Believe It or Not: A Case Study of the Role Beliefs Play in Three Middle School Teachers' Use of Computers in Teaching Science

By

CARMIA SUZANNAH FELDMAN
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Teacher Beliefs and Teaching with Computers

ABSTRACT

In the past twenty years, teacher beliefs have been found to have a strong influence on the way teachers teach in many disciplines, but only recently is research being done in relation to teaching with computers. As computers become more ubiquitous in schools, it is more important than ever to determine how computers are being used in classrooms, how they could better support student learning, and the reasons why they may not be used in ways advocated by research.

In this study, I used a conceptual model of the beliefs that have been shown to influence teaching behavior, an in-depth interview technique (Munby Repertory Grid Technique - RGT) to uncover beliefs, and an exemplary case study methodology to highlight the relationship between the beliefs and teaching with computer behaviors of three middle school teachers. The cases were exemplary in that many of the barriers research has shown to hinder teachers' ability to integrate computers in their teaching were minimized. The teachers all taught at the same technology magnet school and had strong administrative and technological support, professional development in the use of computers, and permanent access to student laptop computers equipped with wireless Internet. To get a complete picture of the teachers' belief systems, I used the Munby RGT with each teacher to explore their teaching with computer beliefs, their science teaching beliefs, and their general teaching beliefs. I then collected data on their teaching with computer behavior through classroom observations, lesson plan report forms, teaching behavior logs, and written reflections, among others.

Teacher Beliefs and Teaching with Computers

I found that the teachers' beliefs did influence their teaching with computer behavior. For example, although all teachers expressed beliefs that could support student-centered and inquiry-based teaching with computers, some of their beliefs, such as teacher-centered behavioral management beliefs, were more dominant and may have kept the teachers from reaching full implementation of best practices. Often their general teaching or science teaching beliefs were more dominant than their teaching with computer beliefs.

Implications for teachers' professional growth in teaching with computers, and professional development of teachers in general, are discussed.

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CHAPTER I: INTRODUCTION

Schools in the United States are undergoing an unprecedented amount of change (Fullan, 2001). Politicians, school administrators, and the public back reforms such as "standards-based instruction" and "teacher accountability." Based on the number of science education reform documents written in the last 10 years, science education has been no exception to the call for reform (American Association for the Advancement of Science, 1993; California Department of Education, 2000; National Research Council, 1996). One area that has been a result of science education reform (as well as reform in other disciplines) is the increased spending on computer technology in education.

Many of the current science reform documents address use of computer technology in some way. Some only tangentially mention computer use as a tool for certain tasks, skills, or projects. Others make the integration of computer use a centerpiece of reform. In either case, the assumption is that computers will be available to students and teachers and that they will be used as part of the reform effort. As reform mandates more computer use, and schools become better equipped with computer resources, there has been a concurrent increase in concerns about the actual use of computers in schools.

The *Benchmarks for Science Literacy* (Benchmarks) (AAAS, 1993) and the *National Science Education Standards* (NSES) (NRC, 1996) are examples of reform documents that only lightly prescribe the use of computer technology as one tool for the science reform goals. Benchmarks describes computer use in the Habits of Mind section. Without explicit standards on the topic, it assumes computers will be used to "solve mathematical problems...store and retrieve information...make tables, graphs, and spreadsheets...[and] locate information." NSES goes a step further in its Science as Inquiry standards by specifying use of equipment, tools, and technology (including computers) for each grade range. In addition, NSES states that teachers must "make the available science tools, materials, media, and technological resources accessible to students" in its Science Teaching Standards. Schools must also provide the necessary equipment, funding, and technical support for technology. The NSES Science Education Program Standards state that "some equipment is general purpose and should be part of every school's science inventory...[such as] computers with software for supporting investigations...Furthermore, policy makers need to bear in mind that equipment needs to be upgraded frequently and requires preventative maintenance" (p. 220).

Not surprisingly, one of the reform documents that most ardently supports the use of computer technology in education is the *National Educational Technology Standards* (NETS) by the International Society for Technology in Education (ISTE) (International Society for Technology in Education, 1998). ISTE's website describes its mission as being dedicated to "promoting appropriate uses of information technology to support and improve learning, teaching, and administration in K–12 education and teacher education." The standards for students and for school administrators reflect this mission by promoting computer and other technology use in every facet of school life, from the classroom to the administration, as a tool for reform.

California has a slightly different focus in its recently adopted science standards and draft framework, which guides teachers in implementing those standards. The standards themselves start referring to computer use in the 6th grade. The Investigation and Experimentation standards state that students will "select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data" (California Department of Education, 2000, p. 110). Instead of assuming computer use is beneficial, as in the other reform documents, the framework devotes a whole chapter to a discussion of the issue of computers in education. It explores the pros and cons of educational computing, stating that computers can "enhance learning" but have "not yet been proven to increase academic achievement." Nevertheless, the framework concludes that computers should be made available in schools and that "pre-service…[and] practicing teachers need to be trained to use different technologies in a variety of ways that are appropriate to the grade levels of their students" (p. 304).

No matter how it is addressed in these reform documents, computer use in schools is definitely mandated by these documents and the current political climate in the nation as a whole, and California in particular. Huge amounts of resources are being poured into the purchase and maintenance of computer technology for education (Fabry & Higgs, 1997). It is therefore crucial to determine how computers are being used today, how they could be better used, and the reasons why they may not be used in ways advocated by the reformers.

Evidence is mounting from research in the last 10-20 years that teacher beliefs play a large role in their acceptance and integration of new reform efforts, including those related to science and technology (Cuban, 1986, , 1990; Czerniak, Lumpe, Haney, &

Beck, 1999; Fang, 1996; Fullan, 2001; Kagen, 1992a; Myhre, 1998; Nespor, 1987; Pajares, 1992). In fact, the failure to address teacher beliefs has been identified as one of the primary reasons why many large-scale, top-down reform efforts are unsuccessful (Cuban, 1986; Fullan, 2001; Myhre, 1998).

My interest in teacher beliefs as they apply to using computers in science education came from my work on a science-based, educational computer software program. I was intrigued with the many creative ways teachers used the software. They often modified the use of the program and accompanying activities in ways I had not expected. I felt some of these changes were improvements and others were not. I began to wonder what causes a teacher to change curricular materials in general, and computer-based activities in particular, and how teachers decide what changes to make. This started me on a search that led me to the literature on teacher beliefs. I was fascinated at the ways complex systems of beliefs mediate teachers' decisions and behavior.

I had the opportunity to study this role of beliefs in science teachers' use of computer technology when I was given permission to observe a professional development program that incorporated computer technology, specifically the program I had helped develop. Through surveys that I administered during the program, I knew that some of the science teachers who participated were already computer-using teachers (either in their personal or professional lives), and some taught at schools with exceptional access to technology. With the exposure to good models of computer integration, these teachers were primed for success in terms of being able to use computers in ways that could be considered "best practice." I decided to study these teachers' beliefs and subsequent use of computers to help elucidate this important relationship, which ultimately affects the quality of science education in our schools.

CHAPTER 2: LITERATURE REVIEW

Three literature areas guided me during this research study: teacher beliefs, the state of computers in education, and the barriers to computer integration in instruction. The teacher belief literature provided the foundation for my focus on this important aspect of teaching. The belief theories helped me determine the constructs of interest in research on teacher beliefs, as well as the methodology for studying them. The literature on computers in education highlighted the important research that has already been done in this area and pointed to the many important questions that have yet to be explored. The recommendations for best practices in computer use gave me a framework for the exciting possibilities we have to improve student learning and a lens through which to view teachers' uses of computers in science education. The literature on barriers to the integration of computers in instruction provided evidence of the link between teacher beliefs and teaching with computers.

Teacher Beliefs

A growing consensus, if not unanimity, exists among researchers from many fields that there is a relationship between the beliefs a person holds and his or her eventual actions (Ajzen, 2001; Armitage & Conner, 2001; Bandura, 2001). There are a number of different theories about the nature of this connection, as well as the specific types of beliefs considered important. Educators have more recently been interested in beliefs of teachers and how these beliefs influence what teachers do. This literature review section will explore several theories that have influenced the field of education since the latter part of the 20th century: the Theory of Planned Behavior, Self-efficacy

Theory and Motivational Systems Theory. The theories' utility in studying science teachers' beliefs and behaviors will be highlighted. The section will conclude with a conceptual model that combines similar aspects of these theories and provides a useful framework for further research.

Although there have been differences in the ways researchers define beliefs, most would agree that beliefs are "predispositions to action" (Pajares, 1992; Rokeach, 1970). That is, a person can be expected to behave in ways that correspond, for the most part, to what the person believes (Kagen, 1992a; Munby, 1982; Pajares, 1992). What is more open to debate is exactly what kinds of beliefs are important determinants of behavior.

General Theories of Behavior

Psychologists historically viewed human behavior as a reaction to both internal (e.g., instincts, psyche) and external (e.g., incentives) forces (Bandura, 2001; Ford, 1992). Humans were not thought to have much personal control over their behavior, and therefore acted much like machines. Specific inputs would result in specific outputs. One influential theory of this type is called operant learning theory or behaviorism (Skinner, 1953, , 1974). Although mechanistic theories continue to influence theory and practice today, modern motivation theories recognize that human beings are also able to make conscious decisions and are responsible for their actions.

This ability of humans to act intentionally according to conscious decisions is known as human agency. Humans have the "power to originate actions for given purposes" and plan for the future (Bandura, 2001). Intentions are present "plans of action" to be carried out in the future. Agents are "self-reactive," meaning they act in response to goals they set for themselves. Agents are also "self-reflective," meaning agents examine their goals, intentions, and behaviors and have the ability to adjust based on their judgments (see also Ford, 1992). Agentic theories emphasize the intimate connection between beliefs and behavior. Three influential agentic theories in education are the Theory of Planned Behavior, Self-efficacy Theory and Motivational Systems Theory.

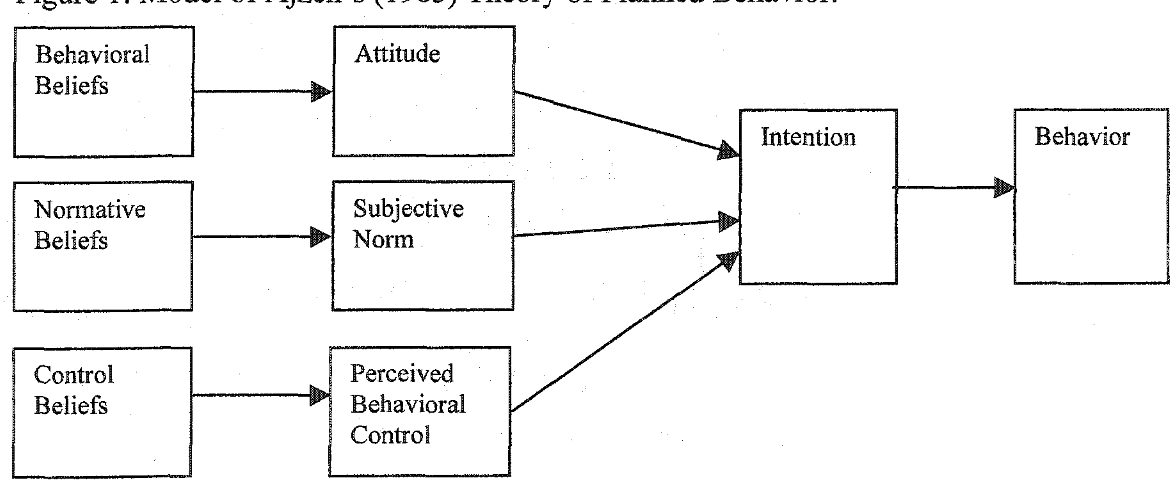
Theory of Planned Behavior

According to the Theory of Planned Behavior (TPB), behavior is controlled by intentions (Ajzen, 1985; Fishbein & Ajzen, 1975). Intentions to perform a behavior must precede the behavior, and one can assume that intentions will turn into behavior unless something changes before the behavior is executed. A precursor to the Theory of Planned Behavior, the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975), only explains and predicts behaviors that are completely under a person's control. These behaviors might include going to the movies, studying for a test or wearing a particular article of clothing. The TRA has only limited applicability because many behaviors can be hindered or completely halted by internal or external factors that are beyond a person's control. Lack of necessary skills is an internal factor that might impede performance of a behavior. For example, a person might intend to run a mile in under six minutes, but not have the physical fitness to be successful. External factors include time and opportunity to perform a behavior. In addition, a person might need help from other people in order to successfully perform a behavior. For instance, a person might intend to meet a friend for lunch, but fail to do so because the friend had a prior engagement.

Due to this lack of complete control, intentions in the Theory of Planned Behavior (TPB) are actually defined as intentions to "attempt to perform a behavior" (Ajzen, 1985, p. 29). Therefore, the "likelihood of actual performance" of a behavior is determined by how much a person tries to perform the behavior (*strength of attempt*) and the amount of *control* a person has over the behavior (p. 30). Therefore, the TPB adds a component of degree of control to the original Theory of Reasoned Action.

According to the Theory of Planned Behavior (TPB), the major determinants of intention are a person's positive or negative evaluation of attempting to perform a behavior (*attitude*), perception of social pressure related to the attempted performance of the behavior (*subjective norm*), and perception of amount of control over attempting to perform a behavior (*perceived behavioral control*) (Ajzen, 1985, p.12). Certain underlying, or "salient," *beliefs* (cognitions about the behavior) play a large role in attitude, subjective norm, and perceived behavioral control, and are therefore the fundamental determinants of behavior (see Figure 1) (Ajzen, 1985; Crawley & Koballa, 1994).

Figure 1: Model of Ajzen's (1985) Theory of Planned Behavior.



In closely examining the theory, it becomes clear that all intention-determining constructs (e.g., attitude, subjective norm, underlying beliefs) revolve around performing a behavior. This is a basic change over previous attitude theorists who thought that the sum of attitudes about a thing or object would predict a person's behavior relating to that object (e.g., Rokeach, 1970). For example, it was thought that a teachers' attitudes about science itself (an object) would predict his or her science teaching behavior. In a test of this definitional shift in the Theories of Reasoned Action and Planned Behavior, Koballa (1986) found that assessing a teacher's attitude towards science (object) was not enough to predict whether he or she would teach science (target behavior). Instead, assessing a person's beliefs and attitudes towards teaching science (a behavior) was a much better predictor of their future behavior.

Underlying Beliefs in the Theory of Planned Behavior

In the Theory of Planned Behavior, an attitude is determined by the interaction between a person's beliefs that performing a behavior will lead to a particular outcome and evaluations of that outcome (see Figure 1) (Ajzen, 1985; Ajzen & Madden, 1986). A behavioral belief is always linked to an outcome. For example, a person might believe that "studying biology for two hours" (behavior) "will result in a good grade on the test" (outcome). The person could evaluate the outcome in many different ways, such as being beneficial in terms of future opportunities or detrimental in terms of standing among peers. One attitude about a particular behavior can be made up of many behavioral beliefs (and associated outcome evaluations). The behavioral beliefs and outcome evaluations are considered indirect measures of intention, while attitude is the direct measure.

In a similar way, subjective norm is determined by a person's beliefs about whether or not other people want the behavior performed and how much the person is motivated to act in accordance with the perceived wishes of those other people (Ajzen, 1985; Ajzen & Madden, 1986). For example, a person might have a normative belief that "my parents want me to study," but lack the motivation to act because "I don't care what they think." As with the attitude measure, normative beliefs and motivation to comply are considered indirect measures of intention and subjective norm is the direct measure.

As attitude and subjective norm are determined by underlying beliefs, perceived behavioral control is determined by a person's control beliefs. Control beliefs include assessments of both personal ability and control over external variables (Ajzen, 1985; Ajzen & Madden, 1986). For example, a long distance runner may have a control belief that "I have superior strength and endurance." She might also believe that "the race course is familiar to me." Therefore, her perceived behavioral control may be high. What she does not have actual control over is the training of the other runners and the fresh rock fall over part of the course. In the theory, control beliefs are the indirect measure of intention and perceived behavioral control is the direct measure.

Ajzen & Fishbein (1980) outline detailed steps about how to quantify the constructs in the Theory of Planned Behavior through the use of questionnaires in which subjects rate statements on a semantic differential scale. The statements on the questionnaires are elicited through interviews. A researcher could choose to assess the indirect (e.g., behavioral beliefs and outcome evaluations) and/or direct measures (e.g., attitudes) of intention. Correlation and regression analysis tell the researcher which constructs relate and contribute to predicting intention, as well as behavior if that is measured in the study. As beliefs are considered to be the underlying determinants of attitude, subjective norm, and perceived behavioral control, and therefore intention and behavior, they are considered the best target of intervention that could ultimately lead to a change in behavior (Ajzen & Fishbein, 1980; Haney, Czerniak, & Lumpe, 1996). The Theory of Planned Behavior has been used to explain and predict behavior in many fields, including education in general and science education in particular (Armitage & Conner, 2001; Zint, 2002).

Using the Theory of Planned Behavior to Study Beliefs and Behavior

The Theory of Planned Behavior has been applied successfully to the explanation and prediction of teachers' behaviors in general and science teachers' behaviors specifically (Zint, 2002). Often these studies compare the relative importance of the theories' constructs to predicting intention to teach in a certain way. Crawley (1990) was one of the first to test the applicability of the Theory of Planned Behavior (TPB) to science education. He used the TPB to test elementary and secondary science teachers' intentions to use investigative methods in their physical science teaching over the next school year (n=50). The specific investigative methods were learned in an inservice professional development program. Teachers completed a questionnaire that was created to assess the indirect and direct measures of attitude, subjective norm, and perceived behavioral control, as well as intention to perform the behavior.

Regression analysis showed that attitude, subjective norm, and perceived behavioral control (PBC) significantly contributed to predicting intention. However, the independent contribution of PBC was not significant. Attitude was the greatest predictor in several models he tested (e.g., linear and interaction models). Although PBC did not independently contribute to predicting intention, it did significantly influence which parts of the model were significant. For teachers who had low PBC, attitude was the sole predictor of intention. For teachers with high PBC, both attitude and subjective norm were predictors of intention. Crawley concluded that for teachers who feel they have a great deal of control over the behavior, social support becomes more important. When teachers do not feel they have control, social support is not a factor. Crawley also found that there were differences among teachers in terms of gender, age, and grade level. Older (>34 years) female elementary school teachers were more likely to intend to perform the behavior.

Similar to Crawley's (1990) work, the Theory of Planned Behavior has been used repeatedly by another group of researchers to study science teachers' incorporation of various science education reforms (Haney et al., 1996; Lumpe, Haney, & Czerniak, 1998a, , 1998b). Haney, Czerniak, & Lumpe (1996) argue that many past science education reform efforts failed because policy makers ignored teachers' beliefs and the critical role teachers play in enacting reforms. Rather than predicting teacher behavior, Haney et al. (1996) were concerned with using the TPB to examine the belief structures of teachers that lead to their intentions to enact certain reforms. The researchers first conducted interviews with 13 teachers to obtain the salient beliefs underlying their attitudes, subjective norm, and perceived behavioral control about implementing the Ohio Competency Based Science Model reforms. They then used the beliefs from the interviews to construct four questionnaires (representing the four reform strands) that were sent to 800 randomly-selected science teachers in 2nd, 5th, 8th, and 11th grades. Fifty teachers at each grade level received the same questionnaire representing one of the reform strands. They got a 52% response rate, which was relatively equally distributed among grade levels.

A backwards-solution multiple-regression analysis was conducted. Attitude, and beliefs underlying those attitudes, was the most significant contributor to predicting intention for all four of the reform strands. Additionally, perceived behavioral control (PBC) significantly contributed for two of the four reform strands, and subjective norm for one strand. The researchers hypothesized that PBC would be a large contributor to intention because "lack of teacher training and resources" is often cited as a cause of failed reform. Although they found that PBC was less of a contributor than they expected, the underlying beliefs of PBC that contributed the most were those involving staff development opportunities and having available resources.

Like Crawley (1990), Haney et al. (1996) also found significant differences among teachers by gender, grade level, and years of teaching experience. The found that female elementary school teachers with the least amount of experience had more positive attitudes towards implementing the reform strands. In a further analysis of the results, the researchers found that certain underlying beliefs were significant predictors of attitude, subjective norm, and PBC, and therefore intention. They conclude that these are the beliefs that should be targeted with professional development.

