A detailed description of each type of data collecting procedure follows.

Open-ended interviews.

In the interview phase of this research, conversations were conducted with three science teachers concerning their experiences with block scheduling, their belief structures, and their teaching strategies. A semi-structured format was used so that open-ended questions could be asked. Seidman (1998) wrotes, "In order to give the details of their experiences a beginning, middle, and end, people must reflect on their experiences" (p. 1). Effective teachers are not going to be able to list in algorithmic sterility a precise methodology behind their success in engaging students in the learning process. However, their success will be reflected in their experiences. Therefore the open-ended, semi-structured questioning technique was used.

There were three interview sessions with each participant in the study: a pre-observation interview, an interview as the teaching sessions progressed, and a post-observation interview..

Types of Interview Questions: Pre-observation

Background or demographic questions.

What science content area is your degree in?

How many years have you been teaching overall?

How long have you been teaching at this school?

How long have you been teaching under the 4 x 4 block schedule?

How many classes do you teach?

What classes do you teach?

How many students do you teach in each class?

Teaching Strategies

Within your lesson plans, how do you divide up the 90 minute block of time?

How are students arranged in your classroom?

How do you plan for a lesson?

How would you define teaching strategy?

If I were a student in your classroom last semester, what activities would I have participated in?

Tell me about your teaching strategies over the past few years?

What is the relationship between your teaching strategies and block scheduling?

What strategies do you use within the 90-minute block of time?

Teacher Beliefs

How do students learn?

During the lesson, what types of interactions do you encourage/discourage?

What is your role as the classroom teacher in the learning process?

In science, what do you think students should learn?

How does the choice of strategies reflect your own philosophy of how students learn?

What experiences in your life have influenced your teaching?

What experiences in your life have influenced the way you learn?

How do you feel about SOL testing?

Block Scheduling

Tell me about block scheduling.

If I were a student in your class last semester, what would I be doing for 90 minutes?

How do you think block scheduling affects your teaching strategies?

What are your beliefs about the relationship between how students learn and block scheduling?

If you were a student in your class for 90-minutes, what would be your feelings concerning block scheduling?

Types of Interview Questions: Post-observations

The post observation interview was conducted after the classroom observations. More questions were developed as the observations proceeded based upon the data collected from the pre-interview questions, classroom observations, and the artifacts that were collected. Below are the question protocols that were used as the basis for developing further questions.

> What do you think was the most important student outcome of the lesson/unit that you taught?
>
> How do you think this was affected by your teaching strategies?
>
> How do you think this was affected by the 90-minute time frame?
>
> While you were teaching, how did you decide on what questions to ask your students?
>
> Did the lesson or unit evolve as planned?
>
> When you graded the evaluations, what did you look for?
>
> During the lesson or unit, what types of interactions did you observe?
>
> As the activities were carried out by the students, what was your role? What were their roles?

The purpose of the interviews was to try to make sense of the experiences of science teachers under the 4 x 4 block schedule and to understand what these experiences meant to them. Seidman (1998) wrote, “Interviewing provides access to the content of people’s behavior and thereby provides a way for researchers to understand the meaning of that behavior” (p.4).

Participant observation. The Science Department Head at the high school was contacted and asked to convene a meeting of all science teachers. During this meeting, three science teachers volunteered to participate in the study. Two of them were teaching biology and the other was teaching Earth science.

Field notes and observation records. Within this study details were recorded in a field journal describing the physical setting of the classroom. The size of the room, the number of students in the room, the number of students at each table, and the position of the teacher's table were recorded in writing. A rough sketch of the classroom was hand drawn. Human and social aspects of the environment were also described. These included: how the students were organized, either by themselves or by the teacher; patterns of interactions between the teacher and the students, along with any changes that occurred within these patterns; decision making patterns such as who makes decisions about the activities that take place within the classroom; and specific teaching strategies such as small and large group activities, overhead presentation of notes, lectures, individual assignments, showing movies, computer work, and laboratory exercises.

A time component was developed within the field notes to document how much time the teacher spent describing; how much time the students spent on activities; how much time the teacher spent interacting with specific groups of students. The amount of time students spent interacting with other students was also recorded in the journal.

Document collection. The primary documents that were collected for analysis were those documents either created by the teacher or photocopied by the teacher from ancillary materials. These documents reflected the teachers' beliefs and attitudes about teaching and learning. As Merriam (1998) pointed out, "Because they are personal documents, the material is highly subjective in that the writer is the only one to select what he or she considers important" (p. 116). Examples of the documents collected are in Appendix G, H, and I.

The Setting.

The large rural high school where the research took place adopted the 4 x 4 block schedule ten years ago in 1993. This type of scheduling has students attending four 90-minute classes each day for one semester. The school was on a traditional seven-period day schedule with 45-minute classes prior to blocking. The high school is in a rural district and has an approximate enrollment of 1,250 students. There are 90 full time teachers of whom 9 teach science. It is a four-year school with the student population divided into freshmen, sophomores, juniors, and seniors.

Defining the Multiple Case Study.

Denzin and Lincoln (2000) wrote, "As a form of research, case study is defined by interest in individual cases, not by the methods of inquiry used" (p. 435). The cases in this multiple case study were three science teachers working at the high school. Each case was bounded by the specific and individual views about teaching and learning strategies held by the participant in the study. The case studies that were not studied in this research were science education, block scheduling, or teaching strategies. The latter three lack the "specificity and boundedness to be called a case" (Denzin & Lincoln, 2000, p. 436).

All participants in the study volunteered and each teacher was treated as a separate case within this multiple case study. The purpose behind selecting years of experience as a criterion was to have experienced teachers who were not concerned with just keeping their heads above water, as are novice teachers. Choosing teachers who can reflect on teaching strategies, use of class time, and personal belief structures was critical to this study. The *subjects taught* criteria were selected so that data would not be collected within one subject area. Secondary school science, in most high schools in

Virginia, consists of biology, chemistry, physics and Earth science. Other courses such as oceanography, astronomy, zoology, and anatomy are offered at some high schools.

Data Collection and Analysis

The purpose behind the analysis of the data was to bring meaning in the context of a coherent story (Rossman & Rallis, 2003). In this study, the analysis of data was ongoing and recursive. Data was collected by the recording of field notes as the teacher was teaching; the tape recording of each interview session, and the collection of documents such as hand-outs, assessments, and laboratory activities. Patterns were sought that were compared against each other to show trends, patterns of beliefs, and/or recurring ideas. The constant comparative method of data analysis was used. According to Merriam (1998) "The development of categories, properties, tentative hypotheses through the constant comparative method is a process whereby the data gradually evolve into a core of emerging theory" (p. 191).

The analysis by constant comparative methods in this study was directly linked to the fact that the data had been obtained by observations, interviews and by the collection of documents. The interviews were transcribed from the tape recordings to Microsoft Word for Windows. The transcripts were then analyzed and Data Points tables were established for each participant (see Appendix A, B, and C). Categories were then created from the Data Points tables. The results and conclusions developed from the emerging categories.

Anafara, Brown, and Mangione (2002) argue that refutability and replicability are central tenets behind classical research in science. Because qualitative research is not, in the classical sense, replicable, they recommend "analytical openness" (p. 28) as a means by which qualitative researchers can evaluate the substance and methodology behind the research. They address strategies that they developed while working with graduate students that have provided a way for the students to assess their own methodological rigor.

By analytical openness, Anafara, Brown, and Mangione (2002) mean that it is incumbent upon the researcher to provide to the reader all the necessary information so that the reader can make an informed evaluation of the methodology used to obtain and to analyze the data collected. They write, "Although triangulation, member checks, and other qualitative strategies are mentioned frequently in design or methods sections of research articles, rarely is there evidence of exactly how these were achieved" (p. 29). They use the example of a researcher using the phrase "themes emerged." With this phrase, "the reader is expected to take the word of the researcher that he or she did a credible job in data analysis" (p. 29) and that the themes that emerged are valid conclusions from the data collected. While the phrase “themes emerged” is acceptable, it must be used with caution. It is the responsibility of the researcher to provide the direct links from the data to the themes so that the reader can judge for themselves if these truly were the themes that emerged.

Historically, validity is the standard by which the rigor of quantitative research is measured. Internal validity, external validity, objectivity, and reliability are the benchmark criteria used in the discussion of validity. The meanings behind these criteria have been altered to reflect the varying needs of qualitative researchers. In the process of altering their meanings, new terms have been developed to help in transferring the meanings of validity under the quantitative paradigm to the qualitative paradigm. Table 1 compares some common qualitative and quantitative terms and relates the common strategies employed by the terms.

Table 6

Quantitative and Qualitative Criteria for Assessing Research Quality and Rigor.

Quantitative term	Qualitative term	Strategy employed
Internal validity	Credibility	Prolonged engagement in field
		Use of peer debriefing
		Triangulation
		Member checks
		Time sampling
External validity	Transferability	Provide thick description
		Purposive sampling
Reliability	Dependability	Create an audit trail
		Code-recode strategy
		Triangulation
		Peer examination
Objectivity	Confirmability	Triangulation
		Practice reflexivity

Note: Data taken from "Qualitative Analysis on Stage: Making the Research Process More Public," by V. A. Anafara, K. M. Brown, and T. L. Mangione, 2002, *Educational Researcher, 31(8),* p. 30.

Data collecting. As pointed out by Anafara, Brown and Mangione (2002), "Research questions provide the scaffolding for the investigation and the cornerstone for the analysis of the data" (p. 31). Data obtained from the interview questions were collated in a similar manner as described by the authors. A code was established to identify the interview questions, the source, and how the responses to the interview questions related to the research question. Table 2 demonstrates how a specific answer to a question was associated with one of the two research questions.

Table 7

Research Questions in Relation to Interview Questions

Research question	Interview question Pre-observation	 Post-observation
1. How do science teachers engage student learning under the 4 x 4 block schedule?	2(a, b, c,) 3(a, b, c, d)	3(a, b, c, d, e)
a) What are the environmental factors?		
b) Are common strategies used?		
c) How do teachers plan their strategies?		
2. How do science teachers understand their use Of instructional strategies?	4(a, b, c, d, e, f, g) 5(a, b)	4(a, b) 5(a, b)
a) Opinions concerning block scheduling.		
b) Opinions concerning learning strategies.		
c) Opinions concerning learning philosophies.		

Note. The numbers and letters on the right side of the table refer to the specific interview questions that corresponded to the specific research question on the left side.

By developing this matrix, the responses from the interview questions were related directly to the research questions. From this technique, themes and categories emerged as the data was collected. This above method was also used to collate the data in the observation phase of this research. In this case, the codes corresponded to specific strategies each teacher used and how these strategies reflected their understanding of the strategies they used.

Table 8

Research Questions in Relation to Observations

Research question	Observed strategies
3. How do science teachers engage student learning under the 4 x 4 block schedule?	
a.) Social interactions between students.	
b.) Individual student work.	
c.) Teacher-directed.	
d.) Student-directed.	

Specific teaching strategies that were observed were categorized based upon a, b, c, and d.

Data analysis. The triangulation of data from research devices such as interviews, participant observation, and document collection were used to ensure that the interpretation of the data was as accurate as possible. The analysis of the data began with the collection of data from the first interview sessions. Data collected from the interviews were categorized early on within the study and continued on with each iteration leading to a more refined definition of a category.

Coding. Codes are units of meaning assigned to data. In the first iteration of data analysis descriptive codes were used. Descriptive codes used during the interview phase included: beliefs concerning block scheduling (B-BS), beliefs concerning learning strategies (B-LS), and beliefs concerning learning philosophies (B-LP). Descriptive codes that were used for the observation phase were: interactions between students and teacher (I-ST), how/if the teacher assigns group(T-AG), and the types of teaching strategies employed: inquiry based strategy (IBS), conceptual change strategy (CCS), and/or cooperative learning strategy (CLS) (see Table 3).

Table 9

Types of Codes Used During the Interview and Observation Phase.

Type of code	**Phase of research**	**Codes used**
Descriptive	Interview	B-BS beliefs about block scheduling.
		B-LS beliefs about learning strategies.
		B-LP beliefs about learning philosophies.

Type of code	**Phase of research**	**Codes used**
Descriptive	Observation	I-TS interactions between teacher and students.
		T-GS teacher assignment of activity: group or individual.
		IBS inquiry based strategy. CCS conceptual change strategy. CLS cooperative learning strategy.

In the second iteration of data analysis, interpretive coding was used. The interpretive codes were used to make links between the data collected in the interview phase with the data collected in the observation phase and the document collection phase. A third iteration of data analysis included pattern codes. These pattern codes linked the data not only within each case, but also between the cases. It was through the pattern codes that emerging themes were identified.

The qualitative term *trustworthiness* equates to the measure of external validity and is the degree to which one can generalize the results to other situations. Mertens (1998), who uses the term *transferability*, states "The burden of transferability is on the reader to determine the degree of similarity between the study site and the receiving context. The researcher's responsibility is to provide sufficient detail to enable the reader to make such a judgement" (p. 183). Firestone (1993) described a perspective for generalization that is applicable to qualitative research. The case-to-case translation provides that the burden of proof concerning generalizability lies with the reader and the researcher is responsible for providing the descriptions that allow the reader to evaluate the applicability of the research to another setting. However, "what qualitative research lacks in generalizability it makes up in depth, and for many situations, when depth is more important, qualitative methods are more appropriate" (Slavin, 1992, p. 72).

Summary

This research focused on how science teachers engaged student learning under the 4 x 4 block schedule. Cooperative learning techniques linked with inquiry learning strategies tend to dominate the literature (Eick & Reed, 2002; Keys & Bryan, 2001). It was the purpose of this study to document the strategies used by science teachers under the 4 x 4 block scheduling format and to use the teachers' own voices to describe how the strategies they used reflected their own understandings about teaching and learning.

Data collection was achieved by participant observation, semi-structured interviews, and the collection of documents and artifacts. It was this triangulation of the collection of data that led to a high confidence concerning the credibility and dependability within the analysis and conclusions of this study. Emergent themes were developed from a constant comparative methodology. These themes came from the narratives of the three science teachers. From these narratives, links were made as to how three science teachers view learning, how their understanding about teaching strategies affected their teaching, how these teaching strategies were influenced by the 4 x 4 block schedule, and how these strategies are related to the current trends of social constructivism in science education.

Role of the Researcher

As the primary investigator, the role of the researcher was that of a participant-observer , interviewer, and document collector. The researcher was present in the classroom observing the participants and interviewed them before and after the observations. The strategies that were observed were viewed through the lens of a practicing science teacher. This was a cause for concern because the researcher brought to the research his own set of assumptions and biases about science, science education, block scheduling, and the role of the science teacher. Since I determined the grouping and categorizing of teaching strategies, the data that was collected and analyzed must first pass through my own set of filters. Therefore, it was my interpretation as to what constituted a strategy and how it related to personal understanding.

Transcripts of interviews, field notes on observations, and documents provided by the participating teachers, were all subjective sources of data. It was incumbent upon me to provide the "analytical openness" as defined by Anafara, Brown, and Mangione (2002). Each category and code had to have a direct, traceable link back to the data. Conclusions drawn concerning the relationships between categories were also founded upon the specific data collected.

Informed Consent Procedures

For this study, an exemption through the University Institutional Review Board (IRB) was requested. Once receipt of acknowledgement was received , the process of informing all participants in the study regarding their role was achieved. The three participating teachers were asked to sign a consent form. The consent form outlined areas of concern such as anonymity and confidentiality of the information collected during the study. Although anonymity could not be guaranteed, the assignment of pseudonyms to each participant demonstrated a good faith effort to protecting their identities. Confidentiality was maintained by limiting access to the study to members of the doctoral committee only. See Appendix A for the IRB proposal and consent form.

Results and Findings

Introduction

The purpose of this research was to identify strategies used by secondary school science teachers under the 4 x 4 block schedule and how their beliefs about teaching and learning influenced these strategies. The study was conducted in a larger, rural, secondary school and involved three high school science teachers. Each teacher was observed teaching in the 90-minute block five times and each teacher was interviewed three times with the interview sessions being recorded on a microcassete. Documents such as lesson plans, activity sheets, laboratory sheets, and handouts were collected.

The interviews were transcribed and used to develop the three case studies. From the case studies, observation sessions, and documents collected, the Data Points charts were developed for each participant. From the Data Points Chart a series of categories were developed and placed into the Teacher Beliefs and Strategies chart. The categories are: Beliefs About Teaching, Beliefs About Learning, Observed Strategies, Influences on Strategies, and Conflicts.

This research is important because the National Science Education Standards (NSES) have adopted inquiry-based learning standards and strategies as the backbone for science education. According to Rezba, Auldridge, Rhea (1999), the level of inquiry learning that a teacher reaches in his or her classroom is dependent upon the amount of information that is given to the students. They categorize the level of inquiry based upon if: the teacher asks the initial question, the teacher directs the methods by which the students go about answering the question, and if the answer to the question is given to the students before the investigation. These inquiry levels are predicated upon the constructivist theory that: knowledge is constructed and not transmitted, prior knowledge impacts learning, and that learning requires effort and purposeful activity.

Changes from traditional teaching methods to a more inquiry-based methodology has been slow and difficult to enact (Byers & Fitzgerald, 2002). Some of the reasons given as to why inquiry-based strategies are not being implemented in the science classroom are: they do not allow students to move along at a pace that will cover the entire curriculum in the time given; it is perceived as an activity for “gifted” students and inappropriate for the average science class; lack of control in the classroom; lack of resources. Teacher’s beliefs about teaching and learning are powerful motivators for establishing change (Lumpe, Haney, & Czerniak, 2000). Teacher’s beliefs about the practice of inquiry-based instruction, as well as their beliefs about student learning, are foundational to the efficacy of reform (Keys & Bryan, 2001).

Case Studies

Three science teachers from a large, rural high school participated in this study. At the time of the study, two of the teachers had over 13 years experience as classroom teachers and the third teacher had just over three years of experience. All of the teachers had taught more than one discipline: chemistry, biology, Earth science, at more than one level: basic, honors, advanced placement. All three teachers had previous experiences outside the field of education. Two were former military: a gunnery sergeant and a medical technician and the other had odd jobs. Pseudonyms were used to protect the identity of the participants.

Carl

Introduction. Carl is a science teacher at a large, rural, public high school. He has thirteen years experience at the secondary level and has been teaching at his current school for one year. He has a degree in Zoology and teaches honors biology to mainly sophomores. Carl has five years experience on the traditional seven period day schedule, four years experience with the AB block schedule and four years experience on the 4 x 4 block schedule. The classes he taught this semester typically had between fifteen and eighteen students.

Carl comes to science education after spending 15 years in military service as a gunnery instructor. This past experience with the service has strongly influenced the way he teaches science in the secondary classroom. His written lesson plans are highly organized, detailed, goal oriented, and kept in a notebook that is chronologically ordered with respect to daily content. Within the 90-minute framework Carl maintains a high level of structure. Carl credits his parents for instilling in him a desire to learn. It is this desire to learn that led him to college and ultimately into the teaching profession. Along with his parents, he praises his previous science teachers for making the subject exciting and sparking an interest within him.