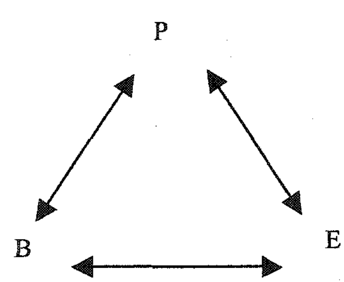
Using similar methodology, Lumpe, Haney, & Czerniak (1998a) explored the Theory of Planned Behavior constructs associated with science teachers' intent to use cooperative learning strategies in their teaching (questionnaire sent to 200 teachers; 53.5% return rate). They found that both attitude and perceived behavioral control (PBC) were significant predictors of intention, but in this case, PBC had the greatest influence. Lumpe, Haney, & Czerniak (1998b) explored the TPB constructs in relation to science teachers' intentions to incorporate science-technology-society (STS) in their teaching (questionnaire sent to 232 teachers; 50.4% return rate). They found that attitude, subjective norm, and PBC significantly contribute to predicting intention, and PBC had the greatest influence.

In summary, the Theory of Planned Behavior has been used successfully to explore the beliefs science teachers hold regarding different aspects of instruction and their intentions to implement certain strategies. Depending on the type of instructional strategy, attitude, subjective norm, perceived behavioral control, or some combination of the three constructs and their underlying beliefs have been found to be significant predictors of teachers' intentions. The theory has also been used to identify the underlying beliefs that may be useful for the development of intervention programs for teachers. Many of the researchers acknowledge that there are too few studies that equate the theories' constructs and intention to actual behavior and that this extension of the research would provide more supporting evidence for the utility of the theory (Crawley, 1990; Haney et al., 1996; Lumpe et al., 1998a; Lumpe et al., 1998b).

Self-efficacy Theory

Self-efficacy Theory is an extension of an important aspect of Bandura's Social Cognitive Theory (Bandura, 1997). In Social Cognitive Theory, it is the interaction among three elements that causes human agency (see Figure 2) (Bandura, 1986) (Bandura, 1997). Both the environment (E) and personal factors (P = cognitive, affective, and biological events) influence behavior (B), as well as each other. Behavior, in turn, influences both the environment and personal factors. Bandura calls this "triadic reciprocal causation" (Bandura, 1997). In Self-efficacy Theory, it is the personal factors (P) that assume primary importance over behavior.

Figure 2: Triadic Reciprocal Causation in Social Cognitive Theory. The arrows indicate relationships of influence among the three determinants; P = personal factors (internal), E = environmental factors (external), and B = behavior.



A foundational aspect of Self-efficacy Theory is the pivotal role that self-beliefs about one's capability play in affecting behavior (Bandura, 1993, , 1997, , 2001). Perceived self-efficacy "refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). When we believe we are capable of doing something, we are more likely to undertake it. When we doubt our abilities, we are less likely to do something. "Among the mechanisms of agency, none is more central or pervasive than beliefs of personal efficacy" (p. 2).

Perceived self-efficacy is a factor in motivation. It affects the types of goals one sets, the amount of effort one expends, how long one continues trying when faced with obstacles, and how one deals with failure (Bandura, 1993; Bandura, 1997). In addition, affective processes are influenced by self-efficacy beliefs in terms of how much a person feels anxiety, stress, and depression in different circumstances. One's sense of self-efficacy can also affect the choices one makes in different situations, from where to live, what career to pursue, and what friendships to cultivate.

An additional aspect of Self-efficacy Theory is the construct of outcome expectancy. Bandura (1997) explains that behavior can best be predicted through a combination of beliefs about self-efficacy and expectations about the types of outcomes that will be produced by performing the behavior (outcome expectancies). These outcome expectancies are often colored by a person's sense of efficacy, because one judges the types of outcomes partly on how much one feels able to achieve those outcomes. For example, a person may believe that he has the ability to complete a difficult homework assignment (self-efficacy about homework completion). He may anticipate several different outcomes of actually completing the assignment. A positive evaluation of the outcome might be getting a good grade or being rewarded by parents. A negative evaluation could be of lost time to play video games with friends. If he did not feel capable of completing the assignment, his outcome expectancies would reflect evaluations of not completing the task.

As with the Theory of Planned Behavior, much evidence exists that self-efficacy beliefs are an important component in what people do. I will review some studies that have tested the utility of self-efficacy beliefs in education in general and science education in particular, focusing specifically on those studies that deal with how self-efficacy beliefs relate to teacher practice. One of the recurring problems with self-efficacy research is in the definitions different researchers give to the construct (Tschannen-Moran & Woolfolk Hoy, 2001). Nevertheless, these studies show that self-beliefs are influential in studying behavior.

Using Self-efficacy Theory to Study Beliefs and Behavior

Guskey (1981) developed a measurement tool called the Responsibility for Student Achievement (RSA) scale. It measured whether teachers felt they had control over a students' successes and failures, or felt those outcomes were beyond their direct control Tschannen-Moran & Woolfolk Hoy, 2001. This definition of teacher efficacy is somewhat similar to Rotter's (1966) distinction between internal and external locus of control. The scale had 30 items that were to be rated by the teacher as either teacher or externally controlled.

Guskey (1988) used a revised RSA scale to study how teachers' efficacy beliefs related to their attitudes towards different aspects of implementing mastery learning instructional strategies (which Guskey defined as "whole-group instruction followed by a diagnostic formative test designed to help students identify and then correct their learning errors"). Elementary and secondary school teachers (n=120) involved in a professional development program filled out the questionnaire. In addition to the RSA items, the questionnaire included items to assess how much teachers liked or disliked different aspects of teaching in general and implementing mastery learning instructional practices specifically.

Results showed that teachers had greater efficacy in relation to the success of their students and lower efficacy when dealing with failures. In other words, they felt they had control over students' successes, but felt students' failures were largely the result of other factors beyond their control. Efficacy was also significantly and positively correlated with attitude towards teaching in general. In terms of attitude towards implementing mastery learning techniques, teachers with greater efficacy also felt more positively about certain aspects of implementation, namely importance of techniques and similarity to present teaching practice, than less efficacious teachers, and felt the techniques were less difficult to implement. Teachers' attitudes towards cost of implementing the techniques (in terms of time and effort) did not relate significantly to efficacy scores. Guskey concluded that highly efficacious teachers are more likely to have positive attitudes towards implementing new instructional practices.

In response to Bandura's (1986) caution about the specificity of self-efficacy beliefs to different situations, Riggs & Enochs (1990) created a self-efficacy instrument to be used to specifically study elementary science teachers' sense of efficacy. They also wanted their instrument to measure both self-efficacy beliefs and outcome expectancies, which resulted in two subscales. The "personal science teaching efficacy belief" (PSTE) subscale (corresponding to self-efficacy) was concerned with teachers' confidence in their own science teaching abilities, while the "science teaching outcome expectancy" (STOE) scale explored teachers' beliefs about whether teaching can affect student learning. This latter construct has been called “Teaching Efficacy” in other studies (Gibson & Dembo, 1984). The scale was called the Science Teaching Efficacy Beliefs Instrument (STEBI-A).

The researchers criticized past scales of personal teaching efficacy as mixing self-efficacy with outcome expectancy items, thereby confusing what should be two distinct constructs. Enochs & Riggs took care to separate the two constructs into their separate subscales. Teachers rated each item according to a Likert scale that went from strongly agree to strongly disagree (corresponding to scores of 1-5). After preliminary tests of the STEBI, a refined instrument was administered to 331 elementary teachers. Factor analysis showed that the instrument indeed consisted of two factors and was consistent for teachers with varying backgrounds. Enochs & Riggs (1990) also created a similar instrument to measure efficacy beliefs of preservice elementary teachers (STEBI-B).

Ramsey-Gassert, Shroyer, & Staver (1996) used the STEBI-A with 23 inservice elementary teachers as a basis for interviews that would explore the past experiences that led to their feelings of science teaching efficacy. After comparing interview data to the original scores on the instrument, the authors concluded that teachers with robust efficacy (high scores on both subscales) had many positive experiences with science and science teaching in their pasts. Teachers with low efficacy tended to have had negative experiences in science and science teaching. Although these teachers had low efficacy beliefs, they were still motivated to teach science after exposure to some external “catalyst” (such as another teacher who supported them). External variables, which teachers viewed as beyond their control, also emerged as having important effects on these teachers. Teachers with high outcome expectancy (STOE) beliefs saw these variables as challenges possible to overcome, while teachers with low outcome expectancy beliefs felt these variables formed unbeatable obstacles for them.

Settlage (2000) used the STEBI-B with 76 preservice elementary teachers to explore their ability to understand and use the learning cycle approach in their science teaching. The preservice teachers filled out the STEBI-B and another survey to assess anxiety towards science (Zuckerman Attitude Inventory) at the beginning of the period of instruction. At the end of the instruction, the teachers filled out the same instruments as well as a Learning Cycle Test that assessed understanding of the instructional approach. The researchers found that only the STOE subscale (outcome expectancy) of the STEBI-B correlated significantly with the Learning Cycle Test. Although the PSTE subscale (personal self-efficacy) and the scores on the Zuckerman Attitude Inventory were significantly correlated with each other, neither related to preservice teachers' understanding of the learning cycle. The researchers concluded that preservice teachers' beliefs in their ability to affect student learning (STOE) was more important in their ability to understand the learning cycle than teachers' belief in their own capabilities as science teachers. In addition, this study gave further evidence that the PSTE and STOE subscales were measuring two distinct constructs.

As can be seen from the studies reviewed here, many researchers have identified two distinct constructs in relation to teachers' self-efficacy. There has been debate among researchers about what the two constructs are really measuring. Guskey (1998) found two constructs relating to ability to affect student successes and ability to affect student failures. Riggs & Enochs (1990), and the researchers who use their instruments, found a distinction between a personal sense of efficacy (ability to teach science) and teaching efficacy (outcome expectancy about being able to affect student learning).

Guskey & Passaro (1994) explored this debate further by reexamining another popular teacher self-efficacy instrument, the Teacher Efficacy Scale (TES) (Gibson & Dembo, 1984). Like the STEBI instruments, the TES is based on a personal versus teaching efficacy model. The TES asks teachers to rate, on a 6-point Likert scale from strongly agree to strongly disagree, items purportedly related to personal efficacy and teaching efficacy. Guskey & Passaro analyzed the instrument and found that all of the items for personal efficacy used the word "I" and were worded positively (e.g., "I have enough training to deal with almost any learning problem"). The positive orientation meant a teacher felt she had the ability and control over the situation. The researchers also found that the majority of the teaching efficacy items used the word "teacher" and were worded negatively (e.g., "Even a teacher with good teaching abilities may not reach many students"). The negative orientation indicated that the situation was out of the teacher's control and the teacher did not have the abilities needed for the situation. Based on the wording of these items, they argued that the scale might be measuring an internal versus external distinction rather than personal self-efficacy versus teaching efficacy (outcome expectancy).

The researchers used a version of the TES (Woolfolk & Hoy, 1990) and added a few additional items. They then altered the items so that one quarter had an internal (positive) and personal focus and one quarter had an external (negative) and personal focus. In the same way, one quarter of the items had an internal (positive) and outcome focus and one quarter had an external (negative) and outcome focus. This revised instrument was administered to a group of 342 preservice and inservice teachers (ranging from K-12 grades). They analyzed the data using a factor analysis to generate a two-factor solution. Factor one contained all items that had a negative and external focus, whether or not they had a personal or outcome focus. All positive and internal items loaded on factor two, regardless of personal or outcome focus. Guskey & Passaro (1994) conclude that while teacher self-efficacy does seem to have two distinct constructs, those constructs reflect an internal versus external distinction rather than a personal versus outcome distinction.

Guskey & Passaro (1994) relate this new understanding of teacher self-efficacy with locus-of-control measures, although caution that the internal/external distinction is not the same as locus-of-control, which sees the two as opposite ends of the same continuum. In teacher self-efficacy, the two factors are not related to each other, and are therefore seen as two distinct parts of efficacy. The researchers do caution that the purpose of their study was to examine existing measures of teacher self-efficacy. Thus they are only reporting on what the instrument was really measuring, not necessarily debating the definition of teacher self-efficacy itself. In fact, Bandura (1997) specifically distinguishes between self-efficacy and locus-of-control constructs, with the former concerning beliefs about "whether one can produce certain actions" and the latter concerning beliefs about "whether actions affect outcomes" (p. 20).

When comparing Bandura's (1997) conceptualization of self-efficacy and outcome expectancies with those used in some of the most popular instruments, definitional differences become clear. Although teaching efficacy beliefs (that actions of teachers affect student outcomes) may be important to the study of teachers, these should probably not be defined as "outcome expectancies" in the way Bandura intended (Tschannen-Moran & Woolfolk Hoy, 2001). Bandura's idea of outcome expectancy would be an evaluation of the consequences of affecting student outcomes. Therefore, if a teacher felt the consequences of raising student achievement were positive (a likely assumption), then she would be more likely to engage in the necessary behavior, assuming of course that she felt she had the ability to do so.

Tschannen-Moran & Woolfolk Hoy (2001) explored these inconsistencies with instruments that measure teacher self-efficacy. They felt that the construct of teaching efficacy as originally conceptualized was not an appropriate measure of outcome expectancies, and that outcome expectancies should not even be a large focus of investigation considering Bandura's (1997) contention that they stem directly from beliefs about self-efficacy. Instead, the researchers felt that an instrument should include "an analysis of the task in terms of the resources and constraints in particular teaching contexts," and created their own instrument (Ohio State Teacher Efficacy Scale - OSTES). In the directions for filling out the OSTES, teachers are told that "this questionnaire is designed to help us gain a better understanding of the kinds of things that create difficulties for teachers in their school activities." The resulting OSTES contained three related subscales that deal with efficacy for instructional strategies, classroom management, and student engagement. Combined, the subscales provide an overall score of teacher self-efficacy that is not related to a specific discipline.

In summary, even with measurement and definitional issues, self-beliefs have been shown to relate to teacher behavior in meaningful ways. The construct of self-efficacy has been successfully applied to studies of science teachers' practice.

Motivational Systems Theory

In Motivational Systems Theory, developed by Ford (1992), motivation is the driving force behind people's intentions and behavior. Ford identifies Personal Agency Beliefs (PABs) as important influences on motivation, and therefore on intentions and behaviors. PABs are made up of two kinds of important beliefs; capability and context beliefs. Capability beliefs are beliefs about whether or not one has the ability to accomplish a specified goal. Context beliefs are beliefs about whether or not the person's environment will assist in or support the accomplishment of the goal.

Lumpe et al. (2000) contend that context beliefs resemble perceived behavior control in the Theory of Planned Behavior and outcome expectancy in Self-efficacy Theory. Context beliefs are more comprehensive than those constructs as they are conceived to include the entire external environment, including the "physical environment (e.g., buildings, equipment), human environment (e.g., students, faculty, parents), and sociocultural environment (e.g., policy, cultural norms)" (Lumpe et al., 2000, p. 278).

People who display certain patterns of personal agency beliefs (PABs) are thought to be more likely to act in certain ways (Ford, 1992). For instance, a person with strong capability beliefs and positive context beliefs would be expected to be "strong and firm in purpose or outlook," and a person with weak capability beliefs and negative context beliefs would "have no expectation of success" (p. 134). People with less extreme beliefs, such as moderate capability beliefs and neutral context beliefs, would be "functioning adequately but may be at risk under conditions of stress." Determining where certain teachers' beliefs fall in this framework would help educators determine appropriate interventions.

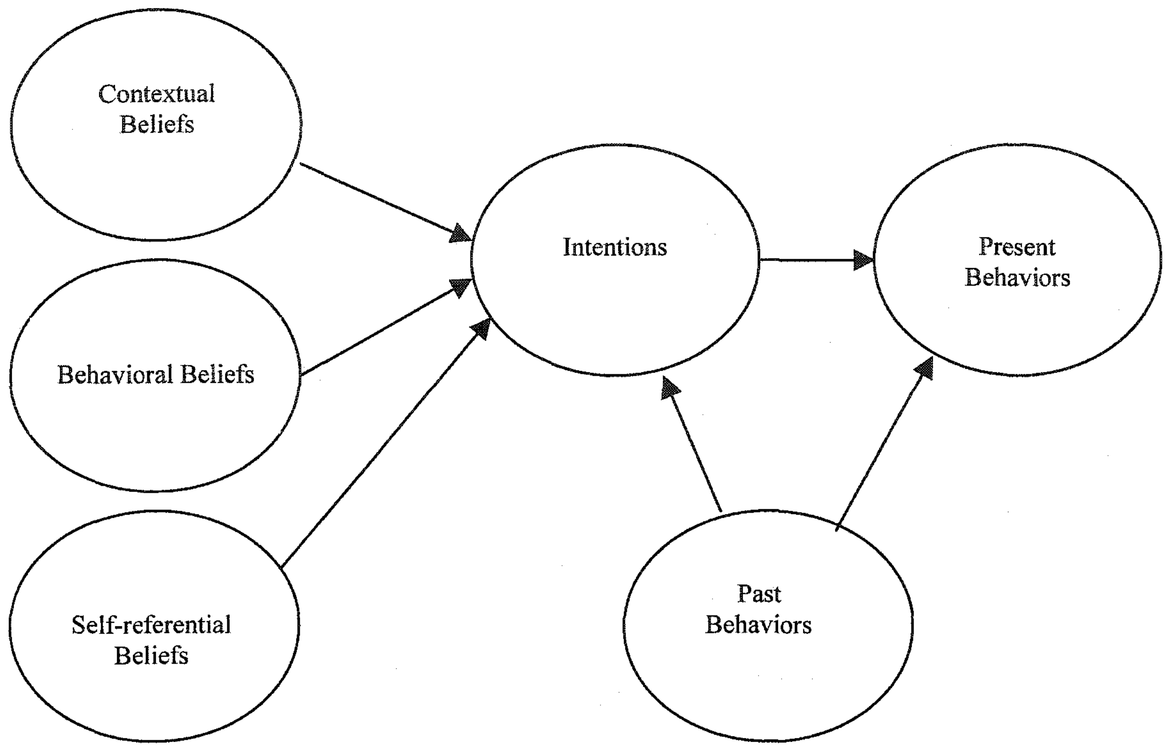
Using Motivational Systems Theory to Study Beliefs and Behavior

Extending their previous work on teachers and reform, Lumpe et al. (2000) developed an instrument to measure science teachers' context beliefs as they relate to incorporating science-teaching-society (STS) into their instruction. They interviewed 130 teachers about what people or groups would approve or disapprove of their incorporating STS, and what "things" would make it easier or more difficult to incorporate STS in the next academic year. They used the most frequently mentioned items to construct a questionnaire. Each item asked teachers to respond in two ways. First teachers were asked to rate the item according to whether it would "enable them to be effective teachers" on a scale from "strongly agree" to "strongly disagree." Then teachers were asked to rate the likelihood that the item would occur from "very likely" to "very unlikely" (see Table 1 for sample items). This distinction was included because context beliefs are thought to encompass "enabling and likelihood of occurrence beliefs" (p. 281). When using this instrument in conjunction with the STEBI (measuring self-efficacy), the researchers found that it yielded an enhanced profile of teachers that can be used to design professional development experiences.

A Conceptual Model for Teacher Beliefs

When comparing the three belief theories, it becomes clear that they have many similarities, and certain aspects of the theories are repeated. These repeated aspects have been shown to be influential in studies of teachers in general and science teachers specifically (Crawley, 1990; Czerniak, Lumpe, Haney, & Beck, 1999; Guskey, 1988; Lumpe et al., 1998a; Lumpe et al., 2000; Ramsey-Gassert et al., 1996). Despite their utility, the constructs in these theories are often confusing and can be confused with one another, as exemplified in the previous sections in this paper. In order to create a useful, clear, theory-based conceptual model for further research, these important and similar aspects can be synthesized and simplified (see Figure 3).

Figure 3: Theory-based conceptual model of beliefs, intentions, and behaviors.



Explanation of Constructs in the Conceptual Model

All three theories contain beliefs that relate to a person's perception of their own abilities to successfully perform a behavior (behavioral beliefs in the Theory of Planned Behavior, self-efficacy beliefs in Self-efficacy Theory, and capability beliefs in Motivational Systems Theory). These beliefs are all related to self-perceptions. In the conceptual model, a category of "self-referential beliefs" attests to the importance of this type of belief.

In addition, both the Theory of Planned Behavior (TPB) and Self-efficacy Theory contained constructs related to evaluations of outcomes of performing a behavior (behavioral beliefs in the TPB and outcome expectancies in Self-efficacy Theory). This category of beliefs is called "behavioral beliefs" in the conceptual model to highlight that these are beliefs specifically *about a particular behavior*. One's beliefs about the behavior, and whether those evaluations are positive or negative, have been shown to be influential.

A third area of similarity in the theories is in treatments of beliefs about external aspects of the environment and their support of one's performance of a behavior. In the TPB, both normative beliefs and the external control beliefs contain aspects of this type of belief. Normative beliefs are concerned with beliefs about other people's influence, while external control beliefs deal with beliefs about the influence of other, non-human aspects of the environment. In Motivational Systems Theory, context beliefs encompass both normative and external control beliefs. In the conceptual model, "contextual beliefs" is the term given to beliefs that deal with human and non-human aspects of the environment.

One other construct has been shown to be influential in studies of intentions and behaviors. Evidence exists to show that past behavior may be important in predicting future behavior (Conner & Armitage, 1998). In critiquing the Theory of Planned Behavior (TPB), some researchers felt that perceived behavioral control was just an "indicator of past behavior," although Ajzen & Madden (1986) found that perceived behavioral control still improved prediction of intention after controlling for past behavior. Nevertheless, many researchers argue that past behavior independently predicts intention and behavior and therefore should be added to belief theories (Bagozzi & Kimmel, 1995).

Past behavior could be very important in studying teachers. Use of certain teaching strategies in the past could make them easier to use in the future, and therefore make the incorporation of new strategies that much more difficult. Many researchers cite the role of past experiences in school and in student teaching as greatly affecting the beliefs teachers hold and the way they teach (Johnston, 1992; Su, 1992). Zint (2002) found that adding past behavior to the TPB significantly improved prediction of science teachers' intentions to teach students about environmental risk.

The strength of this new conceptual model is that it clarifies and simplifies similar aspects of several competing belief-behavior theories. This model is concise and streamlined, and can be useful to researchers because it only includes those aspects of the theories that research has shown repeatedly to be influential in the belief-behavior relationship. This theoretically sound model can be tested in future research as a framework for data collection.

Summary

It is evident from this review of the literature that several prominent belief-behavior theories have similar constructs. A proposed conceptual model hypothesizes that these similar constructs can be combined in a comprehensive framework to study science teachers' beliefs and practices. Specifically, evidence suggests that constructs such as behavioral, self-referential, and contextual beliefs are particularly useful in exploring subsequent motivation and behavior of science teachers. Additionally, past behavior could help researchers in exploring and explaining why teachers teach the way they do. The more that is known about how teachers' beliefs and behavior interact, the more can be done to help them teach in ways that will be beneficial to students.

One technological tool that has been shown to enhance student learning is the computer. The next literature section will explore computer use in education and how computers can enhance student learning. It will be followed by a literature section that links teacher beliefs to their computer use, thereby affecting student outcomes.

Computers in Education

As computers have become more ubiquitous in schools, some people have questioned the benefits of their use, while others have championed them. The arguments against computer use include physical problems from sitting and looking at a computer screen, isolation from peers, reduced outdoor activity, loss of creativity, and even decreased achievement in school (e.g., Cordes & Miller, 2000; Papanastasiou, Zembylas, & Vrasidas, 2003). Although some of these concerns have merit and should be acknowledged and thoughtfully addressed by educators, I will approach this part of the literature review with the assumption that computers are a fact in education (at this point in time), can be beneficial to students if used properly (I will review studies that provide evidence for this), and teachers can learn to use them in ways that are most beneficial to students.

This section of the literature review explores the state of computer technology integration in education, outcomes of computer use for student learning and instruction, and recommendations for best practice in teaching with computers. A brief overview of attempts at introducing educational media into schools over the past 80 years is instructive as a backdrop to current efforts with computers.

A Brief History of Educational Technology Integration

The phrase "educational technology" is often thought to be synonymous with computers in education. However, technology in education, specifically electronic media, has included film, radio, television, videocassette recorders, and other machines before the introduction of computers to the classroom. Although this paper is concerned with computers, it is informative to review the history of these other educational technologies because of the similarities in which they were introduced, promoted, used, and not used. By understanding the history of educational technology, we can have more realistic expectations of what we can expect educators to do with computers and what computers can realistically offer educators.

Examples of educational radio and television will be used to illustrate the pattern of electronic technology introduction in schools. These patterns will mainly be summarized from Cassidy (1998) and Cuban (1986). Radio was introduced to education in the 1920s to much fanfare (Cassidy, 1998; Cuban, 1986; Trotter, 2000). Yet by the 1940s, its popularity for education had waned. In the 1950s, the newest thing was television in the classroom (Cassidy, 1998). There were major efforts to integrate television into instruction in the 1960s, but like radio before it, the promise was never realized and the use of television slowed by the 1970s.

Many politicians and educators had high hopes for both radio and television in education (Cassidy, 1998). Throughout the last century, whenever new electronic media was introduced to schools, enormous expectations accompanied it (Cuban, 1986). The proponents of each type of new media had similar praise for the latest technology. For example, Hugo Gernsback wrote in 1924 that "radio to the young man today is a valuable college education. It not only trains the mind to useful and careful thinking…radio to the youth is the best possible foundation of the future self made man" (Gernsback, 1927, p. 897). William Levenson (1945) predicted that "the time may come when a portable radio receiver will be as common in the classroom as the blackboard. Radio instruction will be integrated into school life as an accepted educational medium."

Cassidy (1998) outlines the common themes found in this praise: solving societal problems, improving learning, and increasing efficiency in education. The first of these themes involved the idea that the technology could solve a "serious national problem" (p. 174). In the case of radio, the need for instilling democratic values was the argument. The radio was introduced to education between the two world wars, and radio was seen as a way to both teach democratic "propaganda" and help children to be "critical listeners so that they would not fall victim to the influence of non-democratic messages" (p. 174). When television came on the scene in the 1950s, it was seen as a way to help the U.S. be competitive during the time of the Cold War. There was a shortage of teachers, and television was seen as a way to reach a maximum number of students. An experiment to bring high quality education to large numbers of students through educational television was conducted in American Samoa between 1964 and 1970 (Cuban, 1986). Lyndon Johnson expressed his praise for the experiment in 1968 when he said, "Samoan children are learning twice as fast as they once did, and retaining what they learn…[T]he one requirement for a good and a universal education is an inexpensive and readily available means of teaching children. Unhappily, the world has only a fraction of the teachers it needs. Samoa has met this problem through educational television" (Cuban, 1986, p.30).

Another common theme in the promotion of new technology in schools was that the media would increase and improve learning (Cassidy, 1998). Radio was thought to be more engaging to students and to make subjects come alive. In addition, it was thought that children remembered things more readily when learning with radio. Television was thought to be more interesting and relevant to students than traditional forms of instruction: television was said to "provide the closest thing to real experiences for many children" (King, 1954, p.20). It was thought that both radio and television were more efficient in delivering information as well (Cassidy, 1998). A third theme was about how the technology could improve teaching. Both radio and television, it was argued, could transmit instruction from the best teachers to a multitude of students. Classroom teachers would also learn from these expert teachers as they listened and watched.

Many of these same arguments are used in conjunction with computers today. Early hype about computers even predicted the technology would completely revolutionize education, as evidenced by this quote from Seymour Papert in 1984.

> There won't be schools in the future…I think the computer will blow up the school. That is, the school defined as something where there are classes, teachers running exams, people structured in groups by age, following a curriculum-all of that. The whole system is based on a set of structural concepts that are incompatible with the presence of the computer (Cuban, 1986, p. 72).

Although schools and teachers clearly still exist after the introduction of computers, it remains to be seen if the use of computers will follow the pattern of electronic media before it; high expectations, large investments, integration by a minority of educators, and then a loss of popularity.

One contributing factor that could help explain this pattern is the incredible rate at which technology changes in our modern society. As radio was losing popularity in education, television was the new, exciting machine in American homes (Cuban, 1986). It is possible that before teachers could really extract the potential of television in education, computers came on the scene. Some researchers posit that new technologies are being introduced much more rapidly than schools can integrate them, based on the relatively slow rate of educational change (Cuban, 1986; Goodlad, 1993). However, use of radio in schools was already decreasing before television was introduced, and television was already relegated to occasional use before computers were introduced (Cuban, 1986). The rate of introduction of new technologies in schools is most definitely a factor, but I propose in the third section of the literature review that other important contributors to the situation are characteristics of the teachers who use technology and the contexts in which educational technology is used.

Regardless of the future of technology in education, there has been an incredible investment in computer hardware in U.S. schools in the past 20 years. In 1988, there were an estimated 27 students per computer (Peck, Cuban, & Kirkpatrick, 2002). Just 10 years later in 1998, there were six students per computer (not necessarily with Internet connection) in public schools (Levin, Hurst, & Burns, 2000), and five students per computer in 2000 (Cattagni & Farris, 2001). By 2000, 98% of public schools had computers that were connected to the Internet. This percentage went up from 89% in

1998 and from 35% in 1994. Is this access equally distributed among schools and among different students?

Gender and Equity Issues with Computers in Education

Several important issues have accompanied the integration of computer technology in schools, namely gender and equity problems. Differences in access and learning between girls and boys and between advantaged and disadvantaged students and schools is a problem in many areas of education, most notably in math, science, and technology (Mark, 1992; North Central Regional Educational Laboratory, 2002a, 2002b). Although these problems have by no means been solved, several reports and studies show that their impact in the area of educational computing is being addressed. As this section is mainly focused on aspects of teachers' use of computers in instruction, only a few articles related to gender and equity will be reviewed.

There is still an unequal distribution of computer equipment across schools. Poorer schools still had more students per computer in the year 2000 (Cattagni & Farris, 2001) than more affluent schools. Schools with over 75% of their students eligible for free lunch had a ratio of nine students per Internet connected computer compared to six students per Internet computer at schools with less than 35% of students eligible for free lunch. Although these differences still exist, the gap in access to computer equipment between low poverty and high poverty schools has been closing in recent years (Cattagni & Farris, 2001). Federal programs, such as E-Rate, have helped provide discounted equipment to underserved schools (Milkin Family Foundation, 2002). Unfortunately, differences in use of computers in these schools still exist. For example, a recent report by the National Center for Education Statistics (NCES) (2000) found that teachers in schools with less poverty and a lower population of minority students were "more likely to use the Internet for a wide range of activities…including instructing students" than schools with high poverty and high minority populations (p. ii). Although gender inequities with computers exist, when girls have equal access to computers they do not differ in achievement from boys (Mann, Shakeshaft, Becker, & Kottkamp, 1999). Once all schools become better equipped with computer technology, the important question remains. How do computers enhance desired student outcomes?

Outcomes of Computer Use in Education

The Milken Family Foundation commissioned a review of several large-scale studies on the effectiveness of computer technology in education (Schacter, 1999). One of these was a meta-analysis of 500 research studies on computer-based instruction conducted by James Kulik (1994). Computer-assisted instruction (CAI) was the most prevalent form of educational software during the 1970s and 1980s, and is still used extensively in schools (Hannafin, Hannafin, Hooper, Rieber, & Kini, 1996). CAI mainly consists of tutorial, drill-and-practice, and tutoring programs (Cotton, 1991). The aim of these programs is to improve the user's ability to solve specific problems (e.g., in mathematics) and understand specific content. Often this is achieved through repetition with directed feedback and successive increases in problem complexity (Hannafin et al., 1996). Overall, Kulik (1994) found in comparing the 500 studies that students exposed to CAI scored significantly higher on standardized achievement tests than students not using CAI (64^{th} percentile compared to 50^{th} percentile). In addition, students learned the same content faster using CAI than students in traditional instruction, and they had more positive attitudes about the subjects.

In another study reviewed by the Milken researcher, 950 fifth-grade students taught by 270 teachers using the West Virginia Basic Skills/Computer Education (BS/CE) program, showed significant improvement in standardized test scores (Stanford 9) (Mann et al., 1999). A separate study by Solmon (2000) showed that when comparing the cost of implementation and gains in achievement from the BS/CE program with other reform initiatives, the "BS/CE program was more cost effective in improving student achievement than 1) class size reduction from 35 to 20 students, 2) increasing instructional time, and 3) cross age tutoring programs" (Schacter, 1999).

The clearest benefit from computer-assisted instruction (CAI) is as a supplement to traditional forms of teaching that emphasize improvement on standardized tests of facts and simple problem-solving abilities (Cotton, 1991). CAI programs help students learn these skills more quickly and more easily than traditional instruction without computers, and help them retain knowledge longer. Nevertheless, with the increased emphasis on cognitive, social, and constructivist learning theories in the last 10 years, many researchers and educators argue that these so-called benefits are not serving students well, since they reinforce decontextualized learning and lack of student empowerment over learning (Cadiero-Kaplan, 1999; Schacter & Fagnano, 1999).

Cadiero-Kaplan (1999) outlined some of the benefits of using computer technology in education beyond raising student achievement through use of drill-and-practice software. These benefits include the creation of an environment in which students are encouraged to "evaluate, manipulate, and present…ideas while demonstrating understanding of curriculum concepts" and to have more control over their learning (p. 15). Concurrently, the use of computers in instruction can cause the teacher to become less of a giver of knowledge and more of a facilitator of learning as the student gains independence. Rather than putting a premium on learning facts and figures, as does drill-and-practice software, this use of computer technology promotes higher-order thinking skills, collaboration among students, and solving problems in creative ways. There is some evidence that as teachers use more computers in their teaching, these types of outcomes become more prevalent (Apple, 1995; Schacter & Fagnano, 1999; Wishart & Blease, 1999).

Cadiero-Kaplan (1999) outlines the necessary environment for successful integration of computer technology in instruction (Table 1). The keys to this environment are access to equipment, availability of multiple resources, and use of the technology as a tool for learning. It is important to realize that the act of fulfilling all of these requirements does not guarantee the computer technology will be utilized effectively. Access to this type of environment, however, can help move both teachers and students towards change in instruction and learning.

Table 1: Recommended environment for effective computer technology integration in instruction (from Cadiero-Kaplan, 1999, p. 18).

Computer Technology…
• is available to all students equally
• is part of the learning process
• includes reading, math, and writing software programs
• includes word processing and database software
• is integrated across curriculum areas
• is information rich, with access to CD-ROM and WWW sources
• includes multimedia software
• is capable of producing dynamic student products
• is capable of accessing outside information sources

In a test of this assertion, the Apple Classrooms of Tomorrow (ACOT) research project equipped five schools with many types of technologies including computers, related hardware, and software (Apple, 1995; D. C. Dwyer, Ringstaff, & Sandholtz, 1990a, , 1990b). Teachers and students had unlimited access to these technologies. In addition, ACOT provided teachers with training and technical support throughout the project. ACOT researchers studied changes in the classrooms and schools over ten years, starting in 1985. Table 2 outlines some of the changes that were observed in instruction, teacher and student roles, and use of technology over the course of the study (Apple, 1995). Although teachers struggled as their assumptions about teaching and learning were tested, many of them ended up changing the way they taught after a number of years in the study (Dwyer et al., 1990a). Students became more independent in their learning and began to share in the decision-making process of instruction. Other benefits of technology integration included reduced absenteeism and a higher percentage of high school students enrolling in college (D. Dwyer, 1994). Students in schools that placed an emphasis on raising student achievement scored significantly higher on standardized tests of vocabulary, reading comprehension, and mathematics. Students in schools that did not emphasize test scores performed equally well as students in non-ACOT classrooms, although they spent less time on the standard curriculum.

Table 2: Changes in teaching and learning from "traditional" to "knowledge construction" that occurred during the ACOT study (from Apple, 1995, p. 13).

Classroom Element	Beginning of Study (Traditional)	End of Study (Knowledge Construction)
Activity	Teacher-centered and didactic	Learner-centered and interactive
Teacher role	Fact teller and expert	Collaborator and sometimes learner
Student role	Listener and learner	Collaborator and sometimes expert
Learning emphasis	Facts and replication	Relationships and inquiry
Concept of knowledge	Accumulation	Transformation
Demonstration of success	Quantity	Quality
Assessment	Norm-referenced and multiple guess	Criterion-referenced and performance portfolios
Technology use	Seat work	Communication, collaboration, information access, and expression

While the ACOT project studied changes when computer access and support were ideal, Wishart & Blease (1999) studied changes in a school in which teachers and students did not always have immediate access to computers. Wishart & Blease studied changes in instruction and learning when a computer network was installed in an English secondary school for the 1996-1997 school year. The network was installed in computer labs in some departments, and in classroom in other departments. The researchers surveyed teachers and students both in the middle and end of the school year. At the end of the year, 92% of the teachers' survey comments reported changes in student learning from using the computer network, and the vast majority were positive. Changes included increased motivation, better products, improvement by less able students, increased learning of relevant job skills, and more independent and enhanced learning experiences. Negative changes included increased ability of students to waste time and the lack of access to relevant software. Sixty-two percent of the students' survey comments also reported changes in their learning at the end of the year. Only 1% of comments indicated a negative effect. Positive changes included increased ease in learning, assistance with research, more enjoyment of learning, ability to work more quickly and produce higher quality products, and assistance with homework.

There was less agreement between teachers and students about changes in teaching over the course of the year. Seventy-five percent of teachers' initial survey comments showed a change in teaching, although 14% of those indicated that using computers made teaching more difficult. At the end of the year, only 4% of teacher comments were negative. Positive changes included lesson improvement, ability to differentiate lessons for different students, improvement in lesson preparation, and ability to give students independent and open-ended work. On the other hand, 53% of students in the initial survey did not feel that teaching had changed with the use of computers. They felt that teachers basically taught the same way. Those that did see changes in teaching reported that lessons were more motivating and allowed the students to be more independent. In the year-end survey, fewer students reported no change in teaching (46%), but the percentage was still much higher than teachers (28%).

When teachers were asked why their teaching did not change, their comments included some of the common factors that research has shown to create barriers to computer integration, including lack of access, software, time, and experience (Fabry & Higgs, 1997; Rogers, 2000; Willis & Mehlinger, 1996). Eleven percent of teachers stated that they consciously chose not to change their teaching. Wishart & Blease (1999) conclude that attitudes, instruction, and learning did improve over the year, but that more changes (in teaching especially) would have been seen if some of the barriers mentioned were diminished.

Neither the ACOT studies nor Wishart & Blease's study described the specific computer software applications used by teachers and students. Schacter & Fagnano (1999) reviewed other studies that showed promising outcomes from using certain kinds of computer programs. The authors recognized that studies of computer-assisted instruction have shown increased student achievement on tests, but argue that these mainly drill-and-practice programs do not help students learn other valuable skills and abilities. Although non-drill programs are less studied, they have the capability to help students learn collaboration, communication, higher order thinking, problem solving, and other important skills that are not composed of the facts that appear on traditional forms of assessment. Schacter & Fagnano (1999) reviewed studies of several programs that promoted these less tested, but highly desirable, educational goals.

For example, Computer Supported Collaborative Learning applications help students learn collaborative skills. One such program, the *Computer Supported Intentional Learning Environment* (CSILE) (Scardamalia & Bereiter, 1996), allows students to ask each other questions, review those questions and answers, and revise answers as they build knowledge together. This program has been shown to improve students' thinking skills, ability to think independently, and depth of understanding (Schacter, 1999; Schacter & Fagnano, 1999). Additionally, students who use this program scored better on standardized language and vocabulary tests than students not using the program.

Two other programs, *Thinkertools* (Frederiksen & White, 1997) and *SenseMaker* (Bell, 1997), were designed to help students collaborate and reflect during scientific research. Studies with middle school students showed that using these tools improved students' ability to understand science concepts and to understand evidence and arguments (Schacter & Fagnano, 1999).

Logo is a computer programming language that allows students to design and create programs, therefore helping them to construct knowledge by doing (Papert, 1993). It was created specifically to promote a constructivist learning philosophy. In two studies (Harel, 1988; Harel & Papert, 1991), children used *Logo* to create educational software for other students about fractions. The students not only learned programming, but they also understood fractions better than students who were taught in a traditional math class (Schacter, 1999; Schacter & Fagnano, 1999).

Other categories of computer software have also showed promising learning outcomes (see Table 3 for examples of other types of educational computer software). Hypermedia is created with programs that allow the user to access "nonsequential, nonlinear" information in the form of text, graphics, video, animation, and sound (Jonassen & Reeves, 1996, p.703). *HyperCard* is one of the best-known types of hypermedia programs. Hypermedia is used as a cognitive tool when users successfully integrate the new information with their existing knowledge. As Jonassen & Reeves (1996) point out, this outcome is not trivial to obtain. Users often need assistance in the form of cues and explicit directions from the programs in order to learn the content. As hypermedia programs have become more sophisticated, teachers have been having students use them to create their own presentations, thereby combining the benefits of learning by doing with the capabilities of hypermedia software to incorporate graphics, videos, and sound (e.g., *PowerPoint*).