Teaching and Learning Strategies in Block Scheduling

Day one. On the first observation day (see Data Points Chart – Day 1) Carl began a unit on evolution by guiding the students through a review of previous material covering the main points of natural selection. He began by asking the students to take out a worksheet that they had completed the previous day. Each question on the worksheet was reviewed by Carl by asking specific students to describe what they had written. For example, Carl would identify a student by name and ask, “What did you write for question number two?” The identified student would then read, verbatim what they had written. When the review of the worksheet was complete, Carl moved to the next phase of his lesson which consisted of having students work on questions that were assigned for homework and that were not completed. These homework questions came from the back of the textbook.

Each phase of the lesson was very organized and kept within a specific time frame. Even though the lesson was very organized and timed, there was no feeling of being rushed. When the review phase was complete, and the students voiced that they felt ready, a quiz was given. This lasted approximately 10 minutes and once completed, it was turned in to the teacher. The next phase of the lesson, presentation of notes on the overhead, began. Students copied down what Carl had listed, in bulleted form, on the overhead. The topics listed on the overhead were: Viruses, Differences, Taxonomy, and Identification. At the bottom of the overhead Carl had drawings of different types of viruses. Next to each drawing was a typed line that he could write on to indicate the name of the virus, how it was identified, or place within the taxonomic sequence. Carl walked around as he lectured, periodically stopping so that questions could be asked or notes written down. The questions that were asked tended to be more technical in nature. “Do you want us to copy the pictures?” or “What’s that a picture of?” are examples of student questions.

Day two. On the second day of observing (see Data Points Chart – Day 2) Carl had his students reviewing for the upcoming midterm exam in Honors Biology. He handed back previously graded unit tests so that the students could use them for review.

He allowed the students to work either in small groups of three or independently. Those students who worked together agreed on which test they would work on and then went through each question, one at a time, discussing the right answer and why they chose the answer that they chose. The two students who chose to work independently, relied on their textbook, their notes, or more heavily on Carl to correct their mistakes.

As the students worked, Carl monitored their progress by walking around the room looking over their shoulders and making corrections and additions or by directly answering questions. The types of questions asked were specific to the test question that the students got wrong. For example, “We all got number 5 wrong and can’t figure out what the right answer should be.” Carl would then read the question with the students and respond with, “You remember, we talked about this when we discussed mutations. Look in your notes and see if you can’t find the information.” The mood was very informal yet directed. By this I mean that Carl kept the banter between himself and the students light. The students could get up out of their seats and work with other students if desired. If the conversation between students strayed too far from the topic, he guided them back.

The second half of the 90-minutes was taken up in the computer lab where the students were directed to log on to the Glencoe publishing site and complete practice tests that were based upon specific units within their textbook. The units were divided up into chapter tests.

Unit 1 Energy, Matter, and Organization

Chapter 1 The Chemistry of Life

Chapter 2 Energy, Life, and the Biosphere

Chapter 3 Exchanging Materials with the Environment

Chapter 4 Autotrophy: Collecting Energy from the Nonliving Environment

Chapter 5 Cell Respiration: Harvesting Chemical Energy

Unit 2 The Cell: Homeostasis and Development

Chapter 6 Cell Structures and Their Functions

Chapter 7 Transport System

Chapter 8 The Cell Cycle

Chapter 9 Expressing Genetic Information

Chapter 10 Animal Growth and Development

Chapter 11 Plant Growth and Development

The students worked individually completing each of the computer generated assignments. At one point, Carl approached me and stated that he really liked this web site because it was different than having the students sit in class, reviewing the "same old material in the same old way." His interaction with the students was much less than during the first part of the class.

Day three. The third day of observing (see Data Points Chart – Day 3) began with the warm-up. Students were directed to page 256 in their textbooks where they completed a series of questions based upon previously covered material about the Peppered Moth. This took approximately ten minutes and the students worked individually. The next ten minutes was spent on going over the answers to the warm-up activity and this was accomplished by Carl directing the discussion through either asking specific students what they had written or allowing any student to raise their hand and answer. An example of a question Carl asked was, "Somebody give me an example of the evidence for evolution." The next 5 minutes of the class was devoted to direct instruction via the presentation of notes on the overhead. These notes were in outline and bulleted forms. The topic was the theory of evolution and the subheadings listed on the overhead were Comparative Anatomy, Homology, Analogous and Vestigial Structures. Most of the talking was done by Carl. Students took notes. Once he was finished with the lecture, Carl handed back a graded activity that they had worked on during the previous week. The activity was a laboratory activity based upon the Peppered Moth (see addendum). Carl used individual student work to illustrate what was right and what was wrong about the work. He would hold up a specific students' work and point out either how complete the answers were or how detailed the drawings were.

Carl used the Peppered Moth activity to begin a discussion about change over time. He once again put bulleted notes up on the overhead and used them to introduce The Scopes Monkey Trial. The bulleted notes consisted of the terms Change over Time, Evolution, Systemic Mutations, and Variation. Carl defined each term as the students copied down notes. He informed students that for the next two days they would be watching a film called Inherit the Wind and that at the end of the movie there would be a short quiz on its content. The rest of the period was used to watch the first part of the movie.

Day four. Day four was used to make connections between the previous material. Carl began with the warm-up which was based upon the identification of the parts of a virus. The students were given a picture of a virus and asked to label all parts. This particular warm-up took longer than most and once again the students worked individually until they finished. The students worked on this for about 20 minutes (see Data Points Chart – Day 4). Once all students had finished and the work had been discussed, Carl began direct instruction using bulleted overhead notes. On the overhead, Carl had drawings of different viruses and bacteria. He used these along with pictures in the textbook to deliver his presentation. It was obvious that the students had not heard of the terms associated with the drawings. Carl was attempting to get the students to associate the terms with every-day experiences. He was trying to get the students to see the relationship between terms, vocabulary, and structure.

The next 20 minutes was used to discuss the laboratory activity that they would be completing tomorrow. Carl told the students that they could receive extra credit if they brought some pond water from around their homes. Carl handed out the guide that the students would be using to help them during the activity. The guide was a copy taken from the Glencoe ancillary material provided to teachers. These were discussed for about five minutes and the rest of the class time was used to watch a short video about viruses and bacteria.

Day five. Day five of observing began with Carl and the students moving into the laboratory and setting up for the pond water lab (see Data Points Chart – Day 5). Students used samples of water that Carl supplied along with samples that were supplied by other students. The students worked either in pairs or individually and made slides of the various samples of water. The students used the hand-out and the guide to help them progress through the activity. In general, Carl allowed the students to prepare the slides, view them, and make drawings as they deemed fit. The students had the guides to help them if they got confused or needed help. When all of the drawings were completed, the students worked in pairs to answer specific questions based upon what they had viewed through the microscope. When this was completed, the students handed the work in to

Carl at the end of the period. The entire activity was somewhat open-ended and the students were allowed to solve the minor problems that arose. Most problems were of a technical nature dealing with the light source or the lenses. Carl would help the students but would tend to answer their questions by asking another question or referring them to their notes or textbook for the information.

Carl used questioning techniques, throughout all observations to keep the students active and to check for understanding. These techniques consisted primarily of choral response questions but he did on occasion call on specific students. The questions would require the students to form a conclusion about the material being presented. Questions that began with how, why, or compare made up the vast majority.

Generally, the students were not encouraged to work together when completing in class assignments. They were not discouraged either (see Data Points Chart Carl – Researcher Interpretations). Some students would occasionally ask another student at their table what or how they were answering some of the questions. Carl would never directly answer questions that were directed at him. His Socratic approach dominated the exchange. The most common question that came from the students was, "What is that?" or "How is it moving?" Carl would respond with "What do you think it is?" or "What could you use to find out what it is?" With that, the students would refer to their guides.

Teacher Beliefs About Teaching and Learning

Carl's beliefs about learning are rooted in his belief that students learn through hard work, independent learning, visualizing material as they search their brains like computer banks, and that information is imprinted on to their brains. His beliefs about teaching are rooted in his beliefs that the teacher should act as a facilitator and promote an environment that stresses independent learning.

Visualizing and imprinting. Carl believes that to learn, students must be exposed to information over and over again in different ways:

> They should actually, as they read, write down things that they think are important because that will make them stick in their brains. So I ask them to do that. As I design my lessons, I realize that they have to do a lot of different things. Lecturing, I think is the least effective method but I think that it is necessary to provide guidance and direction to the students.

The above statement shows that Carl thinks that the link between a student's ability to visualize material and their ability to understand is critical to learning. Carl believes that students learn by visualizing words and physically writing them down on paper, thus imprinting the words directly to their brains (See Teacher Beliefs and Strategies Chart – Section 1). It is important to note that by "visualizing" Carl means the formation of pictures or patterns on the brains of students, via the use of words and/or diagrams. Students learn by having words, diagrams, and drawings imprinted on their brains. The student can recall these images to create the concepts, and form a conclusion based upon these mental images. This is evident in the strategies that he uses: detailed drawing that he puts up on the overhead, the use of movies, laboratory exercises that include looking through a microscope, and textbook assignments that require the students to draw and label pictures (see chart Teacher Beliefs and Strategies).

If one believes, as Carl does, that learning occurs by imprinting words by repetition, and hard work, then a didactic approach to teaching and learning would be an acceptable means by which teaching strategies are used within the classroom. “In science, I am a believer in the fact that it needs to be hands-on because when you do, you work with it, that also reinforces it better in your brain and it sticks with you longer.” This illustrates Carl’s belief that imprinting ideas and knowledge on to the brain is essential for learning to occur. If the hands-on activity reinforces the concepts that Carl believes are important, then learning occurs. The repetition and visualization of words in order to imprint a concept on to the brains of his students is achieved by the more didactic strategies incorporated in his lesson plans: lecturing, copying notes, and answering questions in their notes from the textbook.

Interactions. Carl believes that students learn best when they interact with each other. This is accomplished through the use of his questioning techniques as well. He allows students to tag onto the responses of other students and to elaborate or even to correct previous responses:

> Student interaction is so much more valuable and plus the student who is answering is learning. You learn not from just questioning but from answering. That reinforces their knowledge. Students relate to each other much better than they do to a teacher. That’s why I call it a guided discussion.

The use of guided discussions is a way for Carl to simultaneously have students interact with each other as well as interacting with the teacher. This is important because Carl believes that students learn best when they interact with each other and the teacher acts as a facilitator. However, this does not dominate within his teaching style or lesson plan. He is strongly goal oriented. The use of linear didactic strategies was still the primary mode of teaching in this lesson. As an example, on the fourth day of observation (see chart Data

Points Carl – day 4) Carl had the students complete the warm-ups, continued with the direct instruction with the presentation of overhead notes, and then had the students use their textbooks to draw pictures and answer questions.

Carl wants the flow of knowledge to go from student to student more than from teacher to student. He would like the "flow" of knowledge to be like a gas diffusing through out the room. There is no definite direction to the flow: it's from teacher to student; from student to student; and from student to teacher. However, even with the student-to-student interactions, Carl guides the discussion in the direction that he wants it to go. "I urge them to ask their partners, to work with people at their tables. So you see the flow of knowledge from one student to the other."

The interactions between teacher and student and between student and student are influenced by the type of activity being implemented for that particular lesson plan. Carl believes that the teacher to student interaction is important during the guided discussion phase of the lesson, where more direct instruction takes place. During labs and other activities, he fosters a student-to-student interaction. "Sometimes I think that I am doing them a favor by going up to my desk and leaving them alone. They will rely on each other more to solve problems."

Independent learning and the Eureka effect. When asked about how he thinks knowledge flows in his classroom, Carl used the term "aura" of knowledge around an individual student:

> You like for the student to find knowledge for themselves. You would like for that to happen. And that's the most effective way to get knowledge. You know, 'Eureka, I've found it.' The more hands on you do, the more you hope that that

> will occur. Some students who take ownership of their education and their search for knowledge, I think that happens a lot. The flow is from within. They are finding it for themselves.

By this he means that students bring to class a sense about their ability to learn. Some students are independent learners while others are more reliant on the teacher. To Carl, learning is achieved through hard work and self discovery which leads to what he calls the "eureka effect." He believes that the more hands-on activities that are provided to the student, the more the Eureka Effect will occur (See Teacher Beliefs and Strategies Chart – Section 2):

> In my classes I would say that there is some of that [the eureka effect]. I think that a higher than I would like percent of the knowledge is coming from me to them. I would much rather be a facilitator than an originator of the knowledge. In the higher ability student, there isn't so much of a flow of knowledge as there is an aura of knowledge around them.

This quote illustrates a conflict in Carl's beliefs about how students learn. On one hand, he wishes that the flow of knowledge would be less directional from him toward the students and more from student to student interactions. Carl is aware of the ideas that students learn by being exposed to different strategies and that they may have different modes of learning. This is evident in his use of the terms "facilitator" and "originator" of knowledge:

> Too many of our students never take responsibility for learning and they never become learners. They're not willing to put in the blood, sweat and tears necessary for learning. Students learn by doing. Students learn by putting out

effort. Students learn in many ways and not just one and they all compliment each other.

This illustrates that Carl believes that if the students would put forth the requisite effort, they would be rewarded more often with the "eureka effect." This also shows that the students could obtain the effect if Carl, as facilitator, used more hands-on activities.

Carl's use of more independent learning strategies tended to appear toward the end of the lesson. He strives to have his students work together and learn together (see chart Teacher Beliefs and Strategies Carl – Section 3, Observed Teaching Strategies) in order to make that final connection. Carl tended to use didactic strategies such as lecturing, presentation of notes, and textbook work to introduce concepts and independent strategies such as laboratory activities, small group work, and open-ended questioning to reinforce the concepts (see chart Teacher Beliefs and Strategies – Sections 3 and 4).

Searching computer banks. To Carl, "students search their computer banks" to arrive at a correct answer and his questioning techniques strive to go beyond that. "I don't want to just draw a raw fact out of them…not just getting data off the hard drive. They can relate the information to an activity that we did in class." His questioning techniques vary from choral responses to calling upon individual students. In each case, he tends to start with questions that are of the K*nowledge* level on Bloom's taxonomy but the questions often increase in complexity. For example, on day three of the observation phase (see chart Data Points Carl – Day 3) after completing the warm-up exercise, he asked individual students to comment on the relationship between the warm-up question and the complexity of life illustrated on the overhead concerning the different classifications of bacteria.

Carl uses a goal oriented, A to B approach to teaching. However, he desires that his students go beyond just searching their brains like computer banks. It may be that students search their brains like computer banks because of the goal oriented, A to B strategies that Carl uses**.** Since Carl uses a very well organized and very structured approach to teaching, his students may adopt a very structured and well organized approach to learning. Just as a computer searches its files based on the protocol of the programmer, Carl's students may adopt an algorithmic approach to learning due to his algorithmic approach to teaching. Carl describes his structured approach:

> I shoot for three unique strategies within the 90-minute block schedule. Sometimes it's just two. For example, as you can see here [he flips through his calendar] let's go to where we are right now. Basically, today I did a little warm-up activity where they did a question out of the book and then I went through the evidence for evolution, and they did a worksheet activity, which they didn't finish so they'll have to finish it for homework on tracing the history of the fossil horse. So, that was typical. Yesterday, we took a quiz, we finished up the unit on acquired human genetics, then I introduced life of Earth, then I showed a video on the Galapagos Island.

The above statement shows that Carl is a very structured teacher who uses very structured strategies. With these strategies, students become very structured learners who "search their brains like computer banks."

Influences on Teaching and Learning

Carl's use of specific teaching strategies is strongly influenced by his block scheduling, prior military experience, end-of-course testing, and the level of classes he teaches (general or honors). Carl is an extremely well organized teacher. He has very formal, well-structured lesson plans that he consults and pulls from on a daily basis. This high degree of organization and structure can also be found in his classroom teaching (See Data Chart Carl – Day 3 and Day 4). The first level of organization is the general break-up of the 90-minute class into three distinct sections with each section having its own set of teaching and learning criteria.

Block schedule. To Carl, block scheduling provides more time for activities than does the traditional schedule and block scheduling is a better learning environment because it provides for more continuity of learning (see Teacher Beliefs and Strategies Carl – Beliefs About Teaching, Section 4):

> I do get a reasonable amount of time and again the block schedule facilitates that better than the traditional 45 to 50-minute class…much better. I'm doing more of that for sure than I ever did on the traditional schedule. If I was acting just as a facilitator, if the students would take ownership of their learning and me just facilitating, we would never cover the SOL objectives. I see SOL testing driving the methods used in the classroom more here than anywhere else I have ever taught. I have always been more of quality not a quantity teacher. I've had to go more toward the quantity side and less on the quality to fit my curriculum into the SOL guidelines. Block scheduling provides for a better learning environment.

> There's more continuity. Information can be reinforced in more ways on the block schedule.

As the above statement by Carl suggests, he prefers the 90-minute block of time over the traditional 45-minute. This is because he could divide the 90-minute block of time into three distinct sections. The first 30-minutes of the block was devoted to students working in an independent manner with the goal of getting them refreshed on what the material is that they are currently studying. Within this section, Carl may have his students work from a handout, the textbook, or from the overhead. Whatever it was that he has them working on was not only presented in a highly organized manner but the documents themselves were highly organized. This high degree of organization stems from his prior military experience. As a gunnery instructor, he used a show them-have them do-then show again approach to teaching. This approach has carried over to his teaching style at the public school level (see chart Teacher Beliefs and Strategies – Section 4).

The second 30-minutes consisted of the presentation of notes on the overhead. The students were encouraged to write them down, verbatim, into their notebooks. The final 30-minute block of time consisted of strategies that allowed for the students to be more independent in their learning. Carl is removed from the presentation either completely or plays only a nominal role in the presentation of material. The showing of a movie, completing a laboratory assignment, or having the students work in small groups to complete a writing or drawing assignment are examples of the students working independently of Carl.

The 90-minute format provided by the 4 x 4 block schedule allows Carl to complete concepts within one sitting. Carl believes that the 4 x 4 block schedule has a very positive influence on teaching and learning. The 90-minute time frame allows him to vary his strategies and to accomplish many more activities than he was able to on the traditional schedule. Concepts can be completed in one day and laboratory activities can be assigned, explained, and completed in one block. All of this, according to Carl, leads to a more efficient use of time but there are drawbacks:

> Laboratories are much more efficient. For teaching science, block scheduling is the way to go. I am so much more effective on the block schedule as a science teacher. The trade off is that with the block you have less contact hours with the students. With the traditional schedule, I felt like I got to know my students as well or even better than on the block.

The 90-minute class allows him to introduce different teaching strategies such as having the students work together to not only complete an assignment but to develop the ways and means to accomplish the task; using guiding questions to increase the complexity of the responses from students; having the students perform hands-on and inquiry-based activities such as the analysis of pond water; using demonstrations such as the Peppered Moth activity. Particular sections within a unit can be completed in one block and therefore the need for review is reduced. However, the amount of material required to be covered, which is established by the State SOL's and the County curriculum guide, leaves him little room to do as many hands-on activities as he would like.

The 4 x 4 block schedule creates a better learning environment because it provides for more of a "continuity of learning" than does the traditional schedule. With block scheduling, teachers can begin and end an activity and incorporate more efficient closure type activities. Carl believes that with the two-semester system of block scheduling, classes are smaller. This provides the opportunity for more hands-on learning and also allows him to get graded work back to the students faster so that they can see where they made their mistakes and can then correct them in time for the next assessment.