In a study of outcomes associated with hypermedia programs, seventh and eighth grade students used hypermedia software to create interactive displays for a local zoo (Beichner, 1994). Not only were students highly engaged in the project, they also learned the science content associated with the zoo topics. In another study, eight graders of both high and low ability worked on hypermedia presentations about the civil war using *HyperAuthor* software (Lehrer, 1993). Both high and low ability students were equally engaged in the activity that lasted over a period of seven months. These students did not perform better than students in a traditional class on a test of civil war knowledge, but they did retain their knowledge much longer than the control group. When all students were interviewed a year later, the hypermedia group remembered "elaborate concepts and ideas that they had extended to other areas of history" (Jonassen & Reeves, 1996, p.705), while the control group remembered almost nothing about the civil war.

Table 3: Categories and examples of computer software used in schools.

Categories of educational computer software	Examples of software programs
Computer-assisted Instruction (drill-and-practice, tutorials, tutoring systems)	Math Blaster, Typing Tutor
Reference	Encarta Encyclopedia, various CD-ROMs, Internet
Simulations	SimCity, Voyage of the Mimi, Oregon Trail
Hypermedia	Hypercard, HyperAuthor, PowerPoint
Collaboration and communication	Computer Supported Intentional Learning Environment (CSILE), Thinkertools, SenseMaker, Kid's Space, Internet
Programming	Logo
Utility (word processing, data bases, spread sheets)	Microsoft Word, Filemaker Pro, Excel
Semantic Networking	SemNet, Inspiration, Mind Mapper
Data Collection Tools	Probeware (including probes and software for real-time graphing and analysis), e.g., temperature probes, motion detectors, pH sensors

This section provided a picture of the types of outcomes that computers can help students attain. A number of these outcomes are considered by some educational researchers to be less desirable, such as the enhanced ability to remember decontextualized facts (e.g., Cadiero-Kaplan, 1999). Other outcomes come closer to what many researchers would describe as best practices for teaching with computers. The next section will explore the recommendations for best practice found in the literature on teaching with computers. These same best practice recommendations can be found in the literature on other subject areas, including science, with computers playing the role of a tool for implementing the recommendations.

Recommendations for Best Practice

The previous section highlighted research that has shown benefits to students from using computers. Not only can computers help students perform better on traditional tests of knowledge, they can also help students gain better conceptual understanding in many disciplines and become more independent and active participants in their learning process. These benefits can only occur with proper teaching strategies. In this next section, I will specify some of the recommendations for best practices in teaching with computers that can to lead to these beneficial student outcomes.

Constructivism as an Educational Theory Base

One of the most influential theories in modern educational practice has been Constructivist Learning Theory (Matthews, 1998; Piaget, 1954; Tobin, 1993). Constructivism is a complex theory with many subtleties and iterations, but researchers and educators have successfully applied aspects of it to instruction. Many leading and influential educational researchers (for example: Rodger Bybee in science education and David Jonassen in educational technology) base their instructional recommendations on the central constructivist idea that there is no absolute truth or knowledge except what is built by individuals or groups (Bybee, 1993; Bybee et al., 1989; Jonassen, Peck, & Wilson, 1999). People "construct" knowledge based on personal and shared experiences and fit new information into existing mental schema. Therefore the learner, with his or her past experiences and characteristics, becomes the most important player in the learning process. A teacher cannot impart knowledge, but only serves as a facilitator for the learner to create his or her own knowledge. Instructional practices based on constructivist theory should help students construct their knowledge. These best practices provide opportunities for experiences and reflection to allow the learner to integrate new information.

Strategies that Promote Best Practice

Jonassen, Peck, & Wilson (1999) sum up the ideas of best practice in teaching with computers as those that promote meaningful learning, which they contend is "at the heart of…constructivism" (p. 2). Two major recommendations to achieving constructivist-oriented meaningful learning are repeated in the literature on both teaching with computers and science education. These are the ideas of student-centeredness and inquiry (Bybee et al., 1989; Jonassen et al., 1999; Pedersen & Liu, 2003). Note: I will be presenting common recommendations from the literature instead of arguing for or against the recommendations.

Student-centeredness encompasses the constructivist idea that the learner is the one who makes meaning through experience, rather than the teacher providing meaning to the learners (e.g., teacher-centeredness) (Alexander & Murphy, 1998; Jonassen et al., 1999; Marshall, 1998). Student-centeredness (or learner-centeredness) is defined by McCombs & Whisler (McCombs & Whisler, 1997) as

> The perspective that couples a focus on individual learners (their heredity, experiences, perspectives, backgrounds, talents, interests, capacities, and needs) with a focus on learning (the best available knowledge about learning and how it occurs and about teaching practices that are most effective in promoting the highest levels of motivation, learning, and achievement for all learners). This dual focus then informs and drives educational decision making.

The American Psychological Association developed 14 psychological principles to assist educators in developing programs that use a learner-centered focus (APA Work Group of the Board of Educational Affairs, 1997). The principles are divided into cognitive and metacognitive factors, motivational and affective factors, developmental and social factors, and individual differences. Some of the principles are listed below, but see Appendix 1 for a complete list and description. The research literature supporting these 14 principles is reviewed in Alexander & Murphy (1998). Note: the term "student-centered" is used most often in this paper. Some authors use the term "learner-centered" to emphasize the lifelong nature of the learning process, rather than something that only occurs in a formal school setting (e.g., Lambert & McCombs, 1998).

Cognitive and metacognitive factors:

- Nature of the learning process: The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience.
- Goals of the learning process: The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge.
- Construction of knowledge: The successful learner can link new information with existing knowledge in meaningful ways.

Motivational and affective factors:

- Intrinsic motivation to learn: The learner's creativity, higher order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty, relevant to personal interests, and providing for personal choice and control.

Developmental and social factors:

- Social influences on learning: Learning is influenced by social interactions, interpersonal relations, and communication with others.

Individual differences:

- Individual differences in learning: Learners have different strategies, approaches, and capabilities for learning that are a function of prior experience and heredity.

These principles are meant to serve as a guide for how to develop learner-centered schools and programs. Using these principles, Brown (2003) describes twelve conditions that are necessary to create a learner-centered environment and gives suggestions for how to achieve those conditions. For example, these summaries of some of Brown's conditions give an idea of what a learner-centered classroom might look like. Notice that these principles and conditions can apply to any classroom in any discipline, including science and the use of computers.

Condition 4: Learning must be active, not passive – Brown states that students must be involved in their learning, meaning they should be actively doing rather than passively listening. He recommends that teachers provide hands-on experiences and that students "be allowed to act on their environments and construct their own knowledge" (p. 101).

Condition 7: Students must be allowed to work together – Brown recommends that teachers create situations in which students can work together on a daily basis, instead of being isolated through individual-focused activities. Within these groups, students "share information and support each other's learning" (p. 102).

Condition 8: Teachers must be facilitators of learning, not just presenters of content – Teachers should not be the keepers of knowledge in the classroom. Instead, teachers should guide students to make meaning of what they are studying. Students should be helped to discover concepts, rather than being told by teachers.

Condition No. 9: Teachers must provide students with choices – Students should be given choices in how they carry out assignments and how they present what they have learned. Teachers should provide multiple ways for students to work with concepts.

Jonassen et al. (1999) applied similar learner-centered principles and conditions to technology, which can be seen in the following quote. "If we accept that our goal, as technology-using educators, is to support meaningful learning, then we should use technologies to engage students in active, constructive, intentional, authentic, and cooperative learning" (p. 7). In order to do this, they recommend using computers to facilitate student thinking and construction of knowledge, rather than to deliver information. This See Table 4 for the roles of technology (e.g., computers) to foster student learning suggested by Jonassen et al. (1999).

Table 4: How technology can foster student learning [modified from Jonassen et al. (1999), p. 13].

Role of computers	Purpose
As a tool to support knowledge construction	• To represent ideas and understandings • To produce organized, multimedia knowledge bases by learners
As information vehicles for exploring knowledge to support learning-by-constructing	• For accessing needed information • For comparing perspectives, beliefs, and worldviews
As context to support learning-by-doing	• For representing and simulating meaningful real-word problems • For representing beliefs, perspectives, and arguments • For defining a safe, controllable problem space for student thinking
As social medium to support learning by conversing	• For collaborating with others • For discussing, arguing, and building consensus among members of a community • For supporting discourse among knowledge-building communities
As intellectual partner to support learning-by-reflecting	• For helping learners to articulate and represent what they know • For reflecting on what they have learned and how they came to know it • For supporting learners' internal negotiations and meaning making • For constructing personal representations of meaning • For supporting mindful thinking

These uses of computers echo Brown's recommendations of learning by doing and collaboration. Many specific strategies have been recommended that help create student-centered learning conditions in general, and specifically through computer-based education (Land & Hannafin, 2000). Learning cycles are lesson design models that can foster student ownership over learning and active participation (Bybee et al., 1989; Tobin, Tippins, & Gallard, 1994). In addition, learning cycles are also designed to facilitate another best practice recommendation, that of using inquiry-based instructional strategies. The recommendation for inquiry-based instruction can be found in both science education and teaching with computers.

Inquiry is a somewhat problematic term in science education because it been defined differently in different contexts (Windschitl, 2004). It has been used to describe a general pedagogical strategy of having students delve deeply into topics or concepts using science process or research skills, such as organizing, comparing, inferring, and analyzing. This definition has been tied to problem-based learning in which students use many skills to find answers or create solutions to a broad, ill-defined question or problem (Land & Hannafin, 2000). The term "inquiry" has also been described as a way for students to mimic the work of real scientists by performing experiments through asking questions, designing experiments, collecting and analyzing data, drawing conclusions, and communicating findings, sometimes called the "scientific method."

Learning cycles can help teachers develop activities that incorporate both more process skills-oriented and more scientific experimentation-oriented teaching strategies. They contain from three to seven specific steps that help students discover and understand concepts. For example, one popular learning cycle model, the 5E model, was developed by Rodger Bybee of the Biological Sciences Curriculum Study (BSCS). The BSCS website explains its view of inquiry and how the 5E model supports student doing inquiry (Biological Sciences Curriculum Study, 2004b).

> Our materials reflect the ways in which scientists conduct their work and develop their explanations. Our materials also give students the opportunity to investigate aspects of the natural world in much the same way. For example, our materials provide students with opportunities to make observations, pose questions, study what scientists currently know, design and carry out investigations, and develop explanations based on evidence.

The 5E model has five stages. They are Engage, Explore, Explain, Extend, and Evaluate. See Table 5 for a description of each stage in the model.

Table 5: Description of the 5E teaching model (Biological Sciences Curriculum Study, 2004a).

Stage	Description
Engage	The instructor assesses the learners' prior knowledge and helps them become engaged in a new concept by reading a vignette, posing questions, doing a demonstration that has a non-intuitive result (a discrepant event), showing a video clip, or conducting some other short activity that promotes curiosity and elicits prior knowledge.
Explore	Learners work in collaborative teams to complete activities that help them use prior knowledge to generate ideas, explore questions and possibilities, and design and conduct a preliminary inquiry.
Explain	Learners should have an opportunity to explain their current understanding of the main concept. They may explain their understanding of the concept by making presentations, sharing ideas with one another, reviewing current scientific explanations and comparing these to their own understandings, and/or listening to an explanation from the teacher that guides them toward a more in-depth understanding.
Extend	Learners elaborate their understanding of the concept by conducting additional activities. They may revisit an earlier activity, project, or idea and build on it, or conduct an activity that requires an application of the concept. The focus in this stage is on adding breadth and depth to current understanding.
Evaluate	The evaluation phase helps both learners and instructors assess how well the learners understand the concept and whether they have met the learning outcomes. There should be opportunities for self-assessment as well as formal assessment.

Computers can be used during many of the stages of the 5E model, and many authors recommend using computers to assist with student inquiry (Apple, 1995; Bruce & Levin, 1997; D. Dwyer, 1994; Jonassen et al., 1999; Papert, 1993). Computers can be used to assist students in collecting and analyzing data during scientific experiments (e.g., with probeware and spreadsheet programs), while also helping them gather and process information (e.g., with the Internet and word processing programs). Presentation software and e-mail can help them communicate their ideas to classmates and off-site peers.

Summary

Research has shown benefits to students from certain uses of computers. Regardless of whether one is convinced or skeptical of the computer's benefits in education, it is important to better understand how teachers and students use computer technology and how they can use it more effectively. Best practices in teaching with computers include making activities more student-centered and assisting with student inquiry. Does research show that teachers are able to implement these best practices? The next literature section will explore the reasons why many teachers are not able to integrate computers into their teaching.

Barriers to Integration of Computers in Instruction

In this next section, I will explore the literature on common barriers to the use of computers in education. I will discuss teacher beliefs as a possible underlying cause of many unsuccessful attempts to integrate computer technology in instruction. I will conclude with frameworks of computer integration that trace teachers' development as they increase their use of computers in instruction.

Several promising examples of educational software, uses, and outcomes have been reported in the literature on educational technology, as I reviewed in the previous section. Despite these encouraging examples, and despite the proliferation of available technology and resources in schools, there is substantial evidence that the majority of teachers are either not integrating computer technology in instruction, or that they are still mainly using drill-and-practice software that does not promote educational goals such as higher-order thinking, student empowerment, and collaboration (Cuban, 1993; Fabry & Higgs, 1997; Peck et al., 2002). What are the reasons cited in the research for this situation?

Research on the disconnect between availability of and emphasis on computer technology and the current conditions of its use in schools focuses on barriers that may keep teachers from effectively integrating technology in instruction. The barriers identified by research can be divided into external and internal factors (Fabry & Higgs, 1997; P. L. Rogers, 2000). A large number of external factors have been described, but the most commonly cited include lack of access to computer hardware and software, lack of training in use and instructional integration of computers, lack of administrative and technical support, lack of funding, and lack of planning time (Fabry & Higgs, 1997; Lam, 2000; Ray, 1991; P. L. Rogers, 2000; Spotts & Bowman, 1993; Willis & Mehlinger, 1996). In an attempt to clarify this laundry list of barriers, Rogers (2000) grouped these external factors into three categories: "availability and accessibility, institutional and technical support, and stakeholder development" (p. 459). Many of these studies conclude that decreasing the extent or impact of these external barriers is the answer to increasing effective technology integration (Fabry & Higgs, 1997; Rogers, 2000).

Internal barriers deal more with personal characteristics of teachers, such as age, gender, anxiety, attitudes, and beliefs (Fabry & Higgs, 1997; Lam, 2000; E. M. Rogers, 1995) (P. L. Rogers, 2000; Willis & Mehlinger, 1996). One type of internal barrier often cited in the literature is that of teachers' fear or anxiety about computers (Lam, 2000;

Yaghi & Abu Saba, 1998). Lam (2000) conducted a study to determine if foreign language teachers chose not to use computers and other technology because of fear or other factors. She surveyed and interviewed 10 graduate students of education about their decisions to use or not use technology (not limited to computers) in their teaching. Lam found that fear was not the main factor that influenced the teachers' decisions to use or not use computers (all used other forms of technology, such as audio cassettes and videos). None of the teachers felt anxious or fearful of using computers. Instead, Lam found that it was the teacher's perception of the utility of the computer for specific tasks rather than anxiety about using computers. If a teacher did not feel the computer was useful, or did not understand how to make it useful, he or she would not use the computer. Teachers also cited many of the external barriers found in the literature, such as lack of professional development, lack of time and funding, and lack of administrative and technical support as barriers to their use of computers.

In a 1997 study designed to further explore the types of barriers experienced by teachers at different levels of integration, Rogers (1997) surveyed 1,000 K-12 teachers about their current use of computer technology and barriers to its use (as cited in Rogers, 2000). She categorized teachers' level of computer integration using a 5-level hierarchy of technology adoption (Hooper & Reiber, 1995) from familiarization to evolution, familiarization being the lowest level of adoption. This hierarchy combines actual use with beliefs that accompany that use. Rogers found that teachers at the two lowest levels of technology adoption (94%) were significantly more likely to report external barriers. Those at higher levels of integration, although a minority of respondents, reported significantly fewer external barriers. Rogers concludes that there is a reciprocal relationship among the different types of external barriers and internal barriers (e.g., beliefs).

Czerniak, Lumpe, Haney, & Beck (1999) conducted a study that further corroborates the influence of beliefs as a potential barrier to computer use by teachers. They found that it may be the *belief* in the presence of external barriers that cause teachers to act or not to act, rather than the *actual* presence of those barriers. The researchers first interviewed a small group of teachers about the beliefs that were most important in their decisions about computer use (n=33). The responses were then converted into a questionnaire based on the Theory of Planned Behavior (Ajzen & Fishbein, 1980). A second group of teachers (n=204, 41% return rate) completed the questionnaire. The researchers found that teachers did believe that using computer technology was beneficial to students, but they also believed that they lacked the basic support needed to effectively use computers. They felt they were lacking in support from other people (administrators, colleagues and parents), resources (funding and equipment), technical support, training, and time (to plan and implement). All of these barriers have been identified in other research, but in this case it was the belief that these barriers existed that impeded computer integration. A relatively new, but growing, field studies the links between teacher beliefs and their instructional choices, specifically related to computer technology.

Teacher Beliefs and Use of Computers

Exploring the links between teacher beliefs and a broad spectrum of factors in education is a growing field, evidenced by the number of studies and literature reviews conducted in the past 15-20 years (Crawley, 1990; Fang, 1996; Gibson & Dembo, 1984; Guskey, 1988; Haney et al., 1996; Kagen, 1992a; Lumpe et al., 1998a; Nespor, 1987; Pajares, 1992; Potter, 2000). Within this field of teacher beliefs, only a few studies have focused specifically on the link between teacher beliefs (an internal barrier) and use of computers. As computers become more common in education, this research area is becoming more crucial to understanding how teachers do and do not utilize this important technology. The initial research highlights the major role that teacher beliefs may play in their adoption and integration of computer technology in instruction.

Niederhauser & Stoddart (1994) studied what teachers believe about the uses of technology and how that translates into the way they use it in the classroom. Teachers were asked to rate, using a Likert scale, the effectiveness of computers in helping attain learning goals in the classroom (n=2170, 63% return rate). Using a factor analysis, the researchers found that two factors explained almost 50% of the variance in answers. The factors represented two ways that teachers believe computers are effective in instruction; 1) Construction of Knowledge and 2) Transmission of Knowledge (Niederhauser & Stoddart, 1994).

The survey also asked teachers to list the names of software they used in the classroom. The researchers coded the software according to its type, either transmission-oriented or construction-oriented. In analyzing their results, the researchers found that teachers who had more construction of knowledge views of technology used significantly more construction-oriented software, and teachers who had more transmission of knowledge views of technology used more transmission-oriented software. In addition, teachers who held more transmission of knowledge beliefs tended to use more drill-and-practice activities with their students, such as *Math Blaster* and *Typing Tutor*. Teachers with construction of knowledge beliefs had their students use computers for word processing, interactive games, exploration, programming, and other more construction-oriented activities.

In a study of one teacher's attempt to use computers to teach mathematics, Myhre (1998) found that the teacher's beliefs were very consistent with her practice. She integrated computers as often as she could, both with her own classroom computers and the computers in the school's lab. This corresponded well to her belief in the importance of keeping up with current educational practices. She felt that computers "represented the future" and were therefore a "necessity in a modern classroom" (p. 100). However, the majority of what she used the computers for was to drill students with mathematical problems. This too corresponded with her belief that learning mathematics mainly consisted of a series of procedural steps to be memorized. The computer presented an efficient way for her to present a variety of problems to students and allow them to have rapid feedback on their work. Myhre concludes that this teacher is unlikely to transform her teaching practices due only to the introduction of computers.

Another study investigated two teachers' development of a software program (Hinostroza & Mellar, 2000). These teachers' beliefs had a large influence on the ultimate product. The teachers saw the computer as a tool with two main purposes. The first was to help students practice what they were learning in the classroom, not to teach new content. The second was to help maintain classroom order. Ultimately, the teachers helped to design a piece of software that echoed what they would teach in the classroom. The students would use it to practice, but not learn something new. In addition, the teachers' felt the students' motivation to keep using the computers would take care of behavioral problems. Hinostroza & Mellar contend that it was the teachers' belief in the importance of repetitive practice and classroom management that cause them to use computers for drill-and-practice rather than for higher level thinking skills.