Military experience. The presentation of material, from planning to execution, is organized and well structured. This comes from his prior military experience as a gunnery sergeant. In the military, Carl would teach the recruits how to load and fire high caliber weapons. His strategies in the military were to get the recruits from point A to point B as quickly and efficiently as possible and to work together as a cohesive group. Very little theory was taught to the recruits. The lessons were all hands-on driven. According to Carl:

> Being a retired military officer, the strategies that I use must relate to the overall plan you have to accomplish a goal. You have something that you need to accomplish; the strategy you use will lead you from A to B.

Carl uses strategies in the classroom that will take his students from one point to another in a series of connections that lead to a goal (See Teacher Beliefs and Strategies Carl – Section 3, Observed Strategies). He believes that in science, his strategies should center on hands-on learning because that helps to reinforce it better in the brain and makes it "stick with you longer" (See Teacher Beliefs and Strategies Carl – Section 2). However, in practice, his strategies are mostly didactic in nature. Lectures are still the dominant teaching strategy.

End-Of-Course SOL Exams. The amount of material covered in a biology class strongly influences the strategies that he uses.

> When I looked at the SOL's here in Virginia and how much time I have, I have to drive my students unmercifully from the first nine weeks and half of the second nine weeks in order to get the SOLs covered to an acceptable level. Just about every high school in the country requires biology for graduation. So, if it's that important, and there's tremendous amounts of material to cover, maybe we should break it down into two courses and give the SOL test after the second course.

As Carl was making this statement, he got up from the desk and retrieved the Biology textbook that he uses in class. He drew my attention to the thickness of the book. "Ten years ago, the textbook was less than half this size. There's just so much material, and so little time to teach it."

He believes that the SOL guidelines are driving the curriculum in the science classrooms. This, he feels, will force science teachers to cover more material using didactic strategies rather than covering concepts for understanding using more collaborative or inquiry-based strategies. Carl feels that he can't be the facilitator that he desires due to time and resources restraints. The objectives established by the state and the County pacing guide do not allow for the necessary time to present hands-on, inquiry based strategies.

It is important to note that Carl never calls for the elimination of SOL testing but calls for some sort of modification. To him, the SOL tests have a place in science education but not as they are now formatted and administered. He believes that far too much weight is given to the passing of the exams. At the end of each section, within a unit of study, Carl administers a practice SOL test that comes from the ancillary materials provided to teachers from the publishing company. Carl uses the results from these tests to see where his students are in their learning as far as passing the EOC exams.

Summary Of Carl

There is a match between Carl's beliefs about teaching and learning and the strategies that he uses in his classroom. His belief that students learn through hard work, repeated exposure to material, and the visualization of material by physically writing it down, leads to strategies that are teacher centered. Carl determines the questions to be answered and provides the students with the very structured methods to obtain the answers. This information is imprinted directly on to the student's brain, and they search their brains like computers scan hard drives in order to retrieve the information. The very structured learning environment provided by Carl, leads to very structured learning by students.

The primary learning goal, according to Carl, is for the students to self discover; to come to a conclusion about a concept in an independent manner. If the students can use the independent, hands-on, and didactic strategies provided by Carl to arrive at an understanding, Carl believes that they have learned; they have come to a personal understanding of the material.

To Carl, students learn when teachers use a mixture of strategies. These range from the didactic, student centered, and teacher directed strategies such as lecture, copying notes from the overhead, and answering problems out of the textbook to the more holistic, small group work, allowing students to determine the direction of the lesson through their questions, and using laboratory exercises that allow students to form their own conclusions based upon the data that they collected. However, it is the didactic, teacher centered strategies that dominate.

Carl is aware of other more holistic strategies such as cooperative and inquiry-based learning. He agrees that the incorporation of these strategies would be beneficial to science education. Carl does incorporate these strategies, to a lesser degree, when he has his students perform activities such as laboratory experiments. However, the level of inquiry is quite low because Carl still poses the questions to be asked as well as provides the means by which the students answer the questions or solve the problems. This may be due to the fact that Carl does not know how to implement these types of strategies or to the idea that cooperative and inquiry strategies tend to take longer to implement than do the more didactic strategies that he employs. Carl believes that he is varying his strategies within the 4 x 4 block structure and he is. However, these strategies are still didactic in nature.

With the large amount of material that is required to be covered so that his students can pass the End-Of-Course, Standards of Learning exam, Carl feels that he just doesn't have the time to incorporate these more holistic strategies. Carl believes that the advantages gained by the 4 x 4 block schedule are negated by the ever increasing amount of material that he is required to teach. Carl believes that the Standards of Learning and the accompanying End-Of-Course testing force him to teach quantity over quality.

Rob

Introduction. Rob is a teacher at a large rural high school. He has 20 years experience teaching at the secondary level with four of those at his current location. He received his degree in Earth Science and is certified to teach Earth science and biology.

Sixteen of the 20 years he has taught on the traditional 45-minute, seven period schedule. Currently Rob is teaching three sections of Earth science on the 4 x 4 block schedule. A typical class has an enrollment of between 12 and 15 students with a majority of which are freshman.

When asked about the experiences in his life that most influences his teaching methods, Rob pointed to his previous science teachers and his own experience as a science student. He stated that he was bored in his classes because they did mostly bookwork and that the lack of technology hindered his enthusiasm toward learning. His primary motivation for entering the teaching profession was to bring an increased awareness and use of technology into the classroom. According to Rob:

> To be able to bring something into the classroom based upon what my experience had been in the past. I knew that there was a better way. I knew that there had to be some way of demonstrating that in the classroom.

It was the encouragement of his parents and the interactions with other students that contributed toward his desire to go on to higher education.

Teaching and Learning Strategies in Block Scheduling

Day one. Upon entering Rob's classroom, the students are directed to retrieve their folders from the back of the room and begin work either correcting mistakes made on a previous test or completing an in-class assignment such as a worksheet (see chart Data Points – Rob). There are six large desks in the room at which three students sit per desk. It's very quite. Rob stands behind his desk and takes the roll silently. A student at a table begins to talk to another student and is asked to be quiet by Rob. The student mutters something under his breath and is immediately taken out into the hallway by

Rob. This conference lasts for about five minutes or less. Both Rob and the student return to the classroom and the student sits down and continues working. I am hoping that Rob's reaction to the student isn't an effect of my presence in the classroom.

As the students work on their assignments, Rob walks around the room. His arms are crossed and he does not interact with the students verbally unless he is asked a direct question. His responses to questions are generally short, very specific, and include the correct answer to the question. A student raises her hand and says, "I don't understand why I got this question wrong." Rob walks over and stands directly behind her. "Which question?" Rob asks. "This one." She replies. Rob, pointing to the correct answer, explains why it is the correct choice.

After about 20 minutes, most students had completed whatever task they were working on. Rob, standing in the center of the room, reads out the correct answers to the test and what are the correct responses to the worksheet. He cautions the students to pay attention to him because this is material that will be on their midterm exams. He then directs the students to return their work to the folders at the back of the class.

As the students are returning their work to the folders, Rob is setting up the overhead for the presentation of notes (see Classroom Overhead Notes – Rob). Once the students are seated with notebooks open, Rob begins the presentation. He has projected his notes up on the screen on the sidewall of the classroom. There is no narrative to the notes. They are bulleted, in outline form, and taken directly from the textbook.

An example of what was projected on the screen:

I. Geologic Time Scale

1. Record of Earth's history from present to 4.6 billion years ago

2. Broken into Divisions and Sub Divisions
3. Major events for each division
4. Dates rock layers and fossils

II. Major Divisions

1. Eras: Long periods of time based on changing life forms.
    a. Paleozoic first invertebrates, fish and amphibians later
    b. Mesozoic from amphibians to Reptiles
    c. Cenozoic from Reptiles to Mammals
2. Periods: Subdivision of Eras
    a. Based on existing life and geologic events
    b. Changes in environment due to Continental Drift
    c. Affects life
    d. Affects mountain building and plate movements

    Examples:

    - Appalachian mtns
    - First multicellular organisms observed in the fossil record

These notes go on for an additional five pages. At this point, some of the students have their heads down on their desks; only three of the 16 students are actively taking notes. As Rob lectured, there was no teacher to student interactions. He did not ask any questions nor were any questions asked of him. Once the presentation of notes was complete, Rob directed the students to page 308 in their textbook and had them copy the diagram into their notes. When this was completed, he then directed the students to page 304 where they completed a word search activity.

Day two. The second day of observing (see Data Points Chart – Day 2) began with Rob writing instructions on the whiteboard that was hanging on a side wall of the classroom. The instructions were in list form concerning the use of the computer lab. “Achieve an 80% or better” was the last instruction. Rob old the students that when they got into the computer lab they were to log onto the publishers web site and complete the computer generated quizzes and tests. If they received less than an 80%, they were to retake the quiz or test until they reached that goal. Once they reached the 80%, the students were instructed to move on to the next assessment.

The students were then given permission to leave the classroom and go to the computer lab. They gathered up their books, notebooks, and writing instruments and filed out to the lab. Rob followed after them. Once in the lab, Rob assigned the students to individual computers. Each student worked on their own and Rob walked around looking over their shoulders. In general Rob did not speak to the students unless they spoke to him first. He kept reminding them that this practice on the computer will help them on their SOL exams coming up at the end of the semester. The students worked at their stations until the bell rang ending the class.

Day three. The third day of observing (see Data Points Chart – Day 3) had Rob and the students working on the computers again. However, they were in the media center because the computer lab was in use by another class. Once again Rob walked around the room checking on student progress. At one point, Rob approached me to say that he really likes this type of activity because, “it gives the students many opportunities to succeed on an individual basis.” Approximately 45 minutes later the students were back in their classroom. Rob directed them to get their work from their folders in the back of the room and complete the assignments. He reminds them that the midterm exam is in a few days so they should be making corrections on previous tests and quizzes. Students work individually with very few questions or comments being exchanged between the class and the teacher.

Day four. On day four the students began the class by reviewing for an upcoming chapter test (see Data Points Chart – Day 4). The students retrieved their work from the folders at the back of the class and made corrections on previously graded assessments. Although there were three to four students per table, the students were directed by Rob to work individually and if they had any questions to direct them to him. Rob walked around the room and answered specific questions that were asked by specific students. At the end of approximately 15 minutes, the students put their work away and Rob handed out the chapter test. The last student finished the test in approximately 30 minutes.

For the next 45 minutes, Rob presented notes on the overhead. Once again, these notes were in outline form and taken directly from the textbook. There was no feedback asked for or given from the students. Some students actively took notes, while others read from the note packet. Still others put their heads down on the desk and slept. When Rob completed reading the notes off of the overhead, he directed the students to open their textbooks to a page that had a picture depicting magma formation. He instructed the students to copy the picture into their notes and to answer the questions concerning the picture on the next page of their textbooks. Students worked on this until the end of the period.

Day five. On the fifth day of observing (see Data points Chart – Day 5) Rob presented notes on the overhead as a way to introduce a series of videos that he had downloaded from the internet. Each of the three videos lasted approximately 15 minutes and covered specific topics of plate tectonics. At the end of each video, Rob asked if there were any questions. Very few questions were asked but Rob did answer them all. At the end of the last video, Rob directs the students to open up their textbook to a specific page. He tells the students to copy the pictures on several pages into their notebooks and use colored pencils to label them. As the students complete this work, there **are** some student-to-student interactions. Once student looks over at another student's drawings and they compare their answers. Rob closely monitors this conversation to make sure that they stay on task.

Teacher B*eliefs About Teaching and Learning*

Independent learning. Rob expresses his philosophy of teaching and learning as being able to provide students the opportunity to arrive at solutions on their own (see chart Teacher Beliefs and Strategies Rob – Section 3). He sees his role as the classroom teacher as an instructor:

> I like to perceive my role as more like an instructor. I like to have them research and do a lot of the work on their own that relates to the topic. My goal, as I see it, is to instruct them along the way. I want to keep them on track. I want to keep them focused on what the topic is all about and keep them working toward an understanding of what we've been discussing. I want them to stay on target. I want them to achieve it through self-realization. It finally comes to them; an understanding…and I see it on the expressions of a lot of kids. They'll say 'oh, I understand now.'

His role is to keep the students on track, focusing, and working toward an understanding of the material (see Data Points Chart Rob – day 4). Within his classroom, the presentation of notes, the assignment of activities, and his interactions with students are unidirectional and didactic in nature. The flow of information is from teacher to student.

Controlled Input-Output. Rob believes that students learn best when given a varied instructional approach. These approaches should be related to visual, auditory, and kinesthetic activities. He believes that students must have "sensory input" related to seeing, hearing, and writing. Of the three however, he believes that the kinesthetic or hands-on activities are the most important.

> Hands-on gives the students a direct relationship between physical contact with what they understand and learned in class. It gives them a better understanding, a better viewpoint, a different way of looking at it. It stays better in their minds.

By understanding the material, he means for students to be able to work and understand independently. If the students' understanding of the material does not match what he believes to be the correct understanding, Rob will backtrack and go over the material again. It is important to note why Rob thinks a student's understanding may not be the correct one:

> I'm not saying that students will get it the first time around because you have so many other outside factors that are involved. You've got personal problems that are involved; you've got parental involvement that may be too extreme or may be too little; you have the interactions of students outside of the classroom with after school activities. All of these influence their achievement on a daily basis.

This illustrates Rob's belief that the student's abilities to understand can be affected by outside forces. The outside forces mentioned by Rob tend to be negative ones that he feels affects the behavior of the student that in turn affects the way they learn. From this perspective, Rob adopts strategies that are used to control behavior in his classroom. Teaching and learning is unidirectional, from Rob to the students. The information is then relayed directly back to Rob via assessment tools such as worksheets, tests, quizzes, computer work, and homework.

Interactions. Rob wants the students to use all of the instructional activities that were provided for in the classroom to arrive at a conclusion either on their own, if that's their preference, or within a team. However, this is clearly not demonstrated within the classroom. Rob defines teaching strategies as, "keeping things mixed up but consistent throughout the semester so that they don't get surprised by something new." His goal with these strategies is to keep students actively involved:

> Well, mostly I strive for some type of interactive activity where they're communicating with one another and voicing some type of thing between us. Sometimes it has to do with some interaction on the computer… feedback through the computer and sometimes, more often than not, I try to get them to do some paper work on the videos we do so that they don't just sit there and sleep or whatever.

This statement represents Rob's belief that the interactions between student and teacher carry equal weight as interactions between computer and student. This supports his use of strategies that he believes encourages independence, keeps students on task, and leads to direct contact with the material that leads to understanding. Most if not all of the activities that Rob plans for his students come from the textbook or from the publisher of the textbook. These activities tend to be highly organized and set up in an algorithmic fashion that need little direction or explanation from the teacher.

Although Rob believes that a hands-on approach to learning is important, his teaching strategies tend to center around didactic teaching in order to maintaining discipline. The hands-on activities that were observed in the classroom (see Data Points Chart Rob – Day 1) required the students to work independently using well-structured worksheets or directly from the textbook. The sharing of information between students was discouraged. He stated in almost all interview sessions that the day-to-day interactions between students as they complete their activities were important to learning (see Teacher Beliefs and Strategies Chart Rob – Section 1). To Rob, team-work is an essential component to learning:

> When they interact, it gives them a sense of team-work; of being able to interact with one another. It may help them later in life when they are working in a job related environment to be able to solve problems together instead of relying on what they know to achieve their goal. Interactions allow them to feel confident with what they are doing because they are sharing information between themselves or with me as they proceed through the activity. Mainly my interactions are through activities or labs that we do in the classroom.

He believes that it is this partner-to-partner interaction that helps to identify and correct the weaknesses of students. However, this partner-to-partner interaction was rarely encouraged by Rob.

When asked to describe how students learn, Rob stated, "By various methods starting by sensory input relating to visual, hearing it, writing it and displaying it in some form. Such as, you know, hands on activities or actual performance that demonstrates their ability to understand." The one answer that Rob gave that illustrates this conflict between how he thinks teachers should teach and what he actually does in his class, was in response to a question about how he used strategies: "For example, like how I used the PowerPoint presentations that I do. Reinforcing that with visual stimuli from the videos and other hands-on stuff that I show and demonstrate, helps students to learn." Rob illustrates from this quote that he believes any activity that students can observe, counts as hands-on learning.

Influences on Teaching and Learning

Rob's beliefs about teaching and learning are strongly influenced by his desire to maintain order and discipline within the classroom. To achieve this, he designs strategies that are strictly teacher centered in order to keep students on task and focused. By using these strategies, Rob believes that he is not only teaching his students about independent study but also about independent learning. The strategies that Rob uses in his class are also strongly influenced by the level of the course (basic or honors), the textbook, the 4 x 4 block schedule, and the End-Of-Course exam.

Textbook. Within the next year, the school where Rob teaches will be adopting new science textbooks and Rob is hoping that the publishers will provide science teachers with some interactive materials to use in the classroom. Materials such as CD's, informal activities that can be used to generate excitement, links to internet sites, and video demonstrations for procedures that may be too dangerous to perform in the lab. When linked with his algorithmic presentation of notes that are taken directly from the textbook, it is clear that Rob sees the textbook, and hence the publisher, as the main tool in his pedagogical repertoire:

> You know a lot of teachers and administrators would say that you really don't want to teach out of the textbook. You want to be more innovative than that. You want to present the material on your level because you learn something new every day. You want to present it in such a way that they do the work on their own out of the textbook. You don't want to draw their attention to it every time. But I'm of a different opinion. I think those kids have to have some type of solid physical contact with the material in order to get a better grasp of the topic we discuss that day. They have to have some foundation to work from.

The idea concerning the students having physical contact with the material is fundamental to Robs teaching strategies (see chart Teacher Beliefs and Strategies Rob – Section 2). It is important to note that Rob's interpretation of "hands-on" learning involves physical contact with the material. To Rob**,** the completion of a worksheet, or the use of the computer constitutes hands-on learning because the student has come in contact with the material. The use of textbook generated activities is also considered by Rob to constitute hands-on learning and that the publisher, in conjunction with the State of Virginia, provides useful activities that follow the state mandated objectives in Earth Science.

> I think also that because the State mandates that we should have a textbook for these kids and that the State Department, when they get these textbooks or introductions, the State Department makes sure that they follow the objectives of

> the SOLs. I think it's a guideline for these kids to know….it's a foundation for them to learn the SOL objective.

Rob also uses the textbook because of the State mandates that are put on the publishers to cover SOL objectives. He believes that if he uses the textbook as a guide that will help him to cover what is required by the Virginia State Department of Education. This is another influence that directs his choice of teaching strategies:

> I get an assortment of different students and I can't be at one place too long. I've got to a keep moving around and that makes it very difficult to teach what they need to know in such a short time. My goal is for every student to work at their own pace and to be able to absorb the information at their own pace and so by working out different avenues that I've taught over the years, I'm bringing together different ways in which the students can understand at their own pace. . I hesitate to share a lot of information with them because I want them to get it…to collect it…to put it in a form that they can understand and arrive at their conclusions.

Rob has developed his own tools for teaching over the span of twenty years. Because his students tend to have a wide range of abilities, he states that he designs and chooses his teaching strategies centered on the goal for each student to work at his or her own pace. Yet Rob demonstrates a one size fits all didactic pedagogy. Once again, here he clearly demonstrates that it is his expectations of the students that changes.