The previous studies examine how teacher beliefs shape the way they use computers. How might the use of computers affect teacher beliefs? The next section describes several theoretical frameworks that attempt to explain how teacher beliefs may change as teachers learn more about computers and are therefore able to use them more effectively.

Frameworks for Computer Integration in Education

Several studies have traced the long-term process that teachers go through when learning about and adopting computers in the classroom (D. Dwyer, 1994; Hadley & Sheingold, 1993). These studies describe the process as a series of stages that often ultimately end with reorganization of teaching practices. These stages are reminiscent of the process teachers go through as they move from novice to expert (Fuller, Pilgrim, & Freeland, 1967; Kagen, 1992b; Piland & Anglin, 1993). Both processes involve acquiring new experiences and competencies, confronting prior beliefs, and ultimately gaining new understandings. The caution in all of these studies, however, is that very few teachers actually reach the reorganization stage of computer integration. Therefore, the actual use of computers usually remains at an earlier, and less transformative, stage (Myhre, 1998).

During the long-term Apple Classrooms of Tomorrow studies (reviewed in the third literature review section), researchers saw a pattern of changing computer integration by teachers over time (Apple, 1995). Teachers started at the Entry stage, characterized by simply learning basics about computers and software. Teachers then moved to the Adoption stage, in which they used computers to help them teach in ways that complemented their existing beliefs about teaching and learning, usually corresponding to traditional teacher and student roles. The next two stages were Adaptation and Appropriation, in which teachers used computers to motivate students, improve student work, and finally to foster cooperation among students and project-based learning. The final stage for teachers in the ACOT studies was Invention. In this stage, teachers were discovering and creating new ways to integrate computer technology whenever it would enhance or extend student learning. The change in beliefs that accompanied this metamorphosis is evident from the following representative teacher comment.

> As you work into using the computer in the classroom, you start questioning everything you have done in the past and wonder how you can adapt it to the computer. Then, you start questioning the whole concept of what you originally did. I guess I have to realize that what I am doing is learning how to undo my thinking (Dwyer, 1994).

Hooper & Reiber (1995) propose a similar model of computer integration stages. In their model, the first stage is called Familiarization, in which teachers learn of the existence of computer technologies but don't use them because they don't perceive them as useful. At the next stage, Utilization, teachers try the technology but still do not actively use it in any way. The next stage is Integration. In this stage, teachers use computers often as part of their teaching. Teachers at this stage may not change their beliefs about teaching and learning, but rather use computers to support their traditional ways of teaching. Teachers may proceed to the Reorganization stage, at which point they do confront their beliefs and become facilitators of student learning instead of possessors and givers of knowledge. The ultimate stage in this framework is that of Evolution. At this stage, like the Invention stage in the ACOT study, the teacher uses the computer as a tool to enhance student learning in whatever way is appropriate.

Reinking, Labbo, & McKenna (2000) model their computer integration framework on parts of Piaget's developmental learning theory. In their admittedly simplified explanation of Piaget's theory, people must first assimilate new information into existing knowledge structures before they can truly accommodate it by changing those existing knowledge structures. The ability to actually learn something new comes with experience and maturity. It follows then that a person could lack the experience and maturity necessary to learn something new at a given time, but be able to learn it later.

Reinking et al. (2000) posit that their framework would apply to teachers learning to use new technologies, such as computers. Teachers are at the assimilation stage when they use computers in a way that fits in with their existing instructional strategy. For example, a teacher might have students individually read an article on the computer from a web-based newspaper instead of reading it from a printed source. At this stage, teachers are not changing their beliefs about teaching or computers. Teachers at the accommodation stage use computers in ways that cause them to rethink and restructure their instructional strategies and therefore their beliefs. The same teacher, once in the accommodation stage, might have students work in groups to research topics of their own interest on the Internet and communicate what they've learned to peers at another school through e-mail.

There are some who would criticize the teacher in the first example for not using the technology to its full potential. Reinking et al. (2000) point out, however, that assimilation is an essential step in the developmental process, and teachers will not be able to reach the accommodation stage without it. Similar to Piaget's learning theory, some teachers will not be capable, due to experience or maturity, to move to accommodation right away. Therefore, teachers at the assimilation stage should be supported. Movement to the accommodation stage should also be encouraged, or there is a danger of a teacher never leaving the assimilation stage.

Reinking et al. (2000) give an example of how this framework has influenced their own work and helped teachers integrate technology into their instruction. In this study, middle-school teachers were encouraged to have their students create "multimedia book reviews" on the computer (Reinking & Watkins, 1996). The book reviews were to be put into a database that students would use to learn about books and choose new reading material. Teachers at the assimilation stage had an easy time integrating the technology in their teaching. They could readily accept the new technology as an extension to the traditional written book report. On the other hand, teachers at the accommodation stage could see the added potential to further student collaboration in designing multimedia projects and creating a system for students to take charge of their own reading choices. When the primary goal is to increase teachers' use of computers, accepting and encouraging those uses that fall in the assimilation stage is necessary. When teachers are developmentally ready to move to the accommodation stage and possibly confront and adjust their beliefs, that transition should also be welcomed and encouraged.

These frameworks provide a systematic way of thinking about how teacher beliefs and computer integration are intimately connected. Understanding the important role of teacher beliefs about computer technology and how those beliefs can change will become increasingly important as teachers are expected to use more computer technology in enhanced ways that facilitate student learning.

Summary

This literature review section dealt with common barriers that could relegate computers to the long list of unsuccessful reform initiatives. These external and internal barriers have been shown to hinder teachers' efforts to integrate computer technology in instruction. As teachers are gaining more access to technology and all educators are becoming more knowledgeable about how to lessen the effect of external barriers, it is more evident that the internal barrier of teacher beliefs is crucial to the successful or unsuccessful use of computer technology in education. Frameworks of computer integration not only show how teaching practices can change as teachers use computers, but how their beliefs may also change in the process.

Research Rationale

This literature review has established the importance of teacher beliefs in influencing general and specific teaching practices. Teacher beliefs influence whether teachers are able to teach in ways that maintain traditional roles for students or facilitate students becoming active participants in learning. How beliefs relate to teaching with computers is a relatively new area of interest in the education community. Researchers are only beginning to study the complexities of the influence of beliefs on teachers' computer use and student outcomes, since the computer is a relatively new educational technology. We do know that past research on teacher beliefs has been plagued by issues relating to specificity of beliefs and lack of knowledge of ultimate behavior needed to establish the link between beliefs and behavior (Fang, 1996; Pajares, 1992).

One of the challenges in research on teacher beliefs is defining and capturing the important beliefs that influence behavior (Fang, 1996; Kagen, 1992a; Pajares, 1992). Methodological issues have been a recurring problem, often leading to conclusions that behaviors are not reflective of beliefs or creating confusion about the relationship between the two (Pajares, 1992; Fang, 1996). This lack of consistency between beliefs and behavior may be due to the researcher having an incomplete picture of a teacher's belief system (Fang, 1996). With these issues in mind, how has past research on beliefs and science teaching practices been formulated?

In studying how teacher beliefs relate to implementation of science education reforms, research has been designed at two ends of a continuum, very narrow and very broad. On the narrow end of the continuum, researchers have asked focused questions about how beliefs influence whether or not teachers will enact specific aspects of a reform after receiving directed training. For example, Crawley (1990) studied 50 upper-elementary and high school teachers who participated in a lengthy, prescriptive professional development institute to learn how to use investigative teaching methods to teach physical science. The teachers learned specific "activities and investigations" that they were expected to use, and the researcher studied how teachers' beliefs influenced their intention to do just that. One of the purposes of Crawley's study was to ascertain if the belief-intention link existed in relation to science education reform activities. In order to determine this, he had to create a system that was very well defined in terms of the behaviors that would constitute the reform and the intentions that were needed to execute those behaviors. He could then look at the beliefs that enabled a teacher to have those specific intentions. His study was very important in that it did establish the link between the kinds of beliefs that mapped to important intentions that he describes as necessary for certain behaviors to occur.

Building on Crawley's work and the verification of the belief-intention link, researchers began to look at more open-ended situations in which teachers had greater choice about how to define behaviors and intentions related to science education reform. On this broad end of the continuum, researchers asked questions about how beliefs related to teachers' intentions to enact any number of aspects of a large-scale reform. For example, one group of researchers investigated, in a series of studies, how beliefs influenced teachers' intentions to execute large-scale science education reform efforts (Haney et al., 1996; Lumpe et al., 1998a, , 1998b). The reforms in question were the State of Ohio's Competency Based Science Model (Haney et al., 1996), using cooperative learning in science teaching (Lumpe et al., 1998a), and incorporating science-technology-society (STS) issues in science teaching (Lumpe et al., 1998b) (these studies were previously reviewed in the literature review section on teacher beliefs). In all three studies, the researchers surveyed large numbers of randomly-selected teachers (>100) about their intentions to implement the reform in question. There was no attempt to define how successful implementation of each reform might look, or to have teachers explain exactly what they would do. In essence, there could be a multitude of intentions that would allow teachers to perform behaviors as part of the reform. These research teams, similar to Crawley's, were still looking for beliefs that would define teachers who would enact reforms, but in a more open-ended sense they were looking for broad patterns of beliefs that could map to multiple positive behavior-related intentions. These studies took into account the fact that teachers make many personal decisions about what they are going to do when teaching. These researchers believe that it may be possible to arrive at behaviors from multiple intention sets and initial beliefs. Among problematic issues in these studies, there was no way to determine if a teacher's idea of implementation would even resemble the true meaning of the reform. Again, these researchers chose not to look at eventual teaching behaviors.

Research at both ends of this continuum provides useful information about the presence of a positive teacher belief-intention interaction. From this previous research, we now know that there is a strong link between general pedagogical and science teaching beliefs, what a teacher believes about a reform effort, and how teachers intend to act in their classroom. Crawley's study helped establish that link, but in a necessarily prescribed system. Lumpe et al. reinforced our confidence in the connection between beliefs and intentions, but also allowed for the reality that teachers have their own understandings of what comprises successful implementation of a reform. In other words, teachers' beliefs may manifest themselves through varying teaching intentions.

The obvious next step in this type of research, and one recognized by all of the aforementioned researchers, is to look at what teachers actually do in the classroom (i.e., teaching behaviors). The belief-intention link has been well established in science education reform, but it is incomplete. O'Hara (2000) took that important next step by studying how one teacher's beliefs influenced his intentions to use computer technology in his classroom and his eventual use of computers in his teaching. O'Hara's study fits on the broad end of the continuum in that she did not define how successful implementation of computers, or specific computer applications, would look in the teacher's classroom prior to establishing a lens through which to conduct the research. Since she was interested in getting a broad sense of his computer use and mapping that back to his intentions and ultimately beliefs, all contact with computers, both by the teacher and students, was taken into consideration. O'Hara looked at the belief-behavior interaction in an open-ended behavior system.

Notably, O'Hara's teacher was confronted by many of the external barriers with which teachers must contend. What would we find if teachers did not have to deal with these barriers? As computers become nearly ubiquitous in schools, and as administrators, teachers, and students become savvier about using them, it will no longer be as easy to claim the excuse of these barriers to explain why teachers do not successfully use computers in their teaching. Sufficient studies have been done that conclude these barriers exist and therefore they are too easily blamed for the lack of successful computer integration.

The following study is crafted to provide for a teaching environment that diminishes these barriers and is as full of support as possible. In addition, the teachers in my study have high comfort, confidence, and experience levels related to teaching with technology. These teachers all teach in the same school, therefore eliminating differences in administrative support and access to technology. Moreover, these teachers have access to a wireless Internet connection and a computer software program that is highly connected to the California science standards and is structured in a way that facilitates many types of instructional uses by teachers and students. In this way, many of the common issues/variables that confound this type of research will be, if not eliminated, then greatly decreased. In accounting for issues of abilities, confidence, experience, administrative support, hardware/software access, curricular relevance, planning time, and professional development, what remains at the heart of this study are three teachers who have the ability, resources, and support to successfully integrate the chosen technology in their science teaching. In this way, the study will be able to isolate and highlight the connections between the teachers' beliefs and actual behaviors organized around a well-defined domain of the integration of computers and computer software into the science curriculum.

In addition, I will delve into the complexity of the teachers' beliefs by getting a holistic profile of their belief system. One important aspect of the belief theories upon which this research is based is that the specificity of the beliefs is important, meaning the type of belief examined should closely match the behavior of interest. The behavior of interest in this research is "using computers to teach science." Therefore, I will focus on behavioral beliefs related to three specific behaviors: 1) teaching with computers, 2) teaching science, and 3) teaching in general.

Research Questions

How do teachers' educational beliefs relate to the ways they use computers, including an interactive, science-based computer software program, to teach science in their classrooms?

- What are the subjects' educational beliefs about teaching with computers, teaching science, and teaching in general?
- Within each of the three educational belief categories, what are the behavioral, self-referential (internal), and contextual (external) sub-beliefs of the subjects?
- How do these three sets of educational beliefs complement and compete with each other in relation to the teacher behaviors of each subject in using computers with students?

CHAPTER 3: METHODOLOGY

Case Study Methodology

This study was conducted using a case study methodology. I chose this methodology because it allowed for an in-depth investigation into teachers' knowledge and beliefs (Levine, 1990). The study was an "interpretive" case study because it was used to "illustrate, support, or challenge theoretical assumptions held prior to the data gathering" (Merriam, 2001, p.38). Stake (1994) calls this an instrumental case study. An "instrumental" case study provides "insight into an issue" (Stake, 2000, p.437). He explains that in an instrumental case study, "the case is of secondary interest, it plays a supporting role, and it facilitates our understanding of something else." The case is chosen to illustrate a particular issue of interest. Selecting cases in this way has been called "purposeful" by Patton (1990) or "criterion-based" by LeCompte, Preissle, & Tesch (1993) (as cited in Merriam, 2001, p.61). In a purposeful or criterion-based selection method, the necessary criteria are determined before the study is conducted and then the cases are chosen because they contain those criteria (Merriam, 2001). As described in a preceding section of this dissertation, this study necessitated the selection of cases in exemplary circumstances in order to limit the number of variables and highlight the issue of interest (i.e., the relationship between beliefs and behaviors in relation to using computers software and the Internet to teach science). This type of sample is also called "unique," because the atypical attributes of the case are what make it especially suited to study (Merriam, 2001).

Backdrop of Study

Although this is not a treatment study, it is important for the reader to know that the teachers in the study participated in long-term, science-based professional development over the two years of the study. As part of the professional development program, teachers were exposed to the interactive computer software program, Cal Alive!—Exploring Biodiversity (Cal Alive!), that was a central part of this study. Professional development is important for teachers to learn to integrate new methods and technologies in their teaching (Czerniak et al., 1999; Fabry & Higgs, 1997; Rogers, 2000).

Professional Development Program

Teachers in the study participated in two yearlong professional development programs administered by the K-12 Alliance. The K-12 Alliance is a statewide professional development network that is part of WestEd's Science and Mathematics Program. WestEd is a Regional Educational Laboratory created by the U.S. Congress. Its Science and Mathematics program "offers services and other support aimed at enhancing the efforts of those who provide K-12 science and mathematics education" (WestEd, 2002).

The professional development program is partially funded by federal and state grants (e.g., National Science Foundation), and schools and districts pay for their teachers to participate. Teacher participants are called Teacher Leaders and are charged with disseminating program methods at their school site. The yearlong K-12 Alliance professional development program consists of the following components: 1) a 10-day science-based summer institute in which Teacher Leaders learn and practice general pedagogical methods, educational leadership skills, and specific science content, 2) a one-day follow-up session in the fall, 3) ongoing support throughout the year from Staff Developers and Regional Directors at the school site, and 4) participation in a Teaching and Learning Collaborative (TLC) process at the school site. During the TLC, which lasts over several days, Teacher Leaders, Staff Developers, and a Regional Director jointly plan, implement, and assess a model lesson that incorporates program methods. Note: Regional Directors are employed by the K-12 Alliance, while Staff Developers are teachers from the school sites who help run the pedagogy and leadership sections of the summer institutes and coordinate activities with other Teacher Leaders at the school site during the year.

Content of the Professional Development Summer Institutes

There were three main parts to the summer institutes: pedagogy, leadership, and science content (including computer technology). Staff Developers and Regional Directors jointly planned and implemented the pedagogy and leadership sections of the institute. The institutes were developed purposefully to incorporate many of the best practices in learning, science instruction, and professional development.

Pedagogy.

The pedagogical mission of the institutes was to create learning opportunities for students so they are active participants in the learning process and develop conceptual understanding of science content. Teacher Leaders were taught methods that assist with conceptual understanding, such as conceptual flows, learning cycles (based on the 5E lesson plan), scientific inquiry, and ongoing decision-point assessment. They also learned student-centered methods that enhance active participation in learning, such as cooperative groupings, assessing prior knowledge, making science relevant to students' lives, and questioning strategies.

Leadership.

Teacher leaders were exposed to theories and models about teaching adults (e.g., Myers-Briggs personality theory) so they would be prepared to conduct staff development programs at their school sites. They were also given opportunities to make presentations about the pedagogical and science content portions of the institutes. They worked in teams to develop presentations, and then received feedback from peers and instructors. On the second to the last day of the institute, school site administrators were invited to attend the Teacher Leaders' final presentations. This participation by administrators served two purposes. One, it raised the level of performance of the Teacher leaders (not to mention anxiety), and two, it helped foster administrative understanding and support for what the Teacher Leaders were doing at the institute, and hopefully at the school site in the future.

Science content.

Teacher Leaders participated in sessions on science concepts related to earth science (year one) and the biological diversity and habitats of California (year two). The theme of year one was "Earth Systems" (e.g., atmosphere, biosphere, lithosphere) and the theme for year two was "Interdependence" (e.g., among organisms and their environments). The Cal Alive! software materials were introduced to the teachers when appropriate to the science content, as were many other materials and methods.

Computer technology component.

Cal Alive!—Exploring Biodiversity (Cal Alive!) is a multimedia resource for teachers and students about California's biological diversity. It consists of three CD-ROMs and a Classroom Guide. The Cal Alive! CD-ROMs are organized into four main areas that focus on different aspects of California's biodiversity and cover selected California State Content Standards in earth and life science. The sections are Tutorials (covering geology, ecology, water and climate, and human interaction with the environment), Habitats (53 representative California habitats), Activities (experiments, stories, and games), and Virtual Field Trips (including 360° virtual panoramas and Fly-by transects across the topography of California).

The Cal Alive! Classroom Guide provides ideas for how to use the CD-ROMs in the classroom. The program was developed to be a resource and not a traditional curriculum, and the Classroom Guide mostly serves as a blueprint for teachers to learn to integrate the technology into their own lessons.

Cal Alive! was developed by the California Institute for Biodiversity (CIB), an education non-profit organization. Each year a CIB instructor (a University of California, Berkeley, lecturer with a Ph.D. in ecology) helped teach the science content portion of the institute in a team with a university professor (from California State University, Fresno), and an experienced teacher.

Subjects

The three middle school teachers who participated in this study were chosen from a group of upper elementary and middle school teachers that attended the K-12 Alliance professional development institute (earth science content section) in the summer of 2001.

Process of Selecting Subjects

During the professional development institute, all teachers in the earth science content section filled out a brief survey each day (with 5-10 questions) about their current use of computer technology, both personal and professional, as well as their general instructional practices and school environments (for a total of 10 surveys per teacher) (see Appendix 2 for background surveys). Teachers provided background information about the number of years they had taught, their level of education, their experience teaching science, and more. These background surveys were used to choose the teachers for the case studies.

Analysis of the responses to the surveys identified the teachers who fit the criteria previously established for the cases (e.g., computer savvy and teaching in schools with access to computers and with administrative and technical support for teaching with computers). The pool of possible subjects was narrowed to three teachers who taught at the same technology magnet school. They scored the highest among the teachers for measures of computer access, computer experience, and administrative support. The ability to choose teachers from the same school also increased the "best case scenario" aspect of the cases, as all the teachers would be experiencing the same administrative support and access to computer equipment for teaching purposes.