End-Of-Course SOL exam. Besides ability of his students, another factor that influences his teaching strategies is the state sponsored, End-Of-Course Standards of Learning exams:

> I like to use different methods to introduce it to them and follow up from different avenues. Whether it be notes on the overhead, or notes that they take, or a follow up quiz or some other method of measurement to make sure that they are tuned into it. I try to get as specific as I can, but in the back of my mind I think about what I have to cover in the short amount of time that I have because of the SOL pressures. What I can present and what I'd like to present are two different things. The SOLs restrict the number of activities that I can do with these kids. It doesn't give me time to expand on an idea because of time restrictions. Just like with the film I showed today. I broke it up into three to four minute segments to keep them interested.

The pressures of time constraints due to the amount of material that needs to be covered as per the SOL's has a large influence of the teaching strategies that Rob incorporates into his lesson plans. He feels pressured to cover all of the material, which in his view is impossible. This forces Rob to incorporate didactic strategies such as direct instruction, the completion of word-search worksheets, the use of the computer to access the publishers web site to take practice tests and quizzes, and the reliance on the textbook to illustrate ideas and concepts.

Level of course. Another factor that influences the type of teaching strategies that Rob uses is the level of the classes that he teaches. The Earth Science class is considered a basic science class unlike, for example, an honors biology or honors chemistry class. According to Rob, the range of abilities within the Earth science class is far more varied than in the other honors science classes:

> A lot of activities and lecture notes, stuff that I do, I would present to an honors student much in the same manner but would expect more out of them because honors students are going to read the material. They're going to go over their notes. They're going to make micro-notes of their own as they go through it because they are highly motivated, maybe because of their environment at home or whatever. The average student doesn't tend to do that. Honors students are going to get it at a certain level; average students are going to still get the same information at a certain level, it's just the way that you present it.

The type of student, and the level of the course, influences Rob's outlook on teaching. He believes that those students that are in the upper level courses are more motivated to learn and thus he can expect more out of them than those students in the basic level courses. Once again, he demonstrates a change in expectations of his students based upon the level of course that he teaches.

Rob's use of didactic strategies remains a constant regardless of the level of students that he teaches. The only thing that changes are his expectations. In his lower level Earth Science classes, which are taught to Freshman, Rob's expectations concerning how students learn, their ability to learn, and their motivations to learn, are set fairly low. Classroom management and discipline are the driving forces that lead Rob to a more didactic approach to teaching.

Block schedule. One of the influences on Rob's teaching strategies is the 4 x 4 block schedule. He generally likes the block schedule because it provides him more time to complete laboratory and other hands-on activities. Nevertheless, he does see some drawbacks:

> Normally, on the traditional schedule, I had to set up in the time that I had and that gave me 20 minutes to work on the activities. Then I had to start taking it down for the next class. So block scheduling gives me the opportunity to see it all the way through. I still prefer the 4 x 4 schedule but there are a few drawbacks. I noticed that the kids get so acclimated to this that it swings right back to the old style again. They're looking for shorter time periods to do things in. They want the class to be over as soon as they get in here. So they have got the frame of mind that they don't want to put out much work and they think that they can get it done at any time they want.

Rob's beliefs about how SOL testing influences the effectiveness of teaching strategies within block scheduling are mixed. He believes that with a year-long class, the classroom teacher can cover the material at a more leisurely pace and can introduce more concepts on the traditional schedule than on the 4 x 4 block. Rob states that:

> Within the year long structure, you have them for a whole year and you have more opportunity to introduce more facts and figures into their everyday life, and you expose them to a lot of things and you probably don't have as much stress to reach those SOL objectives so quickly. On the other hand, block scheduling allows you to spread out a lot of material over an hour and a half in labs and activities. You can go through your lecture, do the follow-ups, do an activity or lab all in one hour and a half period. You'd probably have to spread these out over a two to three day period on the traditional schedule.

The 4 x 4 block allows the teacher to go over material in depth and to complete a concept within the 90-minute time frame. Another drawback to the 4 x 4 block schedule, according to Rob, is student absenteeism. “If you’ve got a kid that’s absent for four or five days, that’s like missing three weeks on a traditional schedule. That hurts them. They have a very hard time regaining the information.”

Rob’s beliefs about how students learn under the 4 x 4 block schedule center around the idea that he can provide many different activities and varying teaching strategies that he was unable to do under the traditional schedule. Because he can complete a concept within one class period, he finds that he doesn’t have to review as much as he did before (see chart Teacher beliefs and Strategies Rob – Section 6):

> In block scheduling I just have to go through it one time. I can cover more material in less time to achieve the same results during that one hour and a half than I would in two days or three days during the regular schedule. I also think that it gives the student more opportunity to perform well. That’s why I like the block system. The fact that I can introduce so many topics and follow up with an activity that reinforces what I’ve talked about. I don’t want to move through the period with just one strategy. I want to make sure that they are exposed to different strategies and block scheduling gives me that opportunity.

Rob does use different strategies as his lesson plan progresses. However, they are all didactic. These strategies include direct instruction such as lecturing, individualized work from the textbook, and use of computers in the computer lab. Cooperative learning strategies such as working in a small collaborative group and inquiry-based strategies such as allowing the students to form their own conclusions were not observed. One of Rob’s driving philosophies is the idea that hands-on learning is interpreted to mean any physical contact with the material.

Rob believes that smaller class sizes help because the larger the number of kids, the less time he can spend with individual attention. He believes that block scheduling helps reduce the number of kids because of the two semesters per year format. He also sees a large problem with the amount of information that the students must absorb in a 90-minute time frame:

> I see more and more information coming on to the scene, meaning that all the extra time we had during the block schedule is now being taken up by more information being introduced for kids to learn. So our time is being severely restricted by the fact that SOLs make us cover the material in as sufficient a manner as we can. It puts a lot of pressure on us to show that we covered the material, and the material we really wanted to show, we can't, because we must meet the SOL objectives. I remember when I was in high school, the textbook was about a half an inch thick. Now it's close to two inches thick.

Even though he has more time, the extra material that is being required by the SOL objectives, eats up the time he could spend with individual students. To Rob, as with Carl, the advantages gained by the block schedule are diminished due to the ever increasing amount of material that is being required in order for students to pass the End-of-Course, State mandated exams.

Summary of Rob

Rob believes that students learn best when they are given the opportunity to work as a team. According to Rob, teamwork can uncover student weaknesses. However, most of his strategies are teacher centered and didactic. His choice of strategies lead to independent learning that is designed to maintain discipline. If we look beyond his stated beliefs about learning, that is, students learn best if they work in teams, his beliefs are consistent with the strategies that he chooses to use within his lessons. The presentation of notes is very organized, unidirectional from teacher to students without feedback, and formatted in bullets on the overhead. Rob expects his students to copy the notes directly from the overhead into their notebooks without comment or discussion. This is because, according to Rob, teachers should keep students focused, on track, and not let them be surprised by anything new. This highly controlled method of input-output, allows his students to overcome any negative outside influences that may creep into the classroom and cause disruptions.

Rob uses the textbook as his primary source for notes, activities, assignments, and illustrations. These were used in teacher centered and didactic ways that led to independent work by the students. Students were asked to copy pictures directly from the book, answer questions from the book, or read a section highlighted in the book on their own with no student-to-student interactions.

Greg

Introduction. Greg is a fourth year teacher at a large rural high school who has been teaching on the 4 x4 block schedule all four years. He received his degree in chemistry and teaches chemistry and biology. He has an average student population of between 15 and 18 students per class. For this study, I observed Greg in his non-honors biology class. This class consisted of mostly sophomores.

Greg is an ex-Air Force person who served for four years in the military. He joined the military after he was refused acceptance into medical school. While in the military he served as a surgical technician. When he was discharged from the military, he applied to medical school again and was accepted as an alternate. Before he could attend, he met his wife, got married, had a child and decided to get into the medical field as a civilian surgical technician. He got into teaching as a result of his sister telling him about a person going on maternity leave. He applied and was hired. Greg views his position at the school as temporary until he applies for and gets accepted into medical school.

Teaching and Learning Strategies in Block Scheduling

Students entering Greg's classroom were usually greeted with some sort of salutation from Greg. He would always spend the first five to ten minutes of class talking with individual students. These conversations were generally about things occurring outside of the classroom. He would inquire about how the student was doing or feeling. He would ask about family, the athletic event the night before, or about an injury that a student displayed.

Greg does not write out a formal lesson plan for each day's lesson but bases his instructional strategies on dividing the 90-minute class up into two sections of 45-minutes each. The first section is for the presentation of notes and some type of lecture, while the second 45-minute period is for completing worksheets, homework assignments, hands-on activities or laboratory procedures. During his first two years of teaching, Greg wrote out extensive lesson plans and goes by them with modifications from semester to semester. He has all of his teaching material in a book that he keeps. He hands out a notes packet to each student so that they don't have to take notes. They can follow along as he gives them on the overhead. "It's like how a preacher preaches…He takes the scripture and does expository preaching…I do expository teaching."

Day one. On the first day of observation (see Data Points Chart – Day 1) Greg presented notes on the overhead. He sat in a high chair and talked as he wrote. He started out by listing terms that the students had previously discussed. These terms included: Chromosomes, alleles, traits, and punnet squares. He would write down what the students said on the overhead. The most questions were asked during the presentation of the punnet squares. Questions like, "How did you get those traits in that box?" and "How does that lead to a recessive trait?" The students were also taking notes as Greg proceeded through the presentation. The students would respond to Greg's questions either individually or chorally, "Why is that," and "Why do you think," were asked often by Greg.

At one point in Greg's presentation, a student told the class of her uncles' struggle with sickle cell anemia. Greg allowed the student to tell her story in detail and then used this information to begin a discussion on genetics and heritage. He adds bits and pieces about his own family and genetic heritage. Greg then refocused the student's attention to the overhead where he drew a punnet square. He used this as an example and then had the students draw their own and fill them in. As the students completed this phase of the lesson, they were allowed to either work alone or in small groups. Greg walked around the room, sitting down at each table when necessary to monitor progress. Once all work is completed, Greg had the students look at each other's work.

The last half of the class was devoted to the students completing a handout activity that Greg gave them. The handout was a teacher-generated list of terms that needed to be defined and questions that needed a written response to. The students were instructed to use their notes, textbook, each other, or the teacher as a resource to help answer the questions.

Day two. On the second day of observation (see Data Points Chart – Day 2) Greg handed out a detailed study guide that the students used to review for the midterm exam. Once again, the students were encouraged to work individually or in groups at their assigned tables. As the students progressed, Greg would sit down at each table and discuss the material with the group or individual. When this was completed, Greg broke the students up into five teams of three students to play Biology Jeopardy. Answers where projected onto the wall and students would attempt to come up with the questions.

Day three. The third day of observation (see Data Points Chart – Day 3) began with Greg discussing the disease AIDS. He began with questions to the class about what they had heard about the disease**:** who gets it, and how it is transmitted. During this phase one of the students, in a fairly loud voice responds with "faggots" when the class was asked who gets AIDS? Greg used this to talk about misconceptions concerning diseases. He never responded directly to the student but would ask the class questions such as, "Is that true?" and **"**Are the only section of the population who are infected with HIV AIDS homosexuals?" At the conclusion of the discussion, Greg handed out a worksheet that he described to the students as a guide that they will need when they view a film about HIV AIDS. The worksheet had questions that the students will answer as they watched the movie. The rest of the class time is spent watching the film. Greg sits at the front of the room and the students watch the film and answer the questions on the worksheet.

Day four. A pre-test handout began the fourth day of observation (see Data Points Chart Day – 4). Each student received the handout and all were instructed to ether work individually or in groups to complete. The handout was a mixture of teacher generated questions, questions from the textbook, and questions from previous SOL exams. The students could use any resource: textbook, notes, each other, the teacher, in order to answer the questions. Greg walked around and sat down at each table to monitor progress. He rarely directly answered any of the students' questions. He more often than not responded with another question or urged the students to look the information up. For example, a student working on a question covering material from a few weeks ago said, "Man, I don't remember any of this stuff!" To which Greg responded with "Use the index or table of content in your book. See if you can find anything that pertains to that."

Teacher Beliefs About Teaching and Learning

Collaborative learning. Greg thinks that students learn by visual and kinesthetic means. Greg explains further:

> It's kinda like when I was in the military. In the military we saw how something was done, then we did it, and once we did it, we taught someone else how to do it. You can't teach someone else unless you really know it, so I guess that's why I like to do collaborative learning.

Greg defines collaborative learning as, "working together, teaching one another, you know, not teaching themselves. I'm teaching them but they're taking what I taught and applying it and they're teaching one another." Greg sees his role as the classroom teacher in terms of a big picture about life**:**

> I think that I'm teaching them more than just biology. I'm teaching them about life. I'm teaching them about how to live life. Teaching how to succeed in everything. I think that my role is to teach them how to be people and to grow into

> their potential. It just so happens that biology is the mode that I teach that in. I guess that's the reason I bring so many real world things into my classroom when I explain things.

This shows that his approach to learning science is again centered around the bigger picture. "It gives them the tools to understand things. It gives them the ability to reason and to solve problems."

Making connections. To Greg, the ability to learn and understand is directly linked to their ability to make connections to real life experiences:

> Learning is the process of thought. I think of one thing and it leads to something else which leads to something else. The more pathways that lead to something, the greater that you're going to remember them.

These connections are mediated by the students' personal experiences:

> They bring their home lives to class – relationships, cultural bias. If I can make a connection to that….The first thing that I do is ask them who's your mom? Who's your dad? Grandparents? I grew up here. I'm either kin to half the county on my dad's side or the other half on my mom's' side."

This leads to strategies that are based mostly upon a visual and kinesthetic style. Since Greg classifies himself as a visual and kinesthetic learner, he chooses strategies that fall along those lines. He believes that students learn by forming pictures in their brains and that these pictures are the correct representation of what he taught.

Greg's view on learning centers on the break-up and dissection of information into very small units of study:

> Students will enhance what they already know about the scientific method. They will graph data, learn how to set up experiments, learn about biochemistry because you can't learn biology without knowing some chemistry. Students will learn about cells and all of the parts. They will learn about genetics to establish a good basis for the study of evolution.

This illustrates that Greg believes that learning is accomplished in sequence and that students will understand the material best when a clear link is made by the teacher from one unit to another.

Open structure. The flow of information in Greg's classroom was undefined. He would allow students to raise their hands and talk about the topic even if it meandered. However, he would use that to either transition into or directly confront the concepts he was trying to cover. When asked to define a teaching strategy, Greg drew from his own experiences as a learner. "I'm a visual learner. I find that most of my students are visual learners as well so my teaching strategies tend to be visually and auditorally directed." He designs his lessons around lots of everyday manipulatives like Twizzlers, toothpics, and Dot candy. He relates a lot of what the students are studying to his real life experiences in surgery. His primary objectives are to enhance what the students already know about the scientific method. Prior knowledge and student experience are important to the learning process.

Greg believes that what he teaches is directly reflected within the brains of his students. The strategies that he uses to cover the material include hands-on laboratory procedures, videos, computer time on the internet with internet worksheets, homework assignments – but not a lot, "Why set them up for failure because they're not going to do it." The students go on field trips to his mother's house to do a stream survey, and they will have time to themselves to make ice cream, eat fruits, and have a party:

> They're going to have free time and they're going to have work time. They are evenly dispersed. They get time to talk and have fellowship so that they stay focused during the work time. My classes are very loosely structured.

Influences on Teaching and Learning

The strongest influences on Greg regarding his beliefs about teaching and learning and strategies are his experiences as a student, his military background, the standards of learning exams, and the 4 x 4 block schedule.

Experiences as a student. Greg's own experiences as a student influences the way he teaches. He found the educational system, up through the secondary level "to be a snap." He found it so easy as to not have to study or to work very hard to succeed. This affected his ability to succeed to the degree that he wanted to at the college level. For this reason, he has high expectations of his students. His strong desire to be a medical student also influences his beliefs about teaching. Since Greg looks at teaching from the standpoint of it being a temporary position, he feels that he can teach with less structure:

> I got out of the Air Force and worked in surgery. I still work in surgery but my sister who is an educator said that Virginia had a program where if you had a degree in like chemistry or physics that you could do a provisional license. So I put in an application just to see what would happen. They had a teacher who was taking maternity leave so they hired me for one year just to fill the position.

To Greg, teaching is not a professional pathway for him. It is a temporary position until he passes the MCATS and gets accepted to medical school. This may be a reason for open structure within his classroom.

Military background. Greg thinks that students learn best by completing hands-on activities. This belief stems from his prior military experience:

> If you do it, you're going to learn it. I guess it's kinda like in the military. In the military we saw how something was done then we did it and once we did it, we taught some one else. You can't teach some one else unless you really know it.

In the classroom, Greg's strategies reflect this statement. He presents material then has students work together to answer guest ions or solve problems.

End-Of-Course SOL exam. The single largest influence on his choice of teaching strategies is the SOL test. He doesn't think that the SOL tests are necessarily a "bad thing." He agrees that they should be used to see what the students are learning. His objection is that no one from the State Department of Education has issued any directives on how much depth he is suppose to go into with each individual topic. He also doesn't believe that the results of the SOL test should keep a student from graduating. Greg believes that the SOL criteria and subsequent testing restricts his ability to make the class more enjoyable for the students. According to Greg:

> If we didn't have an SOL, this would be the greatest and coolest biology class that ever was. We wouldn't be pressured and we could go slow enough so that they could really learn things and really understand it by going more in-depth.

Block schedule. Greg states that the 4 x 4 block schedule influences the way he teaches the class. Although he has known nothing else but the block schedule, he feels that, for science education, “the block schedule is great.” It allows for my time to complete the laboratory exercises. He feels that the students don’t feel rushed like they would on the traditional schedule and this allows them to absorb the material. Another advantage is that he can cover the concept in one day without dragging it out over a two to three day period. Students would lose interest and forget the material. However, Greg went on to say, “I don’t think the 4 x 4 is good for the allowance of mastery. I believe that if you had a year to teach it, you could go at a slower pace and that would allow for more mastery between individual concepts.”

Summary of Greg

Greg’s beliefs about teaching and learning are directly illustrated by the strategies that he uses in the classroom. Greg’s use of strategies within the 4 x 4 block schedule closely matches his beliefs about teaching and learning. To Greg, students learn by making connections. These connections are mediated by their own personal experiences. With this as the background, Greg believes that teachers must use strategies that tap into the personal experiences of students.

The strategies used by Greg are generally didactic in nature. He presents organized notes on the overhead however they are not pre-typed. He writes as he talks. This allows Greg to change direction in response to student questions which he does often. Most other strategies such as having students work in small groups to complete worksheets, activities, labs, and practice tests, are teacher centered in that Greg gives specific directions for specific outcomes. However, in reaching those outcomes, Greg takes a route that incorporates the personal experiences of his students.

Greg thinks of himself as a transient teacher who is on a temporary side road on his way to medical school. It may be this lack of ties to the establishment of education that allows Greg to be more open in his beliefs about teaching and learning as well as his use of holistic strategies within the classroom.

Analysis

Introduction

The evidence observed through interviews, observations, and documents suggests that the strategies used by three high school science teachers on the 4 x 4 block schedule remain mostly didactic in nature. Although these three science teachers reported that they used varying strategies, these strategies varied only in number, not in type. The strategies used within the classroom were teacher-centered: lecture based presentation of notes, working directly out of the textbook, activities that were assigned and explained by the teacher, and teacher generated/led solutions to problems. Although different teaching and learning strategies that were more holistic in nature such as inquiry-based learning, cooperative learning, and conceptual change were mentioned by the teachers during interviews, very few were implemented within the 4 x 4 structure of the class.

Since the National Science Education Standards (NSES) have suggested that science educators implement a more inquiry-based approach to teaching, it is important to understand why these science teachers did not adopt these strategies to any great extent. The reasons that these three teachers are not adopting more holistic strategies can be found in: their beliefs about teaching and learning, the Standards of Learning End-Of-Course Exams, the level of course, the use of the textbook, life experiences, the 4 x 4 block schedule, and their understandings of the nature of science.

Connections with the Literature

Beliefs about teaching and learning. Much of what a teacher does within the classroom is influenced by their life experiences and beliefs (Brand & Glasson, 2003; Keys & Bryan, 2001; Pajares, 1992). Two of the subjects within this study stated that their prior military experience influenced how they taught. Both teachers considered their time in the military to be a very positive experience. They adopted teacher directed, A to B, goal oriented strategies because that is how they learned skills in the military. One used these strategies as an instructor and the other was exposed to these strategies as a recruit.

Powell (1994) showed that the personal beliefs about teaching and learning and the strategies adopted by the teacher could conflict. All three teachers relied heavily on repetitive didactic strategies and believed that what they taught was directly reflected on to the brains of their students. However, all three teachers stated that they believed that more holistic strategies involving cooperative learning and inquiry would be more effective**.** As discussed by Golinski (1998)**,** teachers believed that learning occurs when students are actively involved and that knowledge is a shared experience and a human creation made with available material and cultural resources. This is an essential tenet of a constructivist philosophy, yet the teachers in this study believed that knowledge was directly transferred from the teacher to the brains of their students, which is antithetical to a constructivist philosophy.

Constructivism and science education. Constructivist teaching strategies are consistent with the view that science education takes place through inquiry-based learning that is reflecting real world experiences (Dettrick, 1999; Eick & Reed, 2002; Hendry, 1996). One science teacher in this study had the students collect pond water from various locations that were off campus. He then used these samples that the students brought in to show that the diversity of life within a pond is prevalent through-out nature regardless of where the sample comes from. Another teacher used the concepts of genetic diseases to begin a discussion that led to students talking about their own personal experiences with relatives who suffered from Sickle Cell Anemia and other diseases linked to genetic variation. The presentation of activities within the structure of a lab was where the attempt was made most often by the teachers to link real world experiences with content. However, the lab activity was taken directly from the ancillary materials provided by the textbook publishers and the teachers were not observed to make any changes to the protocols.

As pointed out by Lawrenz (1990) and The National Survey of Science and Mathematics Education (2002), the distribution of time spent on various activities does not support the teacher's own commitment to inquiry-based learning. There is a mismatch between what the teacher would like to do, and what the teacher is doing within the classroom. However, more time is spent on inquiry-based and cooperative learning strategies now than in the past. This study found this was the case for all three science teachers. All stated that they preferred to spend more time doing hands-on activities that included cooperative-based and inquiry-based learning strategies. The reasons given for why they were not adopting these strategies was that there is far too much material to be covered in order for their students to pass the state mandated End-Of-course exams.

When presented with the four tenets of constructivism and asked to pick which they most closely associated with, the three science teachers chose tenet one, tenet four, or both one and four. Tenet one states: knowledge is not passively accumulated, but rather, is the result of active cognizing by the individual; tenet four states: knowing has roots in both biological/neurological construction, and social, cultural, and language-based interactions. One teacher expressed a belief that the individualistic learning experiences can have an impact on learning. This showed an association with a radical constructivist philosophy of learning. However, this teacher strictly used didactic strategies within the classroom. Another teacher expressed a belief that those student who achieved at the higher levels did so because they had the broadest social and cultural backgrounds. This is clearly an association with a social constructivist philosophy. Once again however, this teacher used didactic strategies as his primary teaching tools. Little evidence was obtained either in the interview or in the observations that supported any of the three teachers social or radical constructivist beliefs.

Science vs science education. Hodson (1993) showed how a teacher's choice and design of learning experiences were reflective of their views concerning the nature of science. He found that there were inconsistencies between the teacher's expressed views about scientific knowledge as constructed and validated within the scientific community, and their views about scientific knowledge that are implied by the teacher's choice of learning experiences. The current study did not find this. There was consistency between how the teachers viewed science and how they thought science should be taught. That is, if the investigative procedures followed the scientific method, what would be discovered would be reflective of nature; the God's eye view. The strategies that a science teacher uses within the classroom are dependent upon the teacher's own referent (Apppelton & Asoko, 1996; Fischer & Aufshnaiter (1993); Spraque & Dede, 1999). All three teachers in this study could be classified as scientific realists. That is, they all believed that science as a discipline produced laws and theories that reflected immutable truth. This was demonstrated in the activities that were designed to validate existing laws and theories.

For example, the Peppered Moth activity was used by all teachers to demonstrate how the environment can have an affect on genetic variation. The activity was a pencil and paper lab that had students answer specific questions designed to elicit specific answers so that the students would draw conclusions that were already established and accepted by the scientific community.

The concepts associated with the nature of science were not observed nor were they referenced in any of the interviews by any of the teachers. However, all teachers used instructional strategies that could be classified as positivistic and aligned with a scientific realist view on the nature of science. Examples of these strategies included linear, detailed explanations during lectures, followed by detailed instructions on laboratory investigations. The students were then assessed according to how well they answered specific questions concerning existing laws and theories. These strategies portrayed science as reflective of nature because science conforms to the established and accepted tenets of the scientific method. Activities and labs were designed by the science teachers to show that if their students followed the right procedures as established by the scientific method, they would obtain the results that were accepted/acceptable to the scientific community.

Block scheduling and science education. There is a mismatch that occurs between the science teacher's use of a variety of instructional strategies and the amount of time necessary to implement the strategies. Lawrenz (1990) studied the relationship between teaching strategies and learning. She found that the time spent on various activities does not support the teacher's commitment to hands-on learning. There is a clear mismatch between the teacher's desire to provide more inquiry-based learning strategies and the actual class time devoted to the practice of these strategies.

The time format of the various block scheduling scenarios allows for more inquiry-based teaching strategies (Bugaj, 1999; Hackman & Schmit, 1997; Lumpe, Haney, & Czerniak, 1998; Robins, Gregory, & Herndon, 2000). Also, block scheduling allows the teacher to cover the material in more depth (George, 1997; Hamdy & Urich, 1998; Stokes & Wilson, 2000). All three science teachers stated that they viewed the 4 x 4 block schedule as having a positive influence on teaching and learning. They said that the 4 x 4 block schedule allowed them to provide a consistency of learning. By that they meant that they could complete concepts, activities, and laboratory procedures in one sitting.

All three teachers stated that the 4 x 4 block schedule provided the opportunity to include more holistic strategies such as cooperative and inquiry-based learning. What was observed in this study was that the teachers used more didactic strategies. The three teachers believed that providing more strategies in a given amount of time was an advantage provided by the 4 x 4 block schedule. It is interesting to note that the three teachers believed that by providing more didactic strategies a more holistic approach to learning was achieved. This may illustrate that a teacher who is a scientific realist, as are the teachers in this study, believes that a goal oriented, direct approach that links concepts in an A to B sequential fashion, produces learning.

Observed teaching and learning strategies. All three teachers used well organized pacing guides to design their lessons. Two of the three teachers divided the 90-minute block of time into three 30-minute blocks. The third teacher divided the time into two 45-

minute blocks. Those teachers that divided the block into three sections generally used the first section for direct instruction. These strategies included lecturing, copying notes directly from the overhead into a notebook, answering a question based upon previous lessons, and using the textbook to complete an activity. The second 30-minute block of time was used to explore manipulatives either in a formal laboratory exercise or in an activity that was less involved or structured. These activities tended to be cooperative in nature where students worked in pairs or in small groups. The last block of time was generally devoted to summing up, closure, or other strategies used to end the lesson. These strategies included the use of the library, the internet, digital film clips, or the showing of a movie such as *Inherit the Wind*. The teacher who divided the block into two sections used the first block to cover the material using various teaching strategies that included direct instruction, cooperative learning and inquiry. The second block was used for the students to work independently. They could work individually, in small groups, or in large groups if desired. The teacher would roam the room during the second half of the block helping individual students or groups as necessary.

The group work assigned by the teachers was still linear, and teacher directed. The group was generally asked to complete an activity or assignment by following directions given by the teacher. An open ended discussion of student acquired data was not observed. The students were working together in small groups to come up with the "correct" answer as determined by the teacher. In fact, in some cases, the teacher would provide the data if the lab activity didn't produce what was expected.

SOL's and End-Of-Course exams. One of the strongest influences on the choice of teaching strategy was the role of the Standards of Learning End-of-Course (EOC) exam that the students are required to take, and 70% are required to pass. Bacon (1995) argues that there is a mismatch between today's classroom experiences and curriculum, and traditional testing methods. He argues that more holistic teaching methods can not be assessed using traditional testing methods. However, Bacon assumes that science teachers are using more holistic teaching strategies. This current study suggests that science teachers used varying strategies but these strategies were still didactic in nature.

According to the teachers in this study, the amount of material that was required to be covered, especially in a high school biology class, prevented the teachers from incorporating a variety of teaching strategies, such as cooperative learning and inquiry-based strategies. One teacher demonstrated the difference in size between his current biology textbook and one that was written ten years ago. It was double the thickness. All teachers expressed concern that they could cover all of the material. Even if they did nothing but direct instruction and lecture for the entire class time, a significant portion of the course content would be left uncovered. From the teachers' perspectives, the objectives established by the state do not allow for the necessary time to present hands-on learning and inquiry-based learning teaching strategies.

A careful examination of the National Science Education Standards (NSES) shows that the National Research Council (NRC) suggests that science educators plan and adopt an inquiry-based science program for their students (Teaching Standard A). This program, according to the NRC, should be based upon the constructivist tenet that student understanding is actively constructed through individual and social processes. Constructivist science educators would agree with the NSES in that they believe that inquiry-based strategies are beneficial because they will engage and motivate student learning more effectively than didactic strategies. According to the NSES the benefits for the students of an inquiry-based approach are: asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. The question then arises, do the assessment tools as established by the state, such as the End-Of-Course Exams in science measure these benefits?

The assessment section of the NSES states that many methods of data collection should be used when assessing student achievement. These methods should not rely on just the one traditional paper-and-pencil method associated with standardized tests. They suggest that all aspects of science achievement – the ability to inquire, scientific understanding of the natural world, and understanding of the nature and utility of science--are measured using multiple methods such as performances and portfolios, as well as conventional paper-and-pencil tests. However, a study of the Standards of Learning Exam for Earth Science shows not an assessment of inquiry skills as per the NSES, but an assessment based upon scientific fact and static concepts. An example of some of the mismatches between the NSES and state assessment practices is illustrated within the state standard that requires chemistry teachers to teach their students how to use a scientific calculator but the students are not allowed to use a scientific calculator on the End-Of-Course Exam in chemistry.

All three teachers said that the closer they got to the testing date, the more that they reverted to direct instruction strategies to cover more material. As the time for the EOC exam drew nearer, the teachers used more direct instructional strategies. They all stated that they didn't think that this was the best way for students to learn, but they needed to cover all of the material. The teachers would agree with Byers and Fitzgerald (2003) that "content knowledge alone does little to advance the habits of mind and comprehension of the scientific process." However, the teachers in the current study felt that to provide the best opportunity for the students to pass the test, more material should be taught in whatever strategy was required. The strategy required to cover the most material in the least amount of time, in their view, was direct instruction.

The academic level of the students. Two of the teachers in this study taught the general level classes of Earth Science (freshman) and Biology (sophomores). The third teacher taught Honors Biology (sophomores). Those teachers who taught the general level tended to use more structured teaching strategies in order to enforce discipline. They stated that when the students worked in groups, or were asked to develop concepts and theories on their own, there tended to be a sharp rise in disciplinary issues. The implications of this are that those students who are placed in lower level science classes are being denied access to not only science learning but how science works. If science learning is to take place under an inquiry-based program, those teachers who are resorting to didactic strategies for behavioral or disciplinary reasons only, are denying their students an opportunity to participate in the process of learning science.

The textbook. All three teachers relied heavily on the textbook. They developed lesson plans, devised activities, and assigned work that was all centered on the use of the textbook. When asked about the use of the textbook as a teaching tool, one teacher explained that since the publisher and the State Department of Education worked together to provide a resource that had direct links to the SOL objectives, he felt confident that his lesson plans would cover the requisite material, ensuring that his students would be prepared for the EOC exam.

The classroom teacher's reliance on the textbook as a source for instructional material remains unchanged over the past 25 years. McCutcheon (1980) reported that 85 to 95 percent of the teachers in her study relied heavily on the activities provided by the textbook publisher. She stated that the reliance on the textbook may even be higher in states that have state-wide textbook adoption committees that publish a list of acceptable textbooks from which classroom teachers may select. She also noted that with a limited average time of 25 minutes, science teachers were finding it impossible to implement discovery learning activities as presented in the textbooks. Thus, science teachers were modifying the activities to fit the time frame.

The science teachers in this study found it unnecessary to greatly modify the activities because they had 90-minutes with which to work. Science textbooks present science as a collection of immutable truths. Each section within a textbook explains and describes how science arrived at that particular law or theory. Few, if any, alternative views are presented within the structure of the narrative or within the procedures and principles of an activity. This may correlate or even reaffirm the science educators view concerning the nature of science.

Collopy (2003) found that U.S. teachers' perception and use of curriculum materials may not be effective without additional professional development. Along with preservice teachers, established classroom teachers are receiving minimal guidance on how to use the extensive materials now provided by textbook publishers.

Implications

When the National Science Education Standards adopted an inquiry-based approach to learning based upon a constructivist philosophy, the constraint of time became apparent. Teaching strategies associated with inquiry take more time to implement and carry out than do didactic strategies. In the mid to late 1990's, block scheduling was advanced as a way to provide more opportunities for the classroom teacher to adopt inquiry-based and cooperative learning strategies. If a clear link is not established between inquiry learning, cooperative learning, and conceptual change learning, and their philosophical underpinnings, science teachers will not adapt or adopt the necessary strategies needed to advance these learning theories. It is important for pre-service and experienced teachers to link their own personal beliefs about teaching and learning with the strategies that they will use or are currently using in the classroom.

This research found that the three science teachers that participated in the study had beliefs about learning that were consistent. Each of the teachers studied were consistent in their use of didactic strategies within the classroom. The teachers expressed beliefs that were hybrids in their language concerning either the social and cultural influence upon learning or the individualistic process of learning. Although they talked about beliefs that were tangential to more holistic and constructivist philosophies, their use of linear, A to B, and goal-oriented strategies belied a belief that learning is achieved through didactic strategies. They believe that the 4 x 4 block schedule provided the means and the mode by which they could implement more and varied strategies. However, these strategies remained teacher centered, goal-driven, and didactic.

All three teachers stated that the advantages of the 4 x 4 block schedule were being negated by the aura of accountability that is sweeping through the educational establishment. Due to the ever increasing amount of material that needs to be covered in order for the students to have a chance at passing the End-of-Course (EOC) exam, the teachers reverted to direct instructional strategies such as lecturing, independent book and computer work, while spending less time on hands-on learning, inquiry-based learning, or cooperative learning strategies. In their view, they needed to use the strategies that would cover the material the fastest: direct instruction.

Teacher directed learning assumes that the information being provided by the teacher is being assimilated into the learning structures of the student. Constructivist philosophies assume that in order for the new information to be assimilated into the learning structures, it must pass through a filter that is influenced by social and cultural influences. If the student is allowed to pose the question, determine how the problem should be solved, and allowed to used trial and error techniques to arrive at a solution, the student claims ownership of the material. Within the solution sequence, the student has adapted and adopted methods and techniques that he owns. Therefore, he also owns the new knowledge. Byers and Fitzgerald (2002) discuss the advantages of inquiry-based learning and also explain why inquiry has succeeded as an instructional method. They arrive at their conclusions based upon the ideas that: student understanding of science involves more than obtaining a knowledge base alone, scientific understanding is based, in part, upon observations made about the real world, students modify their understanding when they discover conflicts between their observations of the natural world and their personal understanding of natural phenomena, and that learning is a social activity. They argue that inert knowledge that is devoid of deeper conceptual understanding limits the transfer of knowledge to new and unique situations.

Conclusions

Synthesis of findings. The overall view of the understanding of teachers and the strategies that they used under the 4 x 4 block schedule indicates that these three science teachers were using mostly didactic strategies in a system that is directed by accountability. The strategies that were chosen by the teachers in this study were influenced by factors such as End-Of-Course testing, the textbook adopted, the level of class taught, their own understanding of the use of strategies, and the 4 x 4 block schedule. The linear and goal oriented strategies that led to direct instruction were viewed by the three teachers as not necessarily more effective, but as a means by which a tremendous amount of information could be delivered to the students in preparation for the End-Of-Course state mandated exams.

The classroom teachers were not adopting teaching strategies that encompass inquiry-based strategies as suggested by the National Science Education Standards (NSES). Although teachers believed that the 4 x 4 block schedule provided the necessary time, the pressures of covering sufficient amounts of material to pass the Standards of Learning exams, negated the use of more holistic strategies. However, the teachers themselves expressed beliefs about teaching and learning that were aligned with their teaching practices.

All three teachers in this study could be classified as scientific realists in that they believe science provides insight into immutable truth, and that what science measures, records, and observes is reflective of reality. These teachers provided classroom strategies that are based upon this belief: lectures that illustrate techniques devised by science to confirm laws and theories established by science, and laboratory exercises devised to confirm existing facts based upon the scientific method, the fundamental basis for scientific inquiry.

The NSES recommends an inquiry based approach to teaching and learning because in doing this, teachers:

- Develop a framework of yearlong and short-term goals for students.
- Select science content and adapt and design curriculum to meet interests, knowledge, understanding, abilities, and experiences of students.
- Select teaching assessment strategies that support the development of student understanding and nurture a community of science learners.

Within this framework, according to the NSES, students' understanding will be actively constructed through individual and social processes. When asked about the big picture concerning how students learn, two of the science teachers in this study expressed beliefs that correlated to this framework. One said:

> I really do believe that the way you think through things helps you to make sense of what you have been through or felt or experienced. Well, I think to you, the way you perceive things, the way you cognify things is the way that you deal with reality and the way you see the world and so I think that it is a process in some ways to help you accurately represent reality in the world that you live in. Now maybe it is or maybe it isn't but to you it is…the individual.

The other teacher said in response to how he thought students learn:

> I believe that the social background. Cultural background has a huge impact on what you learn. The kids that do the best and learn the quickest are the ones that have the broadest social and cultural backgrounds. The ones who have been

somewhere other than [names the city] their entire life. Have gone to museums, has gone to the zoo, they've had that base already there and established so that when you teach them something new, you can connect to something they already know. The fact of the matter is, with neurological construction, it's been proven that he more pathways you have going from information to information, the more your going to be able to remember and recall.