Setting

The teachers in this study taught at a school located in a Central Valley school district of California, which I will call Fielding School. Fielding School was newly opened for the 2001-2002 school year, the first year of this study. It was designed as a technology and science magnet school (focused on a space theme) in a small city of 75,000 inhabitants. This city is located in a rapidly growing area of California (about 60 miles from San Francisco), and its population had more than doubled in the last ten years. The population was about 60% white, 25% Hispanic, and 15% was a combination of Asian-American, African-American, and other minorities. The school demographics mirrored those of the city.

School Structure

Fielding School is a year-round school that is organized around four tracks: red, green, blue, and yellow. Each track is in session for three months, with one month off. The tracks are staggered, so at any one time only three tracks are in session.

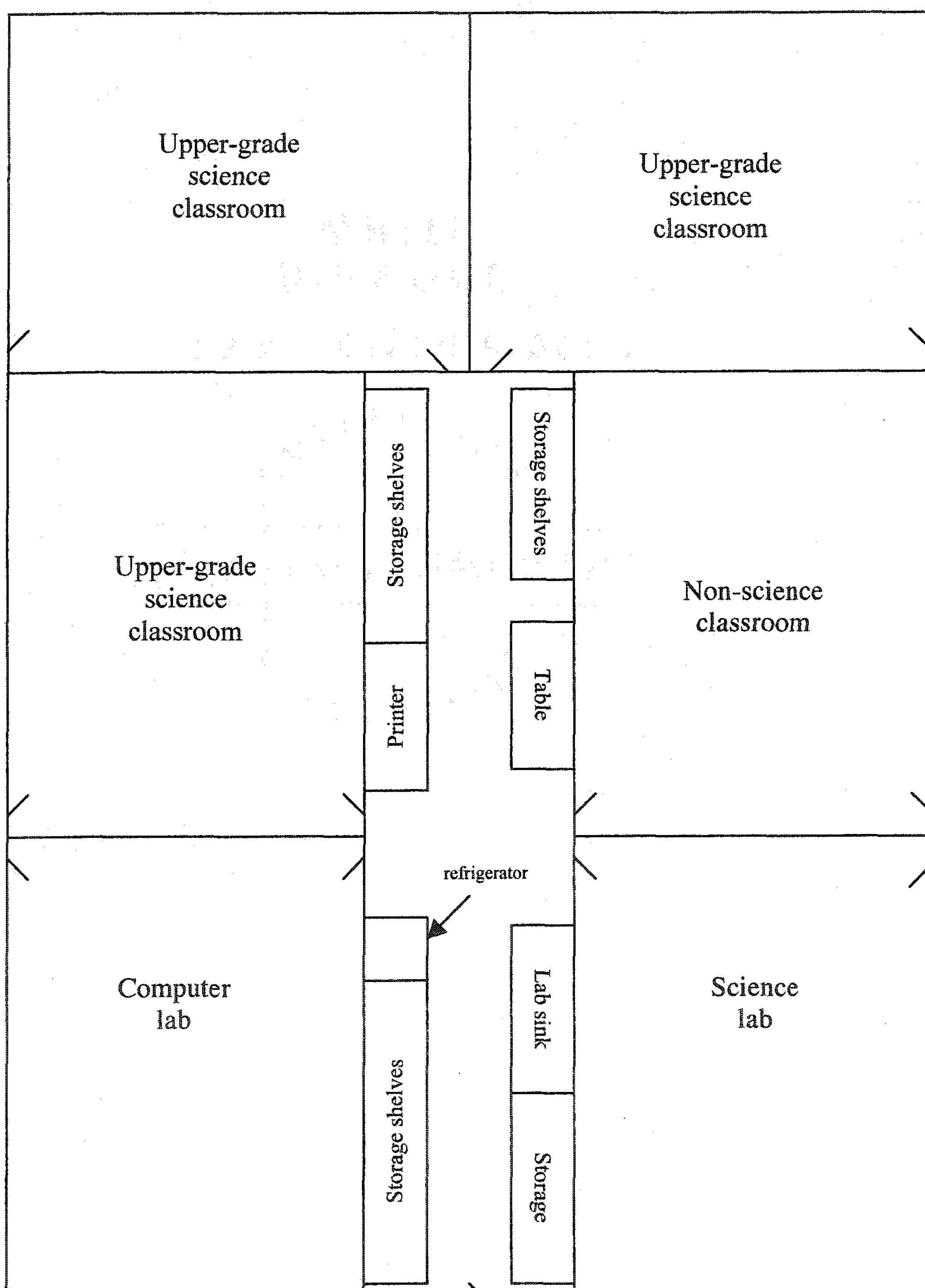
The school will eventually house kindergarten through eighth grade students, but for the first year of the study the highest grade was sixth. Kindergarten through fourth grade students are taught in self-contained classrooms. Fifth and sixth grade students (and eventually seventh and eighth grade students) are treated like middle school students in that they rotate throughout the day to different classrooms for each subject. The three teachers in the study comprised the upper grades science department and taught fifth and sixth grade science. A fourth upper-grades science teacher did not participate in the study because he did not attend the professional development institute.

The school itself looks similar to many elementary schools in California. The campus is comprised of multiple single-story buildings connected by open areas, playgrounds, and playfields. The administrative offices are in a separate building closest to the parking lot. The upper-grades science teachers taught together in one building on the school campus. The building was built specifically to house the science department and contains a dedicated science laboratory room with lab tables and sinks, as well as shared storage in a large hallway accessible from all the classrooms (see Figure 4).

Technology Access

As part of its mission as a technology magnet school, each upper-grade classroom was provided a set of laptop computers for constant teacher and student access (each kindergarten through fourth grade classroom had four desktop computers). Each upper-grade teacher received six to eight Compaq laptops (Windows XP platform) with wireless Internet access in January of 2002. The school had plans to increase the number of school-owned laptops in each classroom and supplement those with family-owned laptops that students would bring to school everyday. The school had a full-time technology coordinator who helped teachers integrate computers into their teaching and fixed technological problems as they arose. The computer lab room in the science building was mostly used by lower-grade classes because they did not have a class set of laptops. Teacher meetings with the technology coordinator were also held in the computer lab room.

Figure 4: Diagram of the upper-grade science building at Fielding School with three dedicated science classrooms, a science lab room, and a computer lab room. The building is freestanding and a single story. Center hallway provides science teachers with shared storage areas for science supplies and curricular materials, as well as a table, networked printer, laboratory-style sink, and refrigerator. Outer doors open to walkways and courtyards that connect with outdoor recreation areas.



Data Sources and Data Collection

Introduction to Data Sources

Case study methodology requires the use of multiple sources of data to allow the researcher to validate findings and conclusions (Stake, 1994; Yin, 1994). This process is called data triangulation (Stake, 1994). I collected data from a variety of sources for each of the constructs of interest in the study. I used the conceptual model I elaborated in the literature review section to guide my research and data collection (see Figure 3). The main constructs of interest are teacher beliefs, teacher intentions, and teacher behaviors. Refer to Figures 4, 5, and 6 for schematics of data sources for each construct. Data sources for teacher beliefs are illustrated in Figure 4, teacher intentions in Figure 5, and teacher behaviors in Figure 6. Some of the data sources were used for more than one construct (Table 6).

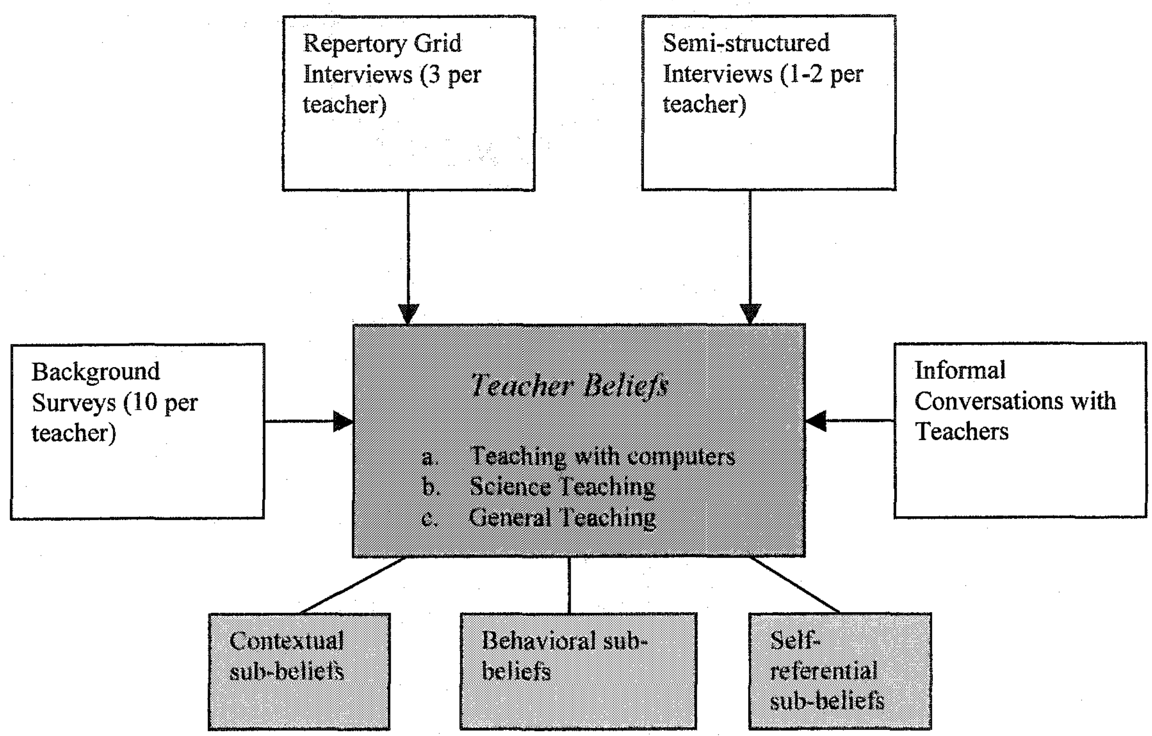
Table 6: Research constructs and associated data sources. Data sources in italics were analyzed for more than one research construct.

	Research Constructs			
Data Sources	Teacher Beliefs	Teacher Intentions	Teacher Behaviors	
			Past	Present
Background Surveys	x	x	x	
Repertory Grid Interviews	x	x	x	
Semi-structured Interviews	x	x	x	
Informal Conversations with Teachers	x	x	x	
Conceptual Flows		x		
Lesson Plans		x		
Lesson Planning Books		x		
Classroom Observations by Researcher				x
Teacher-made Handouts				x
Student Artifacts				x
Lesson Plan Report Forms				x
Teachers' Reflections				x
Teaching Behavior Logs				x
Teacher Presentations to Other Teachers				x

Two data sources, background surveys and informal conversations with teachers, were used for three different constructs: teacher beliefs, teacher intentions, and past behavior. The background surveys covered a broad range of topics, and therefore contained information related to the three constructs. For example, beliefs were inferred from questions about the amount of support teachers get from their administrators in relation to using computers in teaching (a contextual sub-belief about teaching with computers). Behavioral and self-referential sub-beliefs were also indirectly elicited in these surveys (see Appendix 2). Teacher intentions, for instance, were elicited from the surveys through questions in which teachers estimate the number of times (including zero) they thought they would use the Cal Alive! program during the school year following the professional development institute. Teachers also indicated how often they have used particular teaching techniques (e.g., small group instruction) and in what ways they used computers in their professional lives (e.g., to take roll, to record grades). These questions gave information about the teachers' past behavior.

Informal conversations with teachers also provided data related to teacher beliefs, intentions, and past behavior. I had many opportunities to interact with the teachers informally, both during the 10-day institute and while visiting with them at their school. Informal conversations often uncovered important information in a less formal manner than during interviews. As this was an important source of information, I recorded field notes after each of these conversations in a notebook reserved for each teacher for later coding and analysis.

Figure 5: Data sources for the construct of teacher beliefs. This schematic is the same for all three categories of educational beliefs of interest in the study: beliefs about teaching with computers, science teaching beliefs, and general teaching beliefs. Sub-beliefs (behavioral, self-referential, and contextual) pertain to all three categories of educational beliefs.



Data Sources for Belief Constructs

Data for teacher beliefs were collected from four major sources: background surveys, two different interview techniques, and informal conversations with teachers. Refer to Figure 5 for a schematic representation of the data sources.

Belief interviews.

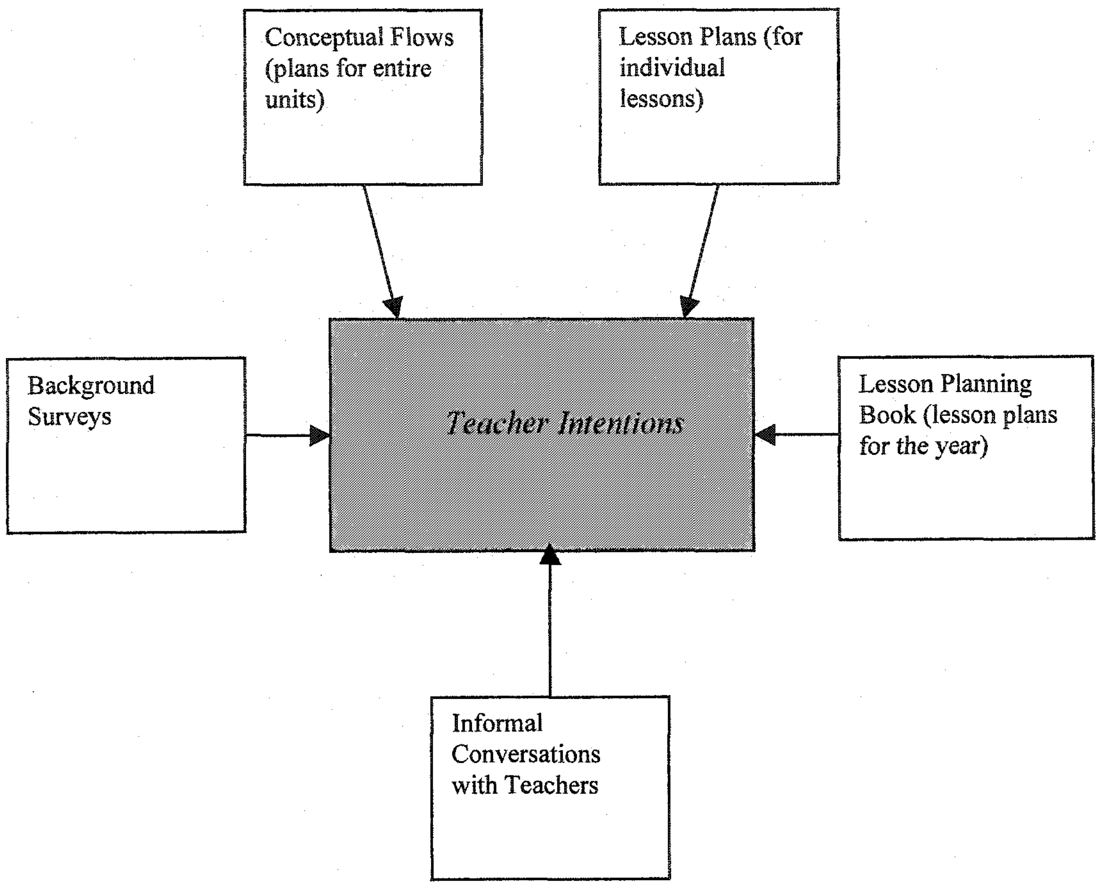
Two types of interviews were used to examine teachers' beliefs. The first type of interview was a version of Munby's (1984) Repertory Grid Technique (RGT), adapted from Kelly (1955). The RGT has been found to be "effective at ascertaining the foundational beliefs of teachers" (O'Hara, 2000). In this study, I used it to explore the teachers' behavioral beliefs about teaching in general, teaching science, and teaching with computers (three categories of educational beliefs). The second type of interview was a semi-structured interview technique using an interview guide (Patton, 1990). This interview was used to more fully explore teachers' beliefs in their own capabilities (self-referential beliefs) and beliefs in the existence or lack of external supports (contextual beliefs) in relation to each of the three categories of educational beliefs.

Repertory grid technique interview: One type of belief that is shown to have major influence on behavior is called a behavioral belief (Ajzen, 1985). Behavioral beliefs are beliefs about *performing a behavior*. As discussed previously, beliefs that affect behavior are specific to the behavior being performed. The specificity of the beliefs is important, meaning the type of behavioral belief examined should closely match the behavior of interest. The behavior of interest in this research is "using computers to teach science." Therefore, I focused on behavioral beliefs related to three specific behaviors: 1) teaching with computers, 2) teaching science, and 3) teaching in general. Each teacher completed a Repertory Grid and a face-to-face interview on each of the three sets of behavioral beliefs.

Each RGT process began with the creation of the grid in two stages, followed by a face-to-face interview. Teachers were given detailed instructions on how to generate the statements that created the grid. As the teachers were computer users and comfortable with electronic communication, the initial grid construction was conducted by e-mail. Each teacher constructed two grids in succession (on teaching with computers and teaching science), and then I conducted the corresponding face-to-face interviews. The teachers then constructed the third grid (on general teaching) and underwent the corresponding interview. The grid construction and interviewing was done in this manner because the process is intensive in terms of time and effort for the teachers. Staggering the work in this way hopefully made the process less onerous. In addition, it provided time in between the interviews to lessen the potential influence of one interview session on another. See Appendix 3 for a detailed description of the RGT process.

Semi-structured interview: Other beliefs are shown to be important in teacher practices but may not be fully explored with the RGT interview. As described in the section on the RGT, this technique is especially useful for investigating behavioral beliefs. Although some of the other belief constructs were touched upon with the RGT, the semi-structured interview was used to further explore teachers' self-referential (internal) and contextual (external) beliefs. In addition, the semi-structured interview was used to find out more about the backgrounds of the teachers.

Figure 6: Data sources for the construct of teaching intentions.



Data Sources for Teaching Intentions

Data for teaching intentions were collected from five major sources. These were background surveys, conceptual flows, individual lesson plans, lesson planning books, and informal conversations with teachers. Refer to Figure 6 for a schematic representation of the data sources.

Conceptual flows.

This was the technique for unit development taught and used during the 10-day professional development institute. Teachers planned an entire unit by first determining the main concept and sub-concepts of the unit. Then teachers identified the order in which they would teach the sub-concepts and specific activities and assessments they would use during each step of the unit.

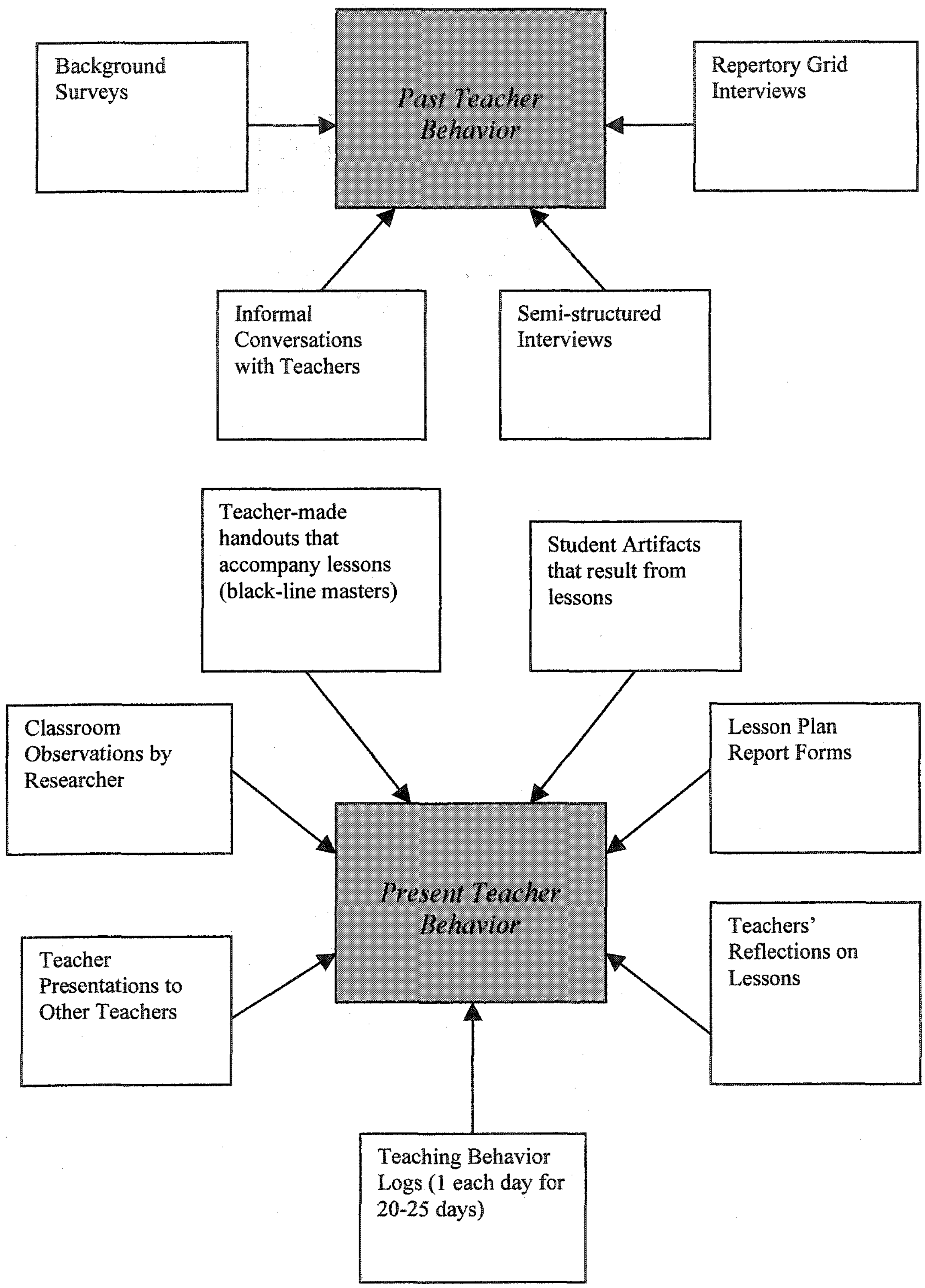
Lesson plans.