The first teacher is expressing a belief that is clearly radical constructivist in nature, while the second teacher's beliefs are based more on a social constructivist philosophy. However, both teachers used didactic teaching strategies as the predominant teaching tool. When the science teachers were focused on the teaching of science content specifically, they expressed beliefs and demonstrated strategies that were teacher centered, linear, and goal oriented. However, when the teachers were focused on how students learn in general, they tended to express beliefs that were constructivist in nature. The National Science Education Standards are an attempt to fuse these two seemingly disparate and conflicting approaches between science, and science teaching and learning.

Even if the NSES are successful in fusing together the holistic teaching and learning strategies of inquiry and constructivism with the scientific realist beliefs of science and science educators, how will this learning be assessed? The current state mandated End-Of-Course exams make no attempt to test how well a science student uses inquiry to solve a problem or research a question. The assessment section of the NSES clearly states that this type of pencil-and-paper assessment should be only one in a series of assessments that include portfolios, practical assessments, and student demonstrations. This conglomeration of assessments should be authentic and the data collected by these assessments should be used by the teacher to evaluate, as a whole, the progress of the student. The national and politically motivated accountability movement that is sweeping through the country removes the classroom teacher's input on assessment. To the government, the only assessment that counts is the pencil and paper test. This is in direct conflict with the national science standards.

Recommendations

Beginning in 2007, the federal No Child Left Behind Act (NCLB) will require that students in science be tested for proficiency. Such a mandate could force schools to consider cutting back on some in-class experiments and could undermine the recommendations of the National Research Council (NRC) for teaching inquiry-based science education (Cavanagh, 2004; National Research Council, 1996). According to Anderson and Helms (2002), NCLB emphasizes state accountability based upon teaching methods that work. The NSES suggest that science educators adopt teaching methods that emphasize strategies that center on student centered learning activities such as laboratory investigations and inquiry-based strategies.

Teacher education programs. Having pre-service teachers analyze curriculum materials that are specific to their teaching content would help to identify activities that are didactic in nature. The pre-service teacher could read and analyze all of the supporting material that is provided by the textbook publisher and identify those activities, both formal and informal, that are didactic in nature in order to convert them to a more inquiry learning approach. Cookbook laboratory exercises that are prevalent in all textbook-linked lab manuals could be converted into strategies that involve inquiry-based, cooperative learning, and conceptual change activities.

For example, in all of the sciences, regardless of level, there are activities that center around the concept of density. The materials provided by the publisher describe what density is, list the materials required to complete the activity, list the procedures to follow in order to complete the activity, and in most cases, provide examples of how to carry out the calculations, record the data, present the results, and draw a conclusion. This is a linear, A to B, and goal-oriented approach to the concept of density. Given this information, the pre-service teacher would be asked to convert this one activity into the three different approaches of inquiry: cooperative learning, and conceptual change teaching and learning strategies.

Experienced teachers. Support for experienced teacher learning is more effective when it is linked to the teachers' classroom context. This learning develops in cycles over extended periods of time (Cohen & Hill, 1998; Edwards, 1996). What this suggests is that experienced teachers need time and opportunity to build new beliefs and knowledge about teaching and learning.

There exists an opportunity that arises once every five to seven years that could be used to provide the classroom teacher with the necessary tools and information to adapt and adopt more holistic teaching methods. Every five to seven years teachers must adopt a new textbook and along with the textbook, new ancillary teaching materials. When the research for this study was underway, the Science Department that the three science teachers belonged to, was just ending the textbook adoption phase. The science department at this school was designed like a wheel with the Department Chairperson located in the center, which was a large open space. The classrooms extended out from this space like spokes in a wheel. The center space was cluttered with the materials provided by the publishers. In order to walk through this space, a person had to navigate around hundreds of books that were stacked, by category, in piles several feet high. Each classroom had adoption materials stuffed on top of shelves, under desks, outside of doorways, and stacked in the back or along the sides of the rooms. It is an impossible task for the teachers to review, in depth, and in an independent manner, all of these materials for more holistic approaches to teaching strategies. In addition, science textbooks revolve around the teaching of content. Very little space is devoted to specific strategies, didactic or holistic. Thus, teachers spend their time reviewing the materials in the context of curriculum rather than the context of strategy. In two case studies involving mathematics teachers and their use of curriculum materials, Collopy (2003) concluded that curriculum materials designed to convey both subject matter and pedagogical content may facilitate teacher learning.

During the adoption phase, the establishment of a partnership between the local schools and teacher education programs which encourage experienced teachers to explore less didactic and more holistic approaches, would lead to a better understanding of scientific principles. Content specific in-service presentations that helped the classroom teacher to critically analyze the textbooks and all ancillary materials for inquiry-based, cooperative learning, and conceptual change learning opportunities, would help assist teachers in building new beliefs structures about knowledge and learning.

Science educators must conduct research that identifies the most critical aspects of how to combine the holistic approach to teaching and learning (as per the directives of the NRC), with the more didactic approaches that science teachers believe are required to cover all of the necessary material. The national standards call for teaching and learning strategies that involve markedly different roles for students and teachers. These strategies cannot be studied or evaluated in isolation because the implementations of these strategies are influenced by various constraints placed upon classroom teachers. These constraints are directly related to the beliefs held by teachers, the environment of the classroom, and gateway testing.

Anderson, Greeno, Reder, and Simon (2000), wrote, “Educational innovations should be informed by the available scientific knowledge base and should be evaluated and analyzed with rigorous research methods; the advance of education requires continued research efforts on a large scale” (pg.13). They point out that it will to be a balance between the philosophy based upon individual learning, and the philosophy based upon social learning, that will ultimately advance education. This may be true, unless these philosophies about learning are converted into specific, content based strategies that science teachers not only can use, but also find valuable, didactic strategies will dominate.

.

References

Aguirre, J. M., Haggerty, S. M., & Linder, C. J. (1990). Student-teachers' conceptions of science, teaching and learning: A case study in preservice science education. *International Journal of Science Education, 12(4),* 381-390.

Airasian, P. W., & Walsh, M. E. (1998). *Readings in educational psychology.* Boston: Allyn & Bacon.

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher, 25(4), 5-11*

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Radical constructivism and cognitive psychology. In D. Ravitch (Ed.) *Brookings Papers on Educational Policy* (pp. 227-255). District of Columbia: Brookings Institution.

Anderson, K. E. (1950). The teachers of science in a representative sampling of Minnesota schools. *Science Education, 34(1),* 57-66

Anderson, O. (1997). A neurocognitive perspective on current learning theory and science instructional strategies. *Science Education, 81*, 67-89.

Anfara, V. A., Brown, K. M., & Mangione, T. L. (2002). Qualitative analysis on stage: Making the research process more public. *Educational Researcher, 31(7),* 28-38.

Appelton, K., & Asoko, H. (1996). A case study of a teacher's progress toward using a constructivist view of learning to inform teaching in elementary science. *Science Education, 80(2),* 165-180.

Arnold, D. E. (2002). Block schedule and traditional schedule achievement: A comparison. *NASSP, 86(630),* 42-53.

Bacon, A. (1995). The teacher's perspective on accountability. *Canadian Journal of Education, 20(1)*, 85-91.

Bahktin, M. M. (1984). *Problem of Dostoevsky's poetics*. Minneapolis, MN: University of Minnesota Press.

Beck, J., Czerniak, C. M., & Lumpe, A. T. (2000). An exploratory study of teacher's beliefs
regarding the implementation of constructivism in their classrooms. *Journal of Research in Science Education, 11(4)*, 323-343.

Behnke, F. L. (1961). Reactions of scientists and science teachers to statements bearing on certain aspects of science and science teaching. *School Science and Mathematics, 61*, 193-207.

Bell, J. (1999). *Doing your research project: A guide for the first time researchers in education and social science*. Philadelphia, PA: Open University Press.

Benton-Kupper, J. (1999). Teaching in the block: Perceptions from within. *The High School Journal, 83(1),* 26-34.

Best, J. W. & Kahn, J. V. (2002). Research in education (9th ed). Boston: Allyn & Bacon.

Bentley, M. L. (1999). Constructivism as a referent for reforming science education. In M. Larochelle, N. Bednarz, & J. Garrison (Eds.), *Constructivism and education*. Cambridge: Cambridge University press.

Black, S. (1998). Learning on the block schedule. *American School Board Journal, 185(1),* 32-34.

Bramsford, J. D., Brown, A. L., & Cocking, R. D. (2001). How people learn: Brain, mind, experience and school. *Contemporary Psychology, 46(6),* 570-572.

Brand, B. R., & Glasson, G. E. (2003). Crossing cultural borders into science teaching: Early life experiences, racial and ethnic identities, and beliefs about diversity. *Journal of Research in Science Teaching*, in press.

Bredo, E. (2000). Reconsidering social constructivism: The relevance of George Herbert Meade's Interactionism. In D. C. Phillips (Ed.), *Constructivism in education. Opinions and second opinions on controversial issues.* Chicago: University of Chicago Press.

Brett, M. (1996). Teaching extended class periods. *Social Education, 60(2),* 77-79.

Brickhouse, N. W. (1989). The teaching of the philosophy of science in secondary classrooms: Case studies of teachers' personal theories. *International Journal of Science Education, 11(4*), 437-449.

Brooks, J. G., & Brooks, M. G. (1993). *The case for constructivism in the classrooms*. Alexandria, VA: Association For Supervision and Curriculum Development.

Brown, H. I. (1997). Perception, theory and commitment: The new philosophy of science. Chicago and London: The University of Chicago Press.

Bugaj, S. J. (1999). Teacher/administrator perceptions of intensive scheduling: Implications for secondary gifted students. *NASSP Bulletin, 83(610),* 62-69.

Calvery, R., Sheets, G., & Bell, D. (1999*). Modified block scheduling: An assessment of teacher's and student's perception*. Paper presented at the meeting of the Mid-South Educational Research Association, Point Clear, AL.

Campbell, B., & Ramsden, J. (1996). The perceived value of classroom research as an element of an initial teacher education course for science teachers. In G. Welford, J. Osborne, & P. Scott (Eds.), *Research in science education in Europe* (p. 351-355). London, UK: Falmer.

Canady, R. L., & Rettig, M. (1995). *Block scheduling: A catalyst for change in high schools.* New Jersey: Eye On Education.

Carroll, J. M. (1994). Organizing time to support learning. *School Administrator, 51(3),* 26-33.

Cobb, P., & Yackel, E. (1996). Constructivist, emergent, and sociocultural perspectives in the context of developmental research. *Educational Psychologist, 31(3/4),* 175-190.

Cobern, W. W. (1996). Worldview theory and conceptual change in science education. *Science Education*, 80(5), 579-610.

Cochran, K. F. (1997). Pedagogical content knowledge: Teacher's integration of subject matter, pedagogy, and student learning. *National Association of Research in Science Teaching*, No. 9702, 1-6.

Creswell, J. W. (1998). Qualitative Inquiry and research design: Choosing among five traditions. London: Sage.

Cronin-Jones, L. L. (1991). Science teachers beliefs and their influence on curriculum implementation: Two case studies. *Journal of Research in Science Teaching, 28(3),* 235-250.

Denzin, N. K., & Lincoln, Y. S. (2000). Handbook of qualitative research (2nd ed.). London: Sage

Derry, S. J. (1996). Cognitive schema theory in the constructivist debate. *Educational Psychologist, 31(3/4),* 163-174

Doolittle, P. E., & Camp, W. G. (1999). Constructivism: The career and technical education perspective. *Journal of Vocational and Technical Education, 16(1). 1-22. Retrieved from http://scholar.lib.vt.edu/ejournals/JVTE/v16n1/doolittle.html.*

Doolittle, P. E., & Hicks, D. (2003). Constructivism as a theoretical foundation for the use of technology in social studies. *Theory & Research in Social Education, 31(1),* 71-103.

Duschl, R. A., & Gitmer, D. H. (1991). Epistemological perspectives on conceptual change: Implications for educational practice. *Journal of Research in Science Teaching, 28(9),* 839-858.

Duschl, R. A., & Wright, E. (1989). A case study of high school teachers' decision making models for planning and teaching science. *Journal of Research in Science Teaching, 26(6),* 467-501.

Ebenezer, J. V., & Erickson, G. L. (1996). Chemistry students' conception of solubility: A Phenomenography. *Science Education, 80(2),* 181-201.

Eick, C. J., & Reed, C. J. (2002). What makes an inquiry-oriented science teacher? The influence of learning histories on student teacher role identity and practice. Science Teacher

Eineder, D. V., & Bishop, H. L. (1997). Block scheduling the high school: The effects on achievement, behavior, and student-teacher relationships. *NASSP, 81(589),* 45-54.

Fischer, H. E., & Von Aufschnaiter, S. (1993). Development of meaning during physics instruction: Case studies in view of the paradigm of constructivism. *Science Education, 77(2),* 153-168.

Fraenkel, J. R., & Wallen, N. E. (1990). *How to Design and Evaluate Research in Education*. New York: McGraw-Hill.

Freeman, C., & Maruyama, G. (1995). *Report study of the four-period schedule for Anoka-Hennepin District No.11.* University of Minnesota, Center for Applied research and Educational Improvement.

Gallagher, J. J. (1991). Prospective and practicing secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education, 75(1),* 121-133.

Garrison, J. (1986). Some principles of postpositivistic philosophy of science. *Educational Researcher, 15(9),* 12-18.

Garrison, J., Bentley, M. L., Fleury, S. C., Larochelle, M., & Desautels, J. (1999). *Critical-constructivism, science education, and teachers' epistemological development*. Paper presented at the Science and Culture Conference, the Fifth International Conference on the History and Philosophy of Science in Science teaching. University of Pavia.

George, M. A. (1997). I'd never go back: Teachers talk about block scheduling. *American Secondary Education, 25(3),* 23-31.

Gergen, K. J. (1985). The social constructionist movement in modern psychology. *American Psychologist, 40(3),* 266-275.

Gergen, K. J. (1995). Social constructivism and educational practices. In L. P. Steffe & J. Gale (Eds.), *Constructivism in Education* (pp. 17-39). Hillsdale, N.J: Lawrence Earlbaum.

Germann, P. J. (1991). Developing science skills through directed inquiry. *The American Biology Teacher, 53(4)*, 243-247.

Glasson, G. E., & Lalik, R. (1993). Reinterpreting the learning cycle from a social constructivist perspective: A qualitative study of teachers' beliefs and practices. *Journal of Research in Science Teaching, 30(2),* 187-207.

Golinski, J. (1998). *Making natural knowledge. Constructivism and the history of science.* London: Cambridge University Press

Grandy, R. E. (1997). Constructivism and objectivity: Disentangling metaphysics from pedagogy. *Science and Education, 6,* 43-53.

Gruber, C. D., & Onwuegbuzie, A. J. (2001). Effects of block scheduling on academic acheivement among high school students. *The High School Journal, 84(4),* 32-42

Hackman, D. G., & Schmitt, D. (1997). Strategies for teaching in a block-of-time schedule. *NASSP Bulletin, 81*, 1-9.

Hamdy, M., & Urich, T. (1998). Perceptions of teachers in south Florida toward block scheduling. *NASSP Bulletin, 82(596),* 79-82.

Haney, J. J., Czerniak, C. M., & Lumpe, A. T. (1996). Teacher beliefs and intentions regarding the implementation of science education reform standards. *Journal of Research in Science Teaching, 33(9), 971-993.*

Hartman, H. J., & Glasgow, N. A. (2002). *Tips for the science teacher: Research-based strategies to help students learn.* Thousand Oaks, CA: Corwin Press.

Hendry, G. D. (1996). Constructivism and educational practice. *Australian Journal of Education, 40(1),* 19-45.

Hess, C., Wronkovich, M., & Robinson, J. (1999). Measured outcomes of learning under block scheduling. *NASSP*, 83(611), 87-95.

Hewson, P. W., & Hewson, M. G. (1988). An appropriate conception of teaching science: A view from studies of science learning. *Science Education, 72(5),* 597-614.

Hodson, D. (1993). Philosophic stance of secondary school science teachers, curriculum experiences, and children's understanding of science: Some preliminary findings. *Interchange, 24(1),* 41-52

Hottenstein, D. S. (1998). *Intensive scheduling: Restructuring America's secondary schools through time management*. Thousand Oaks, Ca: Corwin Press.

Hottenstein, D. S., & Malatesta, C. (1993). Putting a school in gear with intensive scheduling. The *High School Journal*, 2, 28-29.

Hurley, J. C. (1997). The 4 X 4 block scheduling model: What do students have to say about it? *NASSP, 81(593),* 64-72.

John-Steiner, V., & Mahn, H. (1996). Sociocultural approaches to learning and development: A Vygotskian framework. *Educational Psychologist, 31(3/4),* 191-206.

Jonassen, D. H. (1992). Evaluating constructivist learning. In Duffy, T. M., & Jonassen, D. H. (Eds.), *Constructivism and the technology of education*. Hillsdate, NJ: Erlbaum.

Kennedy, M. (1991). Policy issues in teacher education. *Phi Delta Kappan*, May 1991, 659-665.

Keys, C. W. & Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science teaching*, 38(6), 631-645

King, B. B. (1991). Beginning teachers' knowledge of and attitudes toward history and philosophy of science. *Science Education, 75(1),* 135-141.

Kramer, S. L. (1997). What we know about block scheduling and its effect on math instruction, part I. *NASSP, 81(587),* 69-82.

Kuhn, T. S. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Lawrence, W. W., & McPherson, D. D. (2000). *A comparative study of block scheduling and traditional scheduling on academic achievement*. Journal of Instructional Psychology, 27(3), 178-182.

Lawrenz, F. (1990). Science teaching techniques associated with higher-order thinking skills. *Journal of Research in Science Teaching, 27(9),* 83-847.

Lederman, N. (1990). Improving students' understanding of the nature of science. *National Association for Research in Science Teaching, No. 9004*, 1-2.

Lederman, N. G. (1992). Students and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29(4),* 331-359.

Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of Research in Science teaching, 38(3),* 296-318.

Letts, W. J., Bailey, B. L., & Scantlebury, K. (1997). Preparing science teachers in an era of reform: Practitioners' perspectives of methods courses. *School of Science and Mathematics, 97(4),* 192-199.

Lofty, J. (2000). Reforming time: Timescapes and rhythms of learning. In Patricia Gandara (Ed.), *The Dimensions of Time and the Challenge of School.*New York: State University of New York.

Lord, T. R. (1994). Using cooperative learning in the teaching of high school biology. *The American Biology teacher, 56(5)*, 280-284.

Lorsbach, A., & Tobin, K. (1997). Constructivism as a referent for science teaching. *National Association for Research in Science Teaching,*

Louden, C. K., & Hounshell, P. B. (2000). Student-centered scheduling. *Science Teacher, 65*, 51-53.

Lumpe, A. T., Haney, J. J., & Czerniak, C. M. (1998). Science teacher beliefs and intentions regarding the use of cooperative learning. *Journal of Research in Science Teaching, 98(3),* 123-135.

Lumpe, A. T., Haney, J. J., & Czerniak, C. M. (2000). Assessing teacher beliefs about their science teaching context. *Journal of Research in Science Teaching, 37(3),* 275-292.

Mayer, R. E. (1996). Learners as information processors: Legacies and limitations of educational psychology's second metaphor. *Educational Psychology, 31(4*), 151-162.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco, CA: Jossey-Bass

Mertens, D. M. (1998). Research methods in education and psychology: Integrating diversity with quantitative & qualitative approaches. London: Sage.

Miles, M. B., & Huberman, A. M. (1994). Qualitative Data Analysis: An expanded source book (2^{nd} ed.). London: Sage.

Miller, P. E. (1963). A comparison of the abilities of secondary teachers and students of biology to understand science. *Iowa Academy of Science*, 70, 510-513.

Munby, H. (1984). A qualitative approach to the study of a teacher's beliefs. *Journal of Research in Science Teaching, 21(1),* 27-38.

National Research Council (1996*). National science education standards.* District of Columbia, D.C: National Academy of Science.

National Science Teachers Association (1992). *The content core: A guide for curriculum designers.* District of Columbia, D.C: The National Science Teachers Association.

Naylor, S., & Keogh, B. (1999). Constructivism in classroom: Theory into practice. *Journal of Science Teacher Education*, *10(2)*, 93-108.

Niaz, M. (1995). Cognitive conflict as a teaching strategy in solving chemistry problems: A dialectic-constructivist perspective. *Journal of Research in Science Teaching, 32(9),* 959-970.

Nola, R. (1997). Constructivism in science and science education: A philosophical critique. *Science and Education, 6,* 55-83.

North Carolina State Department of Public Instruction. (1997, May). *Block scheduled high school achievement: Part II. Comparison of End-of-Course test scores for blocked and nonblocked high schools* (1993 through 1996). Raleigh, NC.

Nott, M., & Wellington, J. (1998). Eliciting, interpreting and developing teachers' understanding of the nature of science. *Science and Education, 7*, 579-594.

Office of Program Evaluation. (1996, October). *4 X 4 Block Schedule Evaluation*. Chesapeake, VA.

Ohlsson, S. (1993). Abstract schemas. *Educational Psychologist, 46*, p. 51-66.

Orton, R. E. (1996). How can teacher beliefs about student learning be justified? *Curriculum Inquiry, 26(2),* 133-148.

Osborne, J. F. (1996). Beyond constructivism. *Science Education, 80(1),* 53-82.

Payne, D. A., & Jordan, M. M. (1996). The evaluation of a high school block schedule: Convergence of teacher and student data. *American Secondary Education, 25(2),* 16-19.

Pekarek, R., Krockover, K., & Shepardson, D. (1996). The research-practice gap in science education. *Journal of Research in Science Teaching, 33(2),* 111-113

Phillips, D. C.,(1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher, 24(7),* 5-12.

Pines, L. A., & West, L. H. T. (1986). Conceptual understanding and science learning: An interpretation of research within a source-of-knowledge framework. *Science Education, 70(5),* 583-604.

Pisapia, J., & Westfall, A. L. (1997). *Alternative high school scheduling. Student achievement and behavior.* The Metropolitan Educational Research Consortium. Richmond, VA

Pitman, A., & Romberg, T. (2000). Teacher's use of time in a period of change. In Patricia Gandara (Ed.), *The Dimensions of Time and the Challenge of School Reform*. New York: State University of New York.

Pliska, A., Harmston, M. T., & Hackman, D. G. (2001). The relationship between secondary school scheduling models and ACT assessment scores. *NASSP, 85(625)*, 42-55.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accomodations of a scientific conception: Toward a theory of conceptual change. *Science Education, 66,* 211-227.

Powell, R. (1994). From field science to classroom science: A case study of constrained emergence in a second-career science teacher. *Journal of Research in Science Teaching, 31(3),* 273-291.

Prawat, R. S., & Floden, Robert E. (1994). Philosophical perspectives on constructivist views of learning. *Educational Psychology, 29(1),* 37-48.

Reynold, R. E., Sinatra, G. M., & Jetton, T. L. (1996). Views of knowledge acquisition and representation: A continuum from experience-centered to mind-centered. *Educational Psychologist, 31(2),* p. 93-105.

Richardson, V. (1997). *Constructivist teacher education. Building a world of new understandings.* London & Washington, D.C: The Falmer Press.

Ritchie, S. M., Tobin, K, & Hooks, K. S. (1996). Teaching referents and the warrants used to test the viability of students' mental models: Is there a link? *Journal of Research in Science Teaching, 34(3),* 223-238.

Robbins, P., Gregory, G., & Herndon, L. E. (2000). *Thinking inside the block*. Corwin Press: Thousand Oaks, CA.

Rodriquez, A. J. (1997). The dangerous discourse of invisibility: A critique of the National Research Council's National Science Education Standards. *The Journal of Research in Science Teaching, 34(1)*, 19-37.

Rossman, G. B., & Rallis, S. F. (2001). *Learning in the Field. An Introduction to Qualitative Research (2nd ed.)*. London: Sage.

Russell, T. (1993). Learning to teach science: Constructivism, reflection, and learning from experience. In K. Tobin (Ed.), *The practice of constructivis in science education*, p. 247-258. Hillsdale, NJ: Lawerence Erlbaum Associates.

Rutherford, F. J., & Ahlgren, A. (1992). *Science for all Americans.* New York: Oxford University Press.

Salvaterra, M., & Adams, D. C. (1996). Teacher perceptions of intensive time scheduling in four high schools. *American Secondary Education, 24(4),* 23-29.

Sanchez, G, & Valcarcel, V. M. (1999). Science teacher's views and practicies in planning for teaching. *Journal of Research in Science Teaching, 36(4),* 495-513.

Schroth, G., & Dixon, J. (1996). The effects of block scheduling on student performance. *International Journal of Educational Reform, 5(4),* 472-476.

Skrobarcek, S. A., Chang, H. M., Thompson, J. J., Atteberry, R. W., Westbrook, R., & Manus, A. (1997). Collaberation for instructional improvement: Analyzing the academic impact of a block scheduling plan. *NASSP, 81(589),* 104-111.

Seidman, I. (1998). *Interviewing as Qualitative Research* (2nd ed.). New York: Teachers College.

Shapiro, B. L. (1996). A case study of change in elementary student teacher thinking during an independent investigation in science: Learning about the "face of science that does not yet know." *Science Education, 80(5).* 535-560.

Shortt, T. L., & Thayer, Y.V. (1999). *The complete handbook of block scheduling: Success for students and teachers through efficient use of time and human resources*. Technos Press: Bloomington, IN.

Smith, E. (1997). Constructing the individual knower: A review of radical constructivism. *Journal of Research in Mathematics Education, 28(1),* 106-112.

Smith, P. S., Banilower, E. R., McMahon, K. C., & Weiss, I. R. (2002). *The national survey of science and mathematics education:Trends from 1977 to 2000.* Retrieved September 10, 2002, from http://2000survey.horizon-research.com/reports/trends.php

Smith, E. L, Blakeslee, T. D., & Anderson, C. W. (1993). Teaching strategies associated with conceptual change learning in science. *Journal of Research in Science Teaching, 30(2),* 111-126.

Smith, M. L. & Fey, P. (2000). Validity and accountability in high-stakes testing. *Journal of Teacher Education, 51(5)*, 334-344.

Sowell, E. J. (2001). Educational research: An integrative introduction. Boston: McGraw-Hill.

Spraque, D., & Dede, C. (1999). Constructivism in the classroom: If I teach this way, am I doing my job? *Learning & Leading with Technology, 27(1),* 6-17.

Staunton, J. (1997). A study of teacher beliefs on the efficacy of block scheduling. *NASSP, 81*(588), 73-80.

Staver, J. R. (1998). Constructivism: Sound theory for explicating the practice of science and science teaching. *Journal of Research in Science Teaching, 35*(5), 501-520.

Stofflett, R. T., & Stoddart, T. (1994). The ability to understand and use conceptual change pedagogy as a function of prior content learning experience. *Journal of Research in Science Teaching, 31(1),* 31-51.

Stokes, L. C., & Wilson, J. W. (2000). A longitudinal study of teachers' perceptions of the effectiveness of block versus traditional scheduling. *NASSP Bulletin, 84(619),* 90-99.

Taylor, P. C. S., Fraser, B. J., & White, L. R. (1994). *A classroom environment questionnaire for science educators interested in the constructivist reform of school science.* A paper presented at the annual meeting of the National Association for Research in Science Teaching, Anaheim, CA.

Texas Education Agency Office of Policy Planning and Research. (1999, September*). Block scheduling in Texas high schools.* Division of Research and Evaluation. TX.

Thorndike, E. L. (1932). The fundamentals of learning. New York: Teachers College Press.

Tobin, K. (1990). *Conceptualizing teaching roles in terms of metaphors and belief sets*. Paper presented at the annual meeting of the American Educational Research Association, Boston, MA.

U.S. Department of Education (1991). *America 2000: An education strategy*. Superintendent of Documents, United States Government Printing Office: District of Columbia, D.C.

Veal, W. R., & Flinders, D. J. (2001). How block scheduling reform effects classroom practice. *The High School Journal, 84(4)*, 21-31.

Von Glasersfeld, E. (1992). *Aspects of radical constructivism and it's educational recommendations.* Paper presented at the 7th meeting of the International Congress of Mathematics Education, Quebec, Ontario.

Von Glassersfeld, E. (1995). A constructivist approach to teaching. In L.P. Steffe & J. Gale (Eds.), Constructivism in education (pp. 3-16). Hillsdale, NJ: Erlbaum.

Wallen N. E., & Fraenkel, J. R. (2001). Educational research: A guide to the process (2nd ed.). London: Lawrence Erlbaum Associates.

Wildy, H., & Wallace, J. (1995). Understanding teaching or teaching for understanding: Alternative frameworks for science classrooms. *Journal of Research in Science Teaching, 32(2),* 143-156.

Wilson, J. W., & Stokes, L. C. (1999). Teachers' perceptions of the advantages and measurable outcomes of the 4 x 4 block scheduling design. *The High School Journal, 83(1),* 44-54.

Wilson, J. W., & Stokes, L. C. (1999). A study of teacher perceptions of the effectiveness and critical factors in implementing and maintaining block scheduling. *The High School Journal, 83(1),* 35-43.

Winn, D. D., Menlove, R., & Zsiray, S. (1997). An invitation to innovation: Rethinking the high school day. *NASSP Bulletin, 81,* 10-18.

Yeany, R. H., & Padilla, M. J. (1986). Training teachers to utilize better teaching strategies: A research synthesis. *Journal of Research in Science Teaching, 23(2),* 85-95.

Zeidler, D. L., & Lederman, N. G. (1989). The effects of teacher's language on students' conceptions of the nature of science. *Journal of Research in Science Teaching, 26(9),* 771-783.

Appendix A

Data Points

Carl

DAY	TEACHER PURPOSE AND GOALS	CLASSROOM OBSERVATIONS	DOCUMENTS COLLECTED	RESEARCHER INTERPRETATIONS
1	Review material as prep for test on chapters 12, 13, and 14. (Evolution)	8:35-8:45: Guided practice using review questions from textbook. Allowed students to review previous worksheets, homework assignments, warm-ups in prep for open note quiz. 8:46-9:00: Open note quiz on movie *Inherit the Wind.* Students graded their own quiz as Carl called on specific students to report their answers. 9:01-9:25: Lecture based direct instruction covering topics that would be on the test. Notes presented in bullet form on the overhead projector. Picked students at random to answer questions. 9:25-9:30: Break 9:30 to end of period: Students completed the test.	Test, quiz.	Students were engaged throughout the period. Carl asked questions of most students to keep them active. Questions were directed to specific students. No choral responses. Little to no group work. When students were studying for quiz, or completing the worksheet, they directed their questions to Carl. Students were not discouraged from asking each other questions, but given the opportunity, they most always asked the teacher
2	Review for Midterm Exam. Log on to www.glencoe.com (textbook publisher page) to take practice tests.	The first half of the block, Carl provided previous chapter and unit tests so that the students could review for the midterm. The last half of the block, the students were taken to the computer lab so that they could log on to the publisher's site to take practice tests based upon textbook content.		While the students were on the computers, Carl walked around making sure that they were completing the assignment correctly and answered any questions. At one point he approached me to say that he really liked this site because it was different than just having the students sit in class, reviewing the "same old material in the same old way."
3	Introduce Evolution and Natural Selection	10:10-10:20: Warm-ups. Students were directed to page 256 in their textbooks where they were to complete a series of questions based upon	Copy of page 256; Peppered Moth Activity	Students worked individually on the warm-up exercise. Students receive an A on the

		previous class material. 10:20-10:30: Went over answers to warm-ups. Asked specific students specific questions. 10:30-10:55: Direct instruction. Notes presented on overhead in bullet format. Students copied down notes in their notebooks. 10:56-11:10: Handed back Peppered Moth activity and discussed it with the class. Used students examples to illustrate what was right and wrong about the activity. 11:10-11:35: Introduced the “Scopes Monkey Trial.” Using overhead notes in bulleted form. Informed students that they were going to be viewing a movie called *Inherit the Wind.* Carl talked about the background to the movie. Informed students that there would be a quiz at the end of the movie. 11:35- end of period: Students watched the movie		warm-ups by submitting the completed assignments. Some students not engaged. (heads down on desks; books not open; no writing). Some students slept through the movie.
4	To show the students how evolution affects speciation: starting with the simplest life forms and moving through more complex ones.	10:15-10:40: Warm-ups. Students were directed to draw a picture of a virus using colored pencils to label all parts. 10:40-11:00: Direct instruction using overhead notes (bulleted form): Drawings of viruses and bacteria, and questioning students about the drawings on the overhead. Students were asked to define terms. Directed students to picture in textbook and asked questions to specific students concerning the picture. 11:05-11:25: Students told that they could receive extra credit if they brought in a sample of pond water for the laboratory exercise that they were going to do the next day. A hand-out of	Pond water lab hand-out.	Students worked individually on the warm-ups. A few students did converse a bit during the exercise and this was allowed by Carl. It was obvious that the students had not ever heard of some of the terms associated with the drawings. Carl was trying to get them to associate the terms with everyday experiences. He was trying to get them to see the relationship between terms, vocabulary, and structure.

		the "Pond Water" lab was given to each student and a brief discussion of the procedures took place. 11:25-11:40: A video was shown to the class about viruses and bacteria.		
5	To have the students learn how to use a microscope in order to isolate, view, identify, and categorize "life in a pond."	8:35-8:55: Carl and the students set up the necessary equipment for the lab. Problems emerged when the outlets for some of the microscopes had no power. This was solved by using an adapter so that students could tap into a common outlet. 8:55-10:05: Students used the samples of pond water that were brought in to make slides and view the life in the droplets. Students worked in pairs. The pairs were chosen by the students and not assigned by Carl. Carl walked around the room and assisted the students with any problems that came up. The most common problem was getting the light source on the microscope to work properly. Each student had a written guide that they used to help them proceed through the lab. This helped them to locate, identify, and draw all the different life forms that they saw. When this guide was completed, it was submitted to Carl at the end of the period.		Students worked in pairs while Carl walked the room solving mostly technical problems. Students were engaged and enjoyed looking at all of the life forms in the pond water. Many "Wow" and "come look at this" heard through-out the room. Pairs of students would go over to view other students' slides if something odd or unique was captured under the lens. Carl would answer most of their questions concerning the actual use of the microscope but would normally answer a question about theory with another question. Attempting to get the students to answer their own questions.

Appendix B

Data Points

Rob

DAY	TEACHER PURPOSE AND GOALS	CLASSROOM OBSERVATIONS	DOCUMENTS COLLECTED	RESEARCHER INTERPRETATIONS
1	To describe how plate techtonics influences the Earth	8:28-8:38 Students take out review sheet from chapter 10 which are stored in individual student folders at the back of the room. Rob walks around room addressing individual student questions. Rob reminds students that the test on chapter 10 is tomorrow and that they should complete the review sheet in a timely fashion. He passes out progress reports to the students. 8:38-8:55 Rob stands in the center of the room and goes over specific questions on the review sheet. He reads while students write. Rob defines each term and has the students write them down. All questions from Rob are choral response based questions. 8:57-9:20 Rob presents notes on the overhead as well as handing out a packet that is a copy of what's on the overhead. The notes are taken directly from the textbook and are written in outline form. He reads them to the students and the students copy them down. 9:21-9:40 Rob directed students to turn to page 308 in their textbook and copy the diagram into their notes. As they did this, he walked around checking on	Worksheet from chapter 10	Each student has an assigned folder in the back of the class that has materials in it such as returned and graded work, unfinished worksheets, etc. Students, upon entering the class are directed to the folder to get out whatever work that needs to be completed. Students are seated in groups of three and four around separate tables. Students are prohibited from talking while they work at their seats. Cold. During the note taking, no questions were directed at the students nor was any feedback asked for by the teacher. The interactions between Rob and the students was stiff and uncomfortable. The only words exchanged between teacher and students were directly related to the task at hand.

		progress. 9:41-10:05 Rob directed students to page 304 in the textbook to complete a word search activity. Students worked on this individually until the bell rang.		
2	Have students review for mid-term exam	11:45-12:00 Rob writes directions on the whiteboard concerning the use of the computer lab. “Achieve an 80% or better.” He directs students to log on to the publisher’s web site and complete the computer generated quizzes and tests. Students are to keep taking each quiz and test until they achieve a score of 80% or better then move on to the next assessment 12:10-1:15 The students are assigned a computer. Each student completes each task on the site individually. Rob occasionally walks around and looks over the students shoulder. Rob points out to students that this exercise will also help them for the SOL tests coming up at the end of the semester.		Students work quietly at their stations. Very little interaction between students and teacher. A student at one computer makes a joke about something that she sees on the screen. No reaction from Rob.
3	Continue review for exam	8:30-8:40 Reviews with students how to log on and complete the assessments at the Glencoe site. Tells students that the computer lab is in-use this morning so they will have to use the computers in the media center. 8:40-9:34 Students complete assignments while working at individual stations in the media center. Rob walks around checking on their progress. 9:35-10:15 Students are		At one point, Rob approached me to say that he likes to do these kinds of activities because it “gives the students many opportunities to succeed on an individual basis.”

		back in the classroom where they have accessed their folders. Rob has directed them to review past tests and quizzes so that they will know what to expect on the midterm exam. Students work individually. Very few questions are directed toward the teacher.		
4	To assess their knowledge of plate techtonics and to explain and describe volcanoes and earthquakes	8:30-8:45 Review for chapter test. Students looked over notes and directed questions to Rob. 8:45-9:15 Students took test. 9:15-9:50 Rob lectured using pre-typed notes which were displayed on the overhead and handed out to students. The notes were in outline form taken directly from the textbook. Bulleted as talking points. Some students followed the notes in the packet while others copied them down into notebooks as Rob lectured. 9:50-10:10 Rob directed students to a specific page in their textbook which had a diagram showing the stages of magma formation. Students were directed to copy the diagram directly into their notes and to label each part.		Very little interactions between teacher and student except for direct instruction. No interaction between student and student.
5	To show how shifts in the Earth's plates affects the diversity of life	8:15-8:30 Rob presents notes as a way to introduce a series of short videos that he has downloaded from the internet. Each video is about 15 minutes in length and covers a specific topic. 8:30-9:30 Students view videos that are projected on the whiteboard in class. At the end of each video, Rob		

		asks if there are any questions. A few students ask questions which Rob answers. 9:30-10:15 Rob directs students to specific pages in the textbook where they copy drawings into their notebooks. There is some student to student interaction: a student will look over to see what another student has drawn or written. Some discussion takes place. Rob closely monitors the discussion to make sure he is staying on topic.		