I collected complete lesson plans for each lesson I observed. These lessons plans covered lessons that both include use of the interactive computer software and do not include the software. In the lesson plans, teachers stated their goals and objectives for the lesson. I also collected lesson plans for lessons I did not observe but that occurred during the observation period.

Lesson planning books.

The teachers wrote notes for their lessons in their lesson planning books over an entire year. These were the lessons they intended to do over the course of that year. I collected these from each teacher at the end of the year.

Figure 7: Data sources for the construct of past and present teacher behaviors.



Data Sources for Past Teacher Behaviors

Data for past behaviors were collected from four major sources. These were background surveys, the two different types of interviews, and informal conversations with teachers. Refer to Figure 7 for a schematic representation of the data sources.

Repertory grid technique (RGT) interviews.

Teachers discussed, as part of the RGT interviews, the aspects of their past experiences and behaviors (e.g., childhood, student life, student teaching, past teaching) they think influenced their present teaching behaviors and ideas.

Semi-structured interviews.

The semi-structured interview gave me the opportunity to converse somewhat informally with each teacher about themes they may or may not have already covered in written form. In an oral interview more than in a written format, subjects can easily and quickly add depth to questions about their philosophies, motivations, goals, and behaviors in relation to the topics of interest in the study. This type of interview is especially valuable in allowing the interviewer to "explore, probe, and ask questions that will elucidate and illuminate [a] particular subject" (Patton, 1990, p. 283). During the semi-structured interviews, teachers were asked to describe past teaching experiences that related to teaching with computers, general teaching, and teaching science.

Data Sources for Present Teacher Behaviors

Data for present behaviors were collected from seven major sources. These were classroom observations, teacher-made handouts, student artifacts, lesson plan report forms, teachers' reflections, teaching behavior logs, and teacher presentations to other teachers. Refer to Figure 7 for a schematic representation of the data sources.

Classroom observations.

I conducted two types of classroom observations. One type was prearranged and involved observing during times when teachers were specifically teaching with or without the Cal Alive! program. The lessons without the software program often included other uses of computer technology, such as Internet research. All lessons were science-focused. I visited the teachers' classrooms on a prearranged basis to observe lessons approximately twice a month over two 3-4 month periods. During the classroom visits, I took notes on what the teachers were doing and saying, as well as what the students were doing and saying. I recorded interaction with the software program by both the teachers and students. During lessons not including the software program, I recorded teacher and student activities and any interaction with technology, if applicable.

I also observed lessons taught by the teachers when not specifically invited by them. The purpose of these visits was to gain more insight into the everyday teaching behaviors of these teachers. I was able to use these data as a comparison to the scheduled visits. Conducting unannounced visits helped assure that I was seeing normal teaching behavior that was not specifically designed for my benefit. For the unscheduled visits, I obtained permission to visit the teachers unannounced over a period of about two to three months. During that time, I visited each teacher's classroom between four and six times. This allowed me to observe general teaching behavior as well as science teaching behavior. These lessons sometimes included use of Cal Alive! or other computer-based activities.

Teacher handouts.

Each time I observed a lesson, teachers provided me with copies of any handouts that were used. Handouts included directions for students about the lesson and/or use of the computer, worksheets to be completed while doing the lesson and using the computer, and assessments of student learning.

Student artifacts.

For each lesson observed, teachers provided me with samples of student work associated with the lesson. Samples included completed worksheets, written samples, group work, student presentations, and assessments.

Lesson plan report forms.

After each observed lesson, teachers filled out a lesson plan report form that I designed (see Appendix 4). As part of this form, teachers indicated what they did differently from their original intentions, thereby reporting on their perceptions of their actual behaviors.

Teacher reflections.

After each observed lesson, teachers were asked to reflect on how they taught the lesson, what they thought their students learned from the lesson, and what they would do differently the next time they taught the lesson. In addition, teachers were asked to reflect on their overall teaching at least two to three times during the study period.

Teacher behavior logs.

Teachers completed a simple form on which they briefly catalogued the teaching behaviors they used on a given day (see Appendix 5). They completed one form each day over a 20 to 25 day period. This provided a profile of their preferred behaviors. These logs were compared with data from the classroom observations.

Teacher presentation to other teachers.

During the second professional development institute (Summer 2002), the teachers were asked to conduct an informal presentation with other teachers about their use of the Cal Alive! program. The teachers discussed their own specific uses of the software program, any technical considerations or issues they encountered while using it, recommendations or cautions to other teachers, and how their students reacted to using the software program. They also answered questions from the other teachers. The presentation gave the teachers an opportunity to talk to other teachers about the software program. As the teachers addressed other teachers and their questions, they discussed the practical aspects of, and possible problems associated with, using the software. This data source provided an alternative look into their perceptions about their behaviors and possible barriers encountered when using the software that were used to compare with other behavior data.

Timeline for Data Collection

I collected these data over approximately two school years, including summers. Table 7 outlines the timing of the various data collection activities.

Table 7: Timeline of data collection activities.

Time	Data Collection Activity
Summer 1 (2001)	• first professional development institute • background surveys to all teacher participants
Fall 1	• analyzed background surveys • chose subjects for case studies
Spring 1 (2002)	• conducted three RGT interviews with each subject • began invited classroom observations of Cal Alive! lessons • collect conceptual flows, lesson plans, teacher handouts, student artifacts • subjects filled out lesson plan report forms and wrote reflections on lessons
Summer 2	• second professional development institute • subjects conducted presentation to other teachers about use of Cal Alive!
Fall 2	• conducted unannounced classroom observation visits • continued invited classroom observations of Cal Alive! lessons • continued collecting conceptual flows, lesson plans, teacher handouts, student artifacts, lesson plan report forms and reflections
Winter 2 (2003)	• conducted unannounced classroom observation visits • continued invited classroom observations of Cal Alive! lessons • continued collecting conceptual flows, lesson plans, teacher handouts, student artifacts, lesson plan report forms and reflections
Spring 2	• subjects completed teacher behavior logs over 20-25 days • conducted semi-structured and follow-up interviews

Data Analysis

General data analysis methodology

All audio taped data were transcribed on a computer. This allowed for easier coding and organization. All data were initially coded according to predetermined categories (refer to the gray boxes shown earlier in Figures 3, 4 and 5). Data were analyzed using the constant comparative method (Janesick, 1994) to begin to confirm themes and discover emergent themes that could not be predetermined.

After transcription and coding, data were analyzed to determine the beliefs each teacher held (addressing the first two research sub-questions). Then belief and behavior data for each teacher were reviewed and coded to determine the relationships that existed (addressing the third research sub-question).

Teacher Belief Construct

Evidence for the teachers' beliefs were triangulated from several data sources. All relevant data sources (i.e., two different interview techniques, classroom observations, background surveys, and informal conversations with teachers) were transcribed and coded according to the three categories of educational beliefs (general teaching, teaching science, and teaching with computers). Within each of those categories, data were coded for the three belief sub-constructs (behavioral, self-referential and environmental). I also coded the data for other emerging themes that could not be identified in advance.

Teacher Intentions Construct

Evidence for teaching intentions was triangulated from several data sources. All relevant data sources (i.e., conceptual flows, lesson planning books, individual lesson plans, background surveys, repertory grid technique interviews, and informal conversations with teachers) were transcribed. These data were coded according to intentions related to general teaching, teaching science, and teaching with computers. Additionally, data were coded for evidence of intentions related to teaching with Cal Alive!.

Past Teacher Behavior Construct

Evidence for past behaviors was triangulated from several data sources. All relevant data sources (i.e., background surveys and the two different types of interviews) were transcribed. I coded these data for evidence of past behaviors related to general teaching, teaching science, and teaching with computers.

Present Teacher Behavior Construct

Evidence for present behaviors was triangulated from many data sources. All relevant data sources (i.e., lesson plan report forms, classroom observations, teaching behavior logs, teacher presentations to other teachers, teachers' reflections, teacher-made handouts, and student artifacts) were transcribed. All data were coded for evidence of behavior related to general teaching, science teaching, and teaching with computers. In addition, I coded for any behaviors related to teaching with Cal Alive!. I examined student artifacts for evidence of implementation or non-implementation of teacher intentions and actual behavior. Finally, behavioral data were coded for relation to belief data.

Criteria for Findings

All findings were supported by behavioral evidence that was triangulated from at least two data sources (e.g., observation, lesson plan, interview, reflection).

CHAPTER 4: RESULTS AND ANALYSIS

I will begin the chapter by introducing the three teachers and their classrooms. I will then present the teachers' contextual beliefs, which will provide a picture of the teachers' assessments of their working environment, resources, and support systems. I will discuss the contextual beliefs of all three teachers together, as they were quite similar. This is not surprising since the teachers taught in the same school and the context was relatively consistent for each of them. I will include representative quotes from the three teachers. The contextual beliefs will serve as a foundation for the next part of the chapter, in which I will talk about each teacher individually. In each teacher's subsection, I will first present the behavioral beliefs and then the teaching behaviors that I observed. I will end each teacher's subsection with an analysis of the role beliefs play in that teacher's behaviors.

I will include examples of data sources as they illustrate my findings. As a reminder, I will only present findings that were supported through a process of data triangulation (Stake, 1994) in which two or more data sources provided supporting evidence.

Meet the Teachers

The three teachers in this study had different backgrounds in terms of length of teaching experience, grade levels taught, and science background (see Table 8). In this section, I will provide more background about each teacher and an introductory look into his or her classroom.

Table 8: Teacher background information.

Background	*Julia Wilson*	*Kiran Malik*	*Barry Foster*
Gender	Female	Female	Male
Country of origin	U.S.A.	India	U.S.A.
Years teaching	20	9	5
Grade levels taught prior to this study	K-6, self-contained classrooms and some pull-out science classes	High school science	6th and 8th grade integrated science
Science background	No formal science background	Science-related major in college	Science major in college
Major in college	Elementary Education	Home economics, minor in science	Pre-dental
Science teaching background	Taught some science every year	Food science, home economics, and science	Science

Teacher 1: Mrs. Julia Wilson

Meet Julia

When you meet Julia, the first thing you notice is her friendly, bubbly personality. As you get to know her, you discover her sense of fun and her passion for teaching. Julia knew she wanted to be a teacher since the 3rd grade and has been teaching for over 20 years. She owes her interest in teaching to the inspiration of her 3rd grade teacher.

> I remember my third grade teacher, that's why I'm a teacher today…she was so animated and she taught us in ways where we experienced things instead of just reading, reading, reading or lecturing…She was so funny, she play-acted, she involved us, she engaged her students. (science teaching interview, quote #18)

> And I still remember to this day standing up doing cursive writing and the way we'd use our whole bodies for cursive writing. And I just thought, you know, this would be so much fun to be able to create your own lessons the way kids enjoy them…. So I never wanted to do anything else but teach. (follow-up interview, quote #1)

Julia has taught kindergarten through sixth grade over the years and this wealth of experience has made her very confident in her teaching abilities.

> I have taught every grade for some time period, K through sixth now, and I just, you know, just knowing what works with kids, what doesn't. I mean they're not ever the same group of kids from previous years but you kind of get a feel for what they like and what they don't like and what they need. (science teaching interview, quote #25)

She does not have a formal science background, although she had always included science in her teaching at least once a week and taught a pull-out GATE science class for a few years. Teaching at Fielding School was her first opportunity to be a dedicated science teacher and teach in a middle school-like setting. This was also Julia's first experience with such high access to computers. In her previous school, she only had one computer in her classroom. It was located at the back of the room and she only had students use it to write up reports or in some other way that was not tied to the then current lesson.

Julia has a commanding presence in the classroom. Her students seem to respond to her and want to please her. Julia prides herself on knowing what kids like and being able to see learning from their perspective.

> I can put myself in kids' positions very easily and I try to always think about what they're experiencing and the feelings that they're having during a lesson. Are they excited? Are the bored? Are they questioning? It's just an empathetic-type thing I have. (teaching with computers interview, quote #25)

According to Julia, a quiet environment allows students to learn. She makes it very clear to students that she expects them to pay attention. They usually quiet down easily and get to work quickly when the period begins.

> What's the use of teaching if everyone is fooling around and not listening to you anyway. Of course that is going to happen some, but you need to minimize that as much as possible. In fact, I like it totally quiet so I know kids are listening. And I know that some auditory kids could be doing something and they're still able to

> listen and comprehend, but you want to make sure. So I make them turn around and look at me. (general teaching interview, quote #2)

Along with the discipline though, Julia creates an energetic atmosphere. A typical class period begins with Julia leading a lively discussion in which she guides students to remember previous activities or relevant concepts. If they are having trouble remembering, she might have them pull out posters they made the day before or act out some kind of demonstration. She might also read them an applicable short story, have students play a game, or act out an explanatory skit. After this brief introduction, Julia will have students get into groups and work on a computer research project or hands-on activity. Students spend the majority of class time working in their groups. Julia often circulates around the classroom helping students. Once in a while she calls out for students to listen while she resolves a common issue. Many activities end with students reporting in some way what they have found. Students might outline on whiteboards, answer written questions, make drawings or create posters, which they would then share with the rest of the class.

When she's not teaching her own classes, she is often helping teachers of lower grades do science lessons. She becomes immersed in any project she is doing. It is common to find her dressed in a lab coat or even a NASA jumpsuit if she thinks it will help students become as passionate as she is.

Classroom Set-up

Julia experimented a couple of times with desk placement over the study period and she would maintain that classroom arrangement for one or more trimesters. She does not like to organize the desks so that students are sitting in their groups. This is because she wants students to feel like it is a treat to sit in groups instead of an ordinary occurrence. In addition, she wants students to face her so she has a way to assess whether or not her students are listening to her.

> For the most part, I like *getting* into groups because it's special for the kids. I don't have the kids sitting in groups because they're looking at each other instead of me. I can't stand that. And then it's not as special. When they get to work in groups they're more excited. And they sit in groups but they're always facing me, so they're, you know, basically in their groups already. (general teaching interview, quote #1)

Julia's classroom had about eight wireless Internet-equipped Compaq laptops that were stored in a student-accessible compartment of the television cabinet. When implementing a lesson using computers, Julia usually set up the laptops on certain desks and on the counters that lined two walls of the classroom (see Figures 7 and 8). She would arrange the computers so students would be spaced out around the room. One limiting factor was that the laptops needed to be connected to the electrical outlets since the batteries did not last very long. This reduced the flexibility of the laptops because Julia would have to place them in areas that would cut down on the risk of students tripping over power cords. This often meant some student groups would have to stand instead of sit around a laptop if it was located on the counters.

Figure 8: Julia's classroom arrangement from February to June 2002.

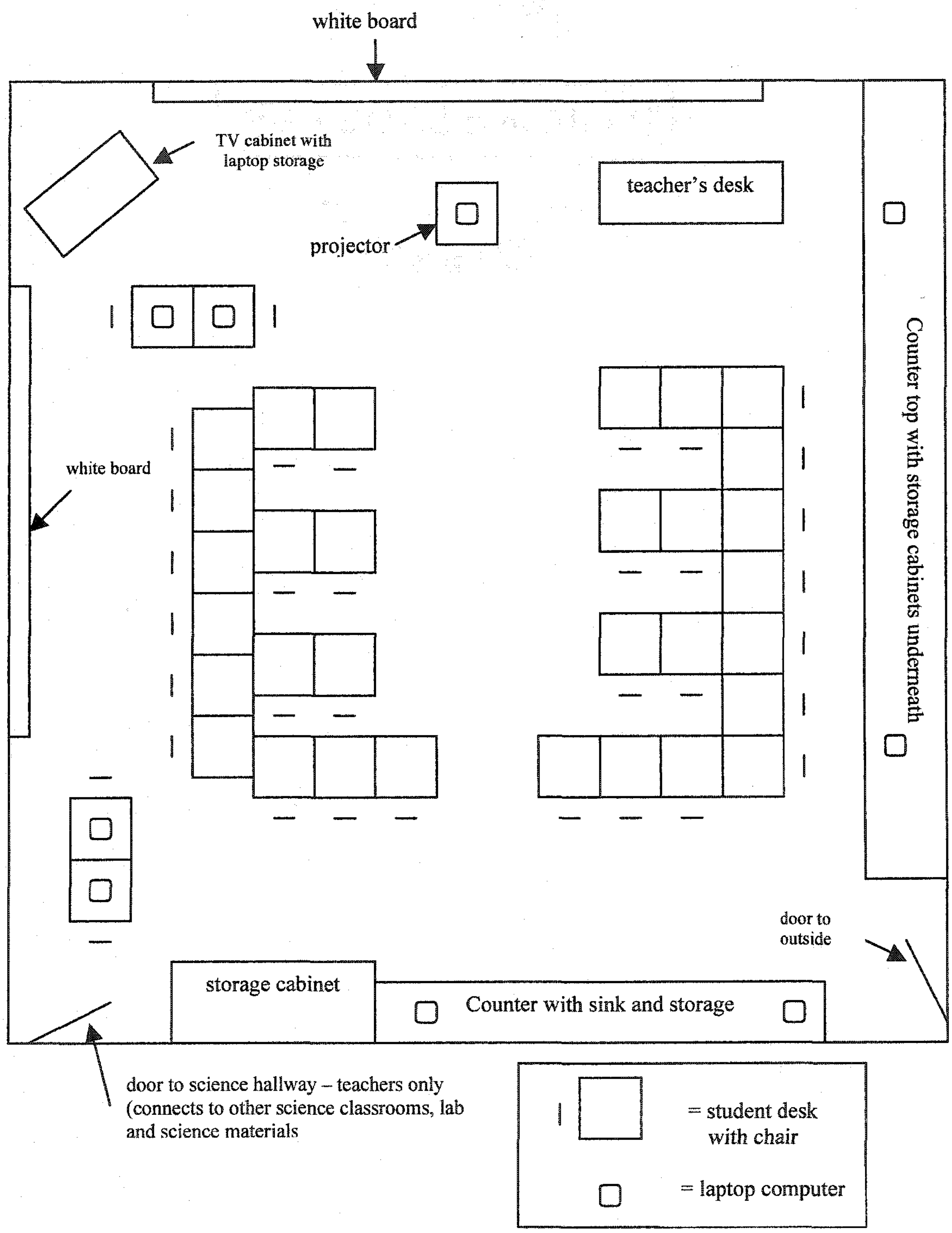
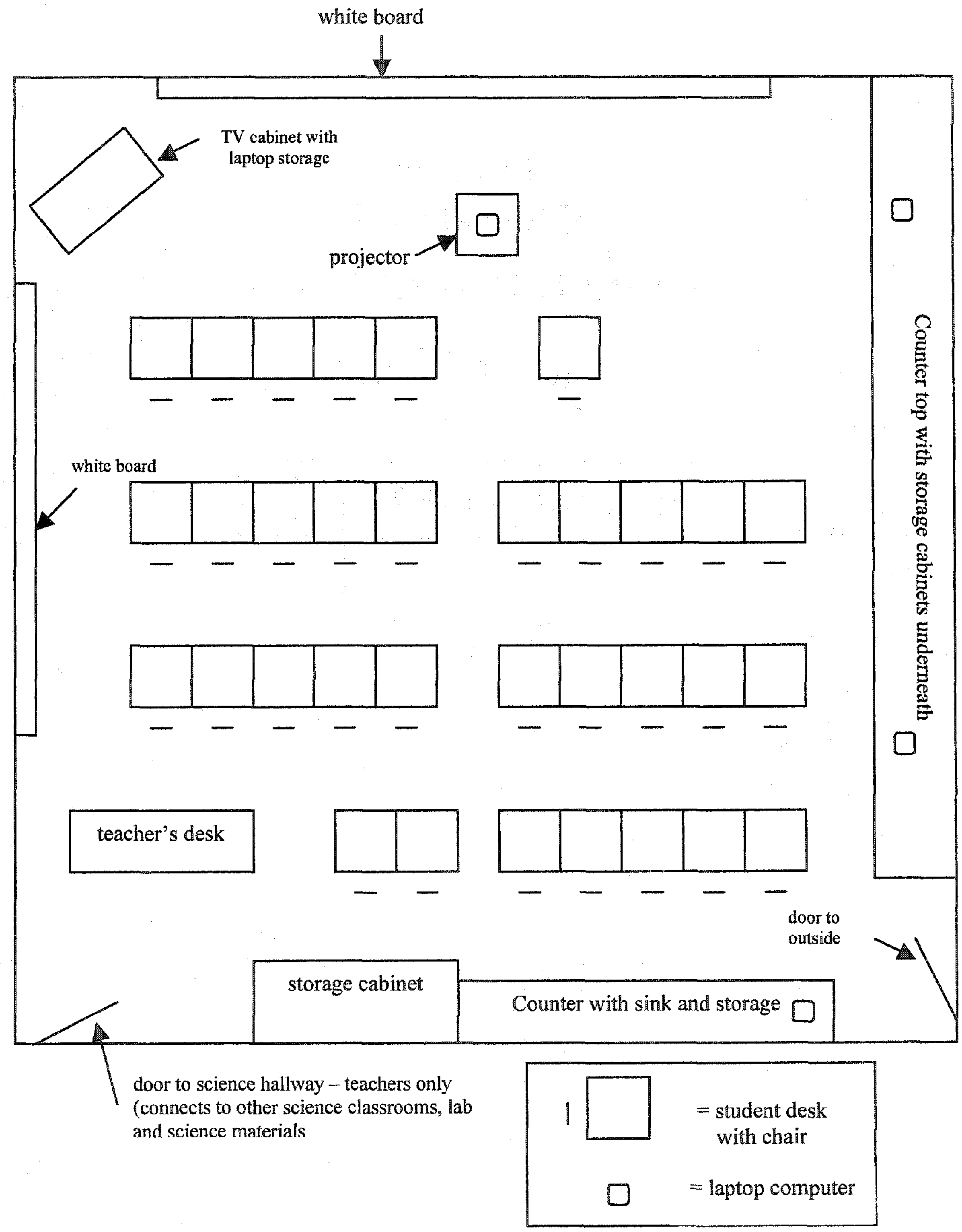


Figure 9: Julia's classroom from January 2003 to the end of the study period (February 2003).



Teacher 2: Kiran Malik

Meet Kiran

Kiran has been a teacher for nine years. She grew up in India and got her bachelor's degree in home science with a minor in science. She then received her master's degree in clothing and textiles with a minor in extension education. While in India, she was an assistant professor at Punjab Agricultural University. She had always planned to become a researcher and teacher, so after coming to the United States in 1993 and starting a family, she decided to get her teaching credential. She had to put her research aspirations on hold while teaching high school for nine years. She then began teaching at Fielding School when it opened. It was her first experience teaching younger students. Like Julia, Kiran did not have the same access to computers in her previous teaching experiences. Her last school had a computer lab, but she was only able to use it about once a month because of high demand.

(Note: It was sometimes challenging to transcribe and understand Kiran's interview tapes because of her accent and dialect. Her thoughts were often made complicated because she would repeat or revise statements mid-sentence or she would stop and restart her thoughts. I have attempted to make her quotes more readable by deleting extraneous words and repetitive phrases. I have marked deleted sections with an ellipse (…) and added clarifying words or phrases in [brackets]. While editing, I tried hard to maintain the original meaning of her words.)

As I got to know Kiran, I began to appreciate her passion for science and her incredible organizational skills. She applies her organization to her teaching, having a place and an order for everything. She believes that structures are beneficial to children in many ways. One structure consists of a ritual she performs during each class period.

The first thing Kiran does at the beginning of a period is stand at the door where her students are lined up to come in. She greets each student individually as she lets them into the room. The students usually come in quietly, put their backpacks down, and take their seats. Kiran believes this routine helps her maintain good behavior in the classroom.

> "Teacher greets students"...this is one of the things that I believe, that I do every single day in the beginning of the period...I think this is like an umbrella to the whole thing. If I greet the kids in the beginning and set like the rapport for that day, it starts their mind....I mean I greet them, they smile back at me...or they say "hello" back to me, or whatever like that. And then, I think, it also gives me an idea of what kind of behavior, what kind of things I may have to avert, which kids I may have to focus on that day. Because I do get to look in their eyes every single day at the beginning of the period, each of the kids. You get to talk to them and I get a feel real quickly who is in what kind of mood today....That tells me, "Okay, from here, what do I need to do? Who do I need to focus on today?" (general teaching interview, quote #1a)

Kiran talks about how much she cares for her students, which is evident in the personal way she interacts with them each day. The greeting ritual also lays the foundation of this personal relationship.

> And that gives me an opportunity to talk to them, to get a feel, "How are you feeling today?" If I see someone a little sad or something, that gives me time to see if this child is doing well or not or if somebody was sick yesterday. Usually because once we start teaching, there's no time. It's like the caring part, right there. And it's easier...settling the class in the beginning and greeting them right in the beginning. (general teaching interview, quote #5)

Kiran also believes that she must be especially organized as a teacher in order to expect her students to pay attention to the class. This also has to do with her understanding her students and their abilities.

> As a teacher, if I want my kids to pay attention, I have to be...organized and know exactly what I'm doing....If I don't have my lesson ready, if I'm not organized, I'm taking ten minutes or five minutes just to look for a transparency, I will lose their attention....Organization, [students] getting ready, those things go together. Because I can't ask them for their patience. Usually they don't have as much patience....It's harder because I can't ask them to just be quiet. I have to tell them exactly what I want them to do. "I would like you to be exploring now." And because if I say you need to be quiet, so they'll go like, "Okay, so what will we do then?" Right? So that's why if I want their attention I have to be organized. (general teaching interview, quote #20)

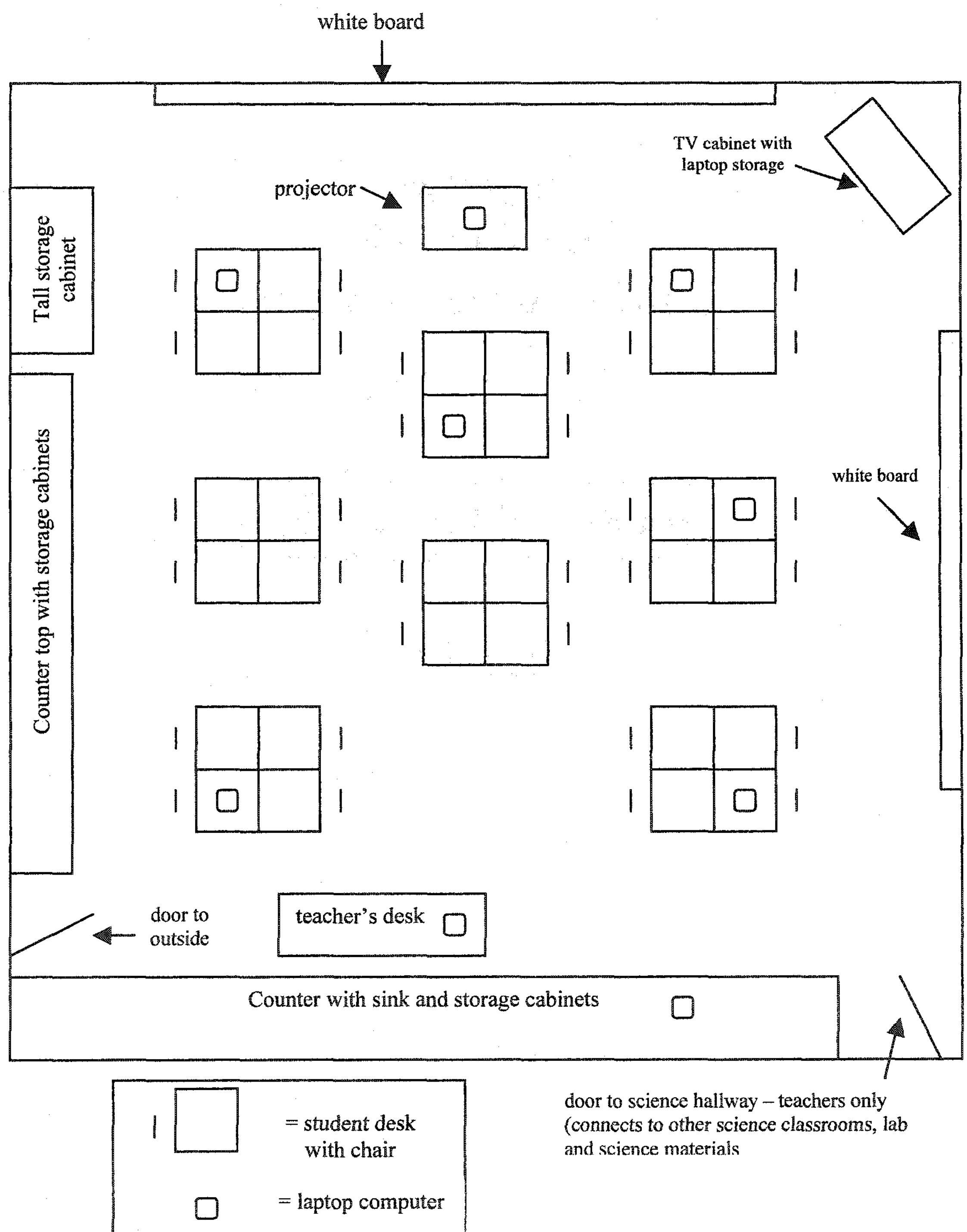
Once students are seated, Kiran has them copy an agenda off the board in their notebooks. Then she might review with them what they did on the previous day, sometimes using a PowerPoint presentation complete with digital pictures she took of them doing an activity. After that, Kiran gives students directions on what they will do for the period. When she finishes, she asks them to turn to their partners and explain to each other what the directions are. Then everyone gets to work. Most of the period is spent with students doing work in groups, either on computers or doing activities. Kiran walks around the room helping student groups or monitoring what they are doing. She may have to attend to a computer that isn't working or stop students to answer questions. As in Julia's class, most classes end with students sharing their work.

Kiran spends many days holding "homework club" in her room after school. It was common for me to see notes that students wrote on the white board with statements like, "Ms. Malik, you are the best. You know how we are," "Thank you for being a great teacher" and "Ms. Malik rocks the house!" Obviously her students also care about her.

Classroom Set-up

Unlike Julia, Kiran has the desks set up in groupings of four so her students are always sitting in groups and not necessarily facing her (see Figure 9). When she has students use computers, she usually lets them get the laptops out of the cabinet to set up either on their desks or on the floor next to the electrical outlets (since there was also the logistical problem of power cords all over the place). I observed several instances of students crowding around laptops on the floor next to the outlets.

Figure 10: Kiran's classroom arrangement for the duration of the study (with only minor adjustments when she moved to new rooms at the beginning of each trimester). Note: students might also set up computers on the floor so they could be plugged in easily to the electrical outlets.



Teacher 3: Barry Foster

Meet Barry

Barry is young, energetic, and in his 5th year of teaching. You can tell he has a fun-loving personality, as he's apt to break into song with the slightest provocation. Barry got his teaching credential in Nebraska, taught sixth grade for two years in Houston, and then returned to Nebraska to teach eighth grade for a year an a half until he moved to California to be near his wife's family. His first teaching job in California was at Fielding School and it was the first time he had taught 5th grade. Barry decided to become a teacher after he was rejected from dental school, a path he had been following since before college. This setback caused him to do some soul-searching and he realized that he didn't know why he had always planned to be a dentist. He figured out that what he really wanted to do was teach, although it was something he had never thought about before.

Barry had been a shy child and didn't interact much with his own teachers. He did, however, appreciate the good ones.

> I had really good teachers that, at the time as a student, you just almost took it for granted....Teachers were there to help and they cared about you, and you were getting the best education that you could. And, it wasn't until college that I really fully appreciated it, because a lot of the introductory science classes that I had, I could kind of see that I've learned some of this already....So, I started appreciate the value of teachers and what teachers can do for you. (follow-up interview, quote #2)

Once he decided to become a teacher, he had to take a few more years of college courses and go through the credentialing program. He never looked back. "I could see this was really it for me. It's what I want to do" (follow-up interview, quote #1).

Barry has a background in science and took many science courses when he was a pre-dentistry student. "I always had that love for science" (follow-up interview, quote #3). He especially loved the hands-on nature of his college science courses.

> I started off as a biology major, so I had a lot of lab classes…and it was obvious that that's the way that you learn….With college it was the first time that you had like a block of time…so it was just, you know, for that week you had that much time for hands-on learning. So that's probably when it became apparent…you can sit there and be bored and call it lecture, but using that information that the professor is giving you and then you're doing it for yourself,…that's when I fell in love with science probably. (science teaching interview, quote #7)

When he came to California, the science and technology orientation of Fielding School was a natural fit for Barry. He even became the science coordinator for the school. He talked of his excitement about the opportunities that the computer equipment would give him and his students.

> I heard from a friend in the district that, you know, [Fielding] was going to be a science and technology magnet, so you just assume well there was going to be a lot more computers there than there would be at another school. But it wasn't until, you know, I started as the science coordinator and saw the potential about how many computers we'd actually have and the idea of having laptops for students, where it's, you know, learning anytime anywhere type of thing. (teaching with computers interview, quote #11)

This was the first time Barry could explore teaching with computers at this level. In his first teaching experience, Barry had only one computer in his classroom and no computer lab at his school. When he moved to Nebraska, he had three computers in his classroom and access to a computer lab. He used these computers mostly to have students write reports and do research that he considered tangential to his normal lessons. He looked forward to being able to integrate computers more seamlessly with his lessons at Fielding. Not only would having lots of computers at his disposal be different for Barry, the grade level he would teach at Fielding was different too. He talked about how that would impact his teaching.

> When I taught 8th grade we did labs, but I did more just note taking and more almost lecture style. And 5th and 6th grade, I knew even before I started that with the difference in age level that that's probably not a good way to teach. And so I tried different things, more of the group work….If I went back to 8th grade…I definitely would [teach differently], because it's, whether you're teaching kindergarten through 12th, even college, I think that student-centered is the best way to teach it….So there's a place for [direct instruction] but just not as the only method. (general teaching interview, quote #11)

Barry has a laid-back attitude in the classroom. He does not seem too disturbed by a noisy classroom. "With the group work, you know, sometimes it's a little bit louder. But there's a noise level that I think is acceptable" (general teaching interview, quote #10a). It usually takes Barry's students a few minutes to quiet down at the beginning of class, with him asking for quiet a number of times. They often become noisy during the period and Barry must repeatedly remind them to lower their voices or pay attention. On days in which they do activities, Barry usually explains what they are going to be doing for the day and then has them get into groups. The students then spend most of the class period on computers or doing an activity or lab, with Barry moving from group to group. There are other days when Barry might be reviewing concepts learned previously or preparing students to take a quiz. On these days, Barry will spend much of the period on a question and answer session with students. During those periods, Barry does most of the talking.

Barry tries to have his students use computers as much as possible. He often has them looking up space news on the Internet or doing other research during class. He also has them do word processing and create computer-based presentations.

Classroom Set-up

Barry arranged his classroom in groupings of four, much like Kiran's, for most of the study period (see Figure 10). In January 2003, towards the end of the study period, Barry changed his classroom arrangement so the students were sitting in rows of four desks facing the front of the room (see Figure 11). His reasons for this change had to do with behavioral management. He said he was having trouble controlling a particular group when they were facing each other in the grouped desk arrangement. He discussed this problem with Julia, who suggested he try seating them in rows. He said the change helped, but he went back to grouping the desks for the following school year (informal conversation, 8/12/04). When students were using computers, they usually grabbed the computers from the cabinet under the television and set them up on their desks.

Figure 11: Barry's classroom arrangement from May 2002 to January 10, 2003.

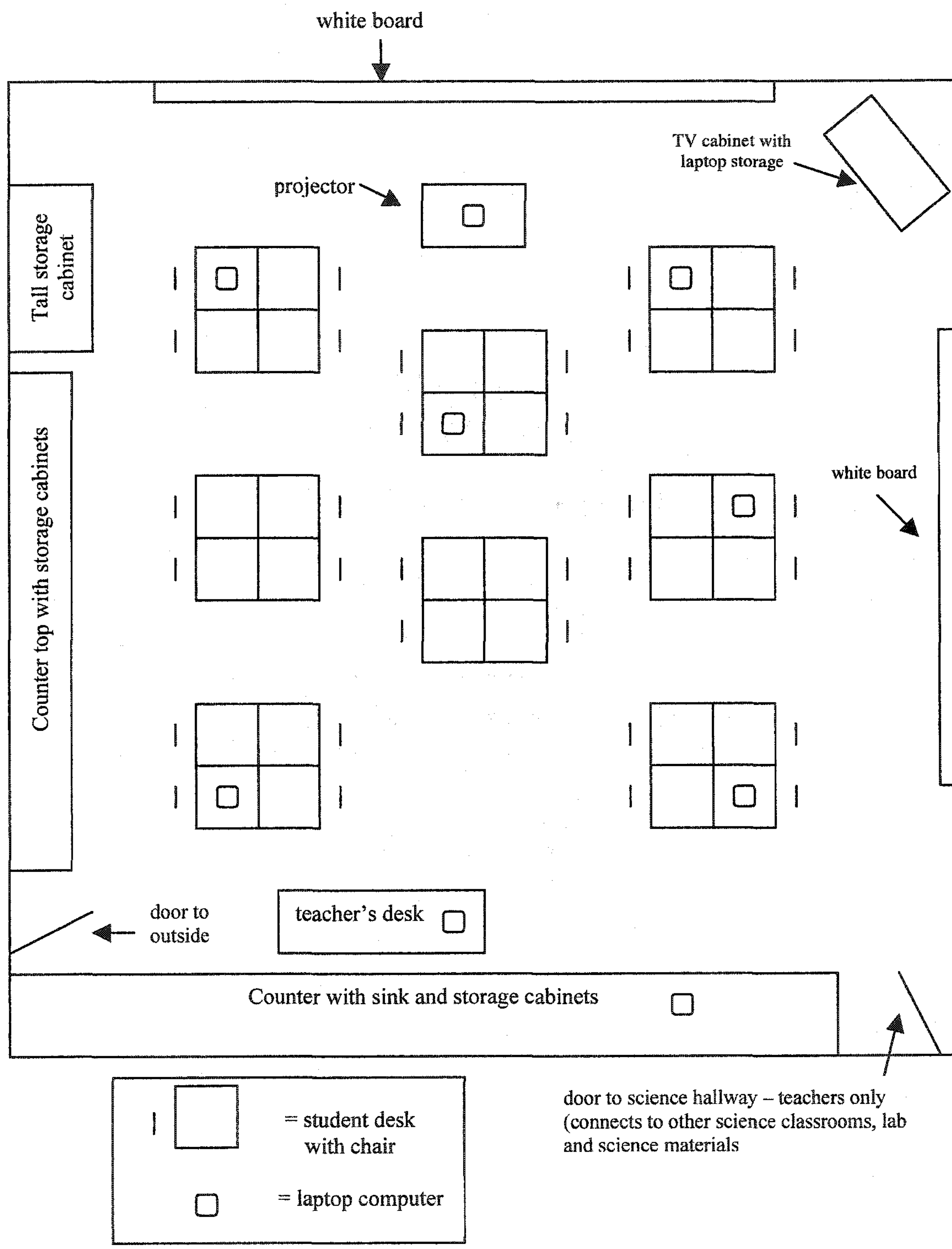