Appendix C

Data Points

Greg

DAY	TEACHER PURPOSE AND GOALS	CLASSROOM OBSERVATIONS	DOCUMENTS COLLECTED	RESEARCHER INTERPRETATIONS
1	Review terms associated with genetics and teach punet squares	1:58-2:25 Greg presents terms on overhead. He writes the notes as he presents them. Students take notes along with Greg. Many choral based and student specific based questions from Greg. "Why is that? And "Why do you think…? Student states that her uncle has sickle cell anemia. Greg uses that and connects to genetic heritage. He talks about his own family and genetics. Greg draws the punet square and has the students do a dihybrid cross. Once they finish the square, he has them look at each others work. 2:27-2:37 Presents an activity for the students to do. Greg guides them through the first few punet squares then tells them to work independently at their seats. He calls on students periodically to gauge progress. 2:38-3:25 Student directed activities. Students have the option to work individually, in pairs or in groups of three or four. Greg sat down at one table where a group of three students were having difficulties. He answers their questions but most often made the students solve the problems themselves.		Many student to student interactions encouraged during the lesson. Greg latched on to students prior experiences to relate to content. He also spent time talking about his own background. One student in particular was struggling with the concept. Greg, having tried to clear things up for 5 to 10 minutes, went to the back of the room and retrieved some items to help the student visualize the concept. Another student took the items and helped Greg to explain the ideas.

2	Review for midterm exam	10:15-10:25 Greg hands out a study guide. Greg reads questions from the guide and elicits choral responses from the students. 10:26-11:35 Broke the class up into five teams of three students to play Biology Jeopardy. Students have the opportunity to discuss the questions and come up with the answers as a group.	Pre-test	Students enjoyed this and the discussions that took place at each table were open. Each student in the group was allowed to voice their thoughts concerning the question and the answer.
3	Introduce the concepts of HIV Aids and how it relates to viral genetics	10:15-10:45 Direct instruction with notes on the overhead. Began with questions from Greg concerning what the students had heard about the disease aids, who gets it, and how it is transmitted. 10:45-11:15 Greg passes out worksheet with guiding questions. Informs the students that they are about to watch a movie/documentary about HIV AIDS and that they need to pay attention in order to answer some of the questions on the worksheet. 11:15-1:55 Students watch movie and take notes/answer questions on worksheet.		Many misconceptions. Greg: “Who gets AIDS?” Student: “Faggots.” Greg: “Is that true?” Class: various responses.
4	Review for chapter test	8:28-10:05 Greg hands out a pre-test that consisted of 150 multiple choice questions. Students are directed to use their notes, the textbook or each other to answer the questions. Most students chose to work together. Greg sat down at each table for a minimum of fifteen minutes in order to help students along.		Very little direct copying was noted. Most students participated in the discussion in order to come up with the correct answer.

Appendix D

Teacher Beliefs and Strategies

Carl

Section	Beliefs About Teaching	Beliefs About Learning	Observed Strategies	Influences on Strategies	Conflicts
Section 1	Teaching should revolve around the belief that students learn by visualizing words and then physically writing them down. This imprints the information directly on to their brains	Students learn through hard work. They learn better by being exposed to information over and over again and by *doing* things over and over again	Extremely organized. Pacing and curriculum guides are correlated to SOLs, days of the week, and content. Having the students complete laboratory assignments, worksheets, textbook assignments, and other activities that were geared toward a more independent or student centered approach.	His prior military experiences as a gunnery instructor. The military uses a show – do – have students do – show again approach to teaching. He has adopted this pedagogy into his own teaching style. Parents instilled in him the idea that learning was hard work.	
Section 2	The more hands-on activities that are implemented, the more self-discovery will occur. Varying teaching strategies so that students can learn content from different angles.	Knowledge is gained through self-discovery or the "Eureka effect." Students learn in many ways that compliment each other.	Divides the 90-minute block into three distinct time frames. Each time frame consists of a different teaching strategy or activity. The use of films to introduce concepts. Using the computer lab and the internet as "something different" in order to facilitate studying for tests and exams.	Block scheduling allows the teacher to vary instructional strategies. Block scheduling allows the student to draw conclusions from a completed concept.	

Section	Beliefs About teaching	Beliefs About Learning	Observed Strategies	Influences on Strategies	Conflicts
Section 3	The teacher should be a facilitator of knowledge and not the direct source.	Students learn better when the flow of knowledge goes from student to student more than from teacher to student	Laboratory activities in which students are paired. Used direct instruction, lectures, direct questioning, etc. to introduce concepts, but then moved towards more collaborative strategies, small group work for labs and textbook assignments, to reinforce concepts. First ten to fifteen minutes of class devoted to "warm-ups." Students work individually, at their seats, on a problem written on the blackboard or overhead.	In order to conduct cooperative learning and inquiry learning strategies, more emphasis must be placed on the quality of instruction instead of the quantity of instruction. The objectives established by the state do not allow for the necessary time to present hands-on or inquiry-based learning. The amount of content required to cover in order to cover the SOLs prevents the use of inquiry-based teaching strategies.	
Section 4	Students should learn how the system works: how to think like a scientist using the skills that science has adopted to solve problems.	Laboratory activities center around self discovery and the scientific method.	Activities that include students answering a question. Protocols based upon presentations, individual and group work, and laboratory activities devised to form conclusions	The military's show-do-they do-show again teaching methodology. This methodology is based upon a high degree of structure.	

Section	Beliefs About teaching	Beliefs About Learning	Observed Strategies	Influences on Strategies	Conflicts
Section 5	Block schedule provides more time than the traditional schedule and that the 4 x 4 block schedule is a much better teaching environment.	Learning is achieved under the block schedule better than the traditional schedule because it is a more effective use of time. Students can make connections, perform hands-on activities, and complete concepts in one sitting.	Divided the 90-minute block into 3 sections. Each section having its own teaching strategy. Presented notes on the overhead describing the various morphologies of bacteria and viruses. Began an activity that had students classify bacteria on the basis of morphology. This activity consisted of the students answering questions on a hand-out, looking up information in their textbook and drawing pictures. Direct questioning techniques asking the students to compare and contrast the various forms of bacteria and viruses. Preparation for the laboratory exercise the next day on bacteria and viruses.	Time to complete laboratory exercises, Block scheduling provides for a continuity of learning.	Between his belief that students learn better when teachers use a more holistic approach and his dependence on didactic strategies. Between the time to incorporate more inquiry-based strategies afforded by 4 x 4 block is negated by the amount of material required to cover in order to meet SOL objectives.

Appendix E

Teacher Beliefs and Strategies

Rob

Section	Beliefs About Teaching	Beliefs About Learning	Observed Strategies	Influences on Strategies	Conflicts
Section 1	Material should be presented using a variety of teaching strategies. The primary role of the teacher is to provide the students many opportunities to arrive at the correct solution to a problem on their own.	Students learn best when given a varied instructional approach. These approaches should be based upon visual, kinesthetic, and auditory activities with kinesthetic or hands-on being the most important.	The use of folders as an organizational tool for the students. All assignments are kept in the student's individual folder that is located at the back of the class. Presentation of digital videos. The use of the internet. No clear division of time within the 90-minute format.	Students need to work individually in order to become self-sufficient and independent learners. The use of the textbook to guide his daily strategies because the State mandates that the publishers incorporate SOL content within the textbook	Between his belief that students learn best when they achieve independence. Independence is achieved by hands-on learning strategies. Hands-on learning is strictly teacher directed.
Section 2	It is important for the teacher to set up a routine for the students to follow.	The interactions of students as they complete their activities, helps them to identify weaknesses Students learn better in smaller class sizes. The semester system reduces the number of students in each class. This allows for more individualized attention. .	Presentation of organized, algorithmic notes on overhead. Note packets handed to students before lectures. Use of word search activities in the textbook. Reading aloud of terms and definitions while students copy. Use of the textbook to illustrate graphs, pictures, and charts. Copied directly into the notes.	Basic level students have a difficult time absorbing all of the material presented in a 90-minute block. The level of the student has a large influence strategies. Students enrolled in basic courses need more structure and routine. This is important not only for learning but also for discipline.	

Section	Beliefs About Teaching	Beliefs About Learning	Observed Strategies	Influences on Strategies	Conflicts
Section 3	The 4 x 4 block schedule provides more time for the students to complete activities and that content can be covered in more depth. He can start and complete a concept in one class block.	There is a greater opportunity for students to learn under the 4 x 4 block schedule than under the traditional schedule.	Topic are introduced and then followed up with an activity in one class period.	More content can be covered in the year long classes than in the semester classes. Even though he has more time, the extra material that he has to cover because of SOL testing “eats up” the time he could be spending with individual students.	

Appendix F

Teacher Beliefs and Strategies

Greg

Section	Beliefs About Teaching	Beliefs About Learning	Observed Strategies	Influences on Strategies
Section 1	He believes that what he teaches is directly reflected onto the brains of his students	The ability for students to learn is directly linked to their ability to form mental pictures inside their heads. The formation of mental images is mediated by different pathways that are influence by personal experience	Greg divides the 90-minute block into two distinct sections. The first 45-minutes is devoted to direct instruction type strategies such as lecture. The second 45-minutes is for the hands-on, kinesthetic type activities such as completing worksheets in collaborative learning environments, working on homework, and completing laboratory exercises.	Since Greg classifies himself as a visual and kinesthetic learner, he adopts teaching strategies that are based upon these approaches.
Section 2	He doesn't just teach biology; he is teaching about life. He is teaching about how to live life and how to succeed at everything	It is important that teaching incorporate real world experiences into the classroom in order for students to make connections.	Greg used questions in order to determine and then to relate to the personal experiences of the students.	Prior experiences as a student influenced his beliefs. He found high school to be a "snap" and he did not have to work very hard to succeed. This affected his ability to do well in college and thus he sets high expectations for his students.

Section	Beliefs About Teaching	Beliefs About Learning	Observed Strategies	Influences on Strategies	Conflicts
Section 3	Greg believes that the 4 x 4 block schedule provides for a better teaching environment because it provides more time to complete laboratory exercises.	The 4 x 4 block schedule is better learning environments because students don't feel rushed and are thus able to absorb the material better.	Greg divides the 90-minute block into two distinct sections. The first 45-minutes is devoted to direct instruction type strategies such as lecture. The second 45-minutes is for the hands-on, kinesthetic type activities such as completing worksheets in collaborative learning environments, working on homework, and completing laboratory exercises.	He can cover the material in one day as opposed to dragging it out for two or three days thus making it boring for the students. Prior military service influences his teaching strategies. In the military, he saw how something was done and then he did it and then taught someone else how to do it.	

Appendix G

Lab Activity

Name ______________ Date ________ Class ________

Investigation **9-1**

Peppered Moth Survey

Introduction

Industrial melanism is the term used to describe the adaptation of an organism in response to a type of industrial pollution. One example of rapid industrial melanism occurred in the peppered moth, *Biston betularia*, in the area of Manchester, England, from 1845 to 1890.

Before the Industrial Revolution, the trees in the forest around Manchester were light grayish-green due to the presence of lichens on their trunks. Peppered moths, which lived in the area, were colored light with dark spots. Their coloring served as protective camouflage against predators, especially birds. As the Industrial Revolution progressed, the trees became covered with soot, turning the trunks dark. Over a period of 45 years, a change in the peppered moths took place.

In this investigation, you will observe the effects of industrial melanism in the peppered moths over the course of 10 years. You will then determine the relationship between the environmental changes and the color variation of the peppered moth by using research data to graph the effects of an environmental adaptation.

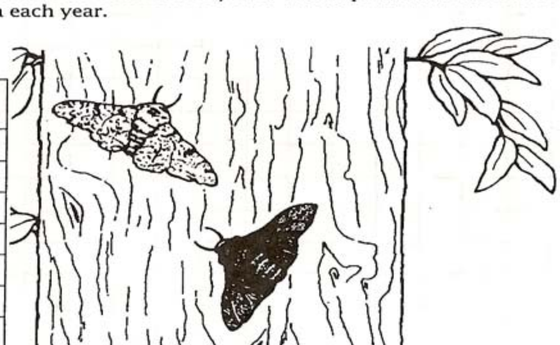
Materials

- Graph paper
- Colored pencils (2) (optional)

1. Table A contains data from a 10-year study of two varieties of the same species of peppered moth. The numbers represent moths captured in each of 10 consecutive years. The traps were located in the same area each year.

Table A

Year	Number of Light Moths Captured	Number of Dark Moths Captured
2	537	112
3	484	198
4	392	210
5	246	281
6	225	357
7	193	412
8	147	503
9	84	594
10	56	638



2. Using the data provided in Table A, construct a graph comparing the numbers of each variety of peppered moth. The axes are labeled with the years of the study (plotted horizontally) and the number of moths captured (plotted vertically). Use different colored pencils (or a solid line and a dotted line) to indicate each of the two color variations of the moth. Be sure to inclue in a key beneath the graph.

3. Use your graph and your textbook, if needed, to answer the following questions:

What preys on the peppered moths?

____

If the bark of trees is dark and the moths that rest there are light, what might happen to the moths?

____

____

What is a mutation?

____

____

What could have caused the first few moths to change from a light variety to a dark variety?

____

What event caused the tree trunks of many trees in England to turn from light to dark?

____

____

Which variety of moth increased over the 10-year period?

____

What is the name of this type of evolutionary change?

____

3.

Using the data on the graph, draw a conclusion concerning the population of peppered moths in the sampled area of England.

Explain the reason for the increase in the number of dark-colored moths.

What means could be used to return the environment of the peppered moth to its original state?

What effect would cleaning up the environment have on the moths?

4.

Appendix H

Assessment

DIHYBRID CROSSES #1

Name ________________________________ Date ________________

1. The position of the flower on the stem of the garden pea is governed by a pair of alleles. Flowers growing in the axils (upper angle between petiole and stem) are produced by the action of a dominant allele T, those growing only at the tip of the stem by its recessive allele t. Colored flowers are produced by a dominant gene C, and white flowers by its recessive allele c. A dihybrid plant with colored flowers in the leaf axils is crossed to a pure strain of the same phenotype. What genotypic and phenotypic ratios are expected in the F_1 progeny?

2. In summer squash, white fruit color is governed by a dominant allele (W) and yellow fruit color by the recessive (w). A dominant allele at another locus (S) produces disc shaped fruit and its recessive allele (s) yields sphere-shaped fruit. If a homozygous white disc variety of gentoype WWSS is crossed with a homozygous yellow sphere variety (wwss), the F_1 are all white disc dihybrids of genotype WsSs. If the F_1 is allowed to mate at random, what would be the phenotypic ratio expected in the F_2 generation?

Dihybrid Crosses C

Name ______________________________ Date ________________________

1. Which of these would all be genotypes for tall, yellow pea plants? (T = tall, t = short, Y = yellow peas, y = green peas)

   a. TtYy, TTYY, TtYY, TTYy
   b. TTTY, TTYY, TYY, TtY
   c. TY
   d. all of these

2. When two plants are crossed and three-quarters of the offspring are tall, the plants most likely were
   a. TT X tt
   b. Ty X Ty
   c. Tt X Tt

3. A green pea plant crossed with another of the same type would produce plants with
   a. three-fourths yellow, one-fourth green peas
   b. one-half yellow, one-half green peas
   c. 100 percent green peas
   d. 100 percent yellow peas

4. Two individuals produce children, three-quarters of whom have brown eyes. The individuals were
   a. hybrids
   b. homozygous dominant
   c. homozygous recessive
   d. heterozygous
   e. a and d

5. Which of these could produce a blue-eyed child?
   a. BB X bb
   b. Bb X Bb
   c. bb X Bb
   d. Bb X BB
   e. Bb X bb

6. In guinea pigs, B = black, b = brown, S = short-hair, s = long-hair. A pure black, heterozygous short-hair is mated to a pure brown, heterozygous short-hair. The results are
   a. 3 black short-hair: 1 black lone-hair
   b. 1 black short-hair; 1 black long-hair
   c. al black short-hair
   d. none of these

7. A pure black, pure short-haired guinea pig
   a. could produce a brown long-haired guinea pig if mated properly
   b. could not produce a brown long-hair
   c. could produce a brown short-hair if mated properly
   d. a and c
   e. all of these

8. In horses, T - trotter, t = pacer, B = black, b = chestnut. If a dihybrid in both traits is mated with a chestnut pacer, the results will be
   a. 1 black trotter: 1 chestnut pacer
   b. 3 black trotters: 1 chestnut pacer
   c. all black trotters
   d. 1 black trotter, 1 chestnut pacer, 1 black pacer, 1 chestnut trotter

9. A color-blind woman is married to a normal man. The sons will be
   a. like the father because the trait is X-linked
   b. like the mother because the trait is X-linked
   c. all normal

10. Which children could not occur if both parents had type A blood?
   a. type A
   b. type O
   c. type AB
   d. type B
   e. c and d

11. Which children could not have a parent that is AB?
   a. type A
   b. type B
   c. type AB
   d. type O

Appendix I

SYLLABUS

DATE	TOPIC	ASSIGNMENT
1	(2 hr. early release) Introduction, Policies, and Procedures *Introduction* *Roll/Seats* *Supplies: Paper, Pen & Pencil, Highlighter, Colored Pencils* *Discipline* *Syllabus* *Grading Procedure* *Issue Textbooks* *Intro: Calvin & Hobbs (Environment)*	Purchase Supplies Read Sec. 1.1 & 1.2 p. 2-7
2	1.1 The Diversity of Life 1.2 Biology, Society, and You *Warm-up: Bio Probe p.5 #3* *Complete Admin.* *Complete Calvin & Hobbs – Write summary paragraph* *Demo Lab: Earth – The Apple of Our Eye* *Safety – review lab safety procedures and equipment* *Handout & Text p.909* *Lect.: 1.1 & 1.2*	Read Sec. 1.3 & 1.4 p.8-12
3	1.3 Characteristics of Life 1.4 Studying Living Things *Warm-up: v/g GHSGT p. 50 1 & 2* *Lect: 1.3 & 1.4* *CW/HW – p.14 Key Terms Review 1-8* *Content Review 1-7 (Ans. Only)* *Practice SOL Test 1-25*	Read Sec. 2.1 & 2.2 p. 16-21
4	2.1 Nature of Science 2.2 Science Skills and Methods *Warm-up: p.20 reinforce* *Metric Review* *Lect.: 2.1 & 2.2* *Practice SOL Test 26-50*	Study Metric Units and Prefixes p.908 col. 1 Read Sec. 2.3 & 2.4 p.22-26

FROM (FRI)MAY 20 2005 13:58/ST.13:57/No.7500000067 P 2

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Institutional Review Board

Dr. David M. Moore
IRB (Human Subjects)Chair
Assistant Vice Provost for Research Compliance
CVM Phase II- Duckpond Dr., Blacksburg, VA 24061-0442
Office: 540/231-4991; FAX: 540/231-6033
email: moored@vt.edu

DATE: March 23, 2004

MEMORANDUM

TO: Peter E. Doolittle Teaching and Learning 0313

FROM: David Moore

SUBJECT: **IRB Expedited Approval:** "Making the Link Between Theory and Practice: Teacher Beliefs About Teaching and Learning" IRB # 04-161

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective March 23, 2004.

cc: File
Department Reviewer Mary Alice Barksdale T&L

05/15/2006 MON 9:45 [JOB NO. 6267] 002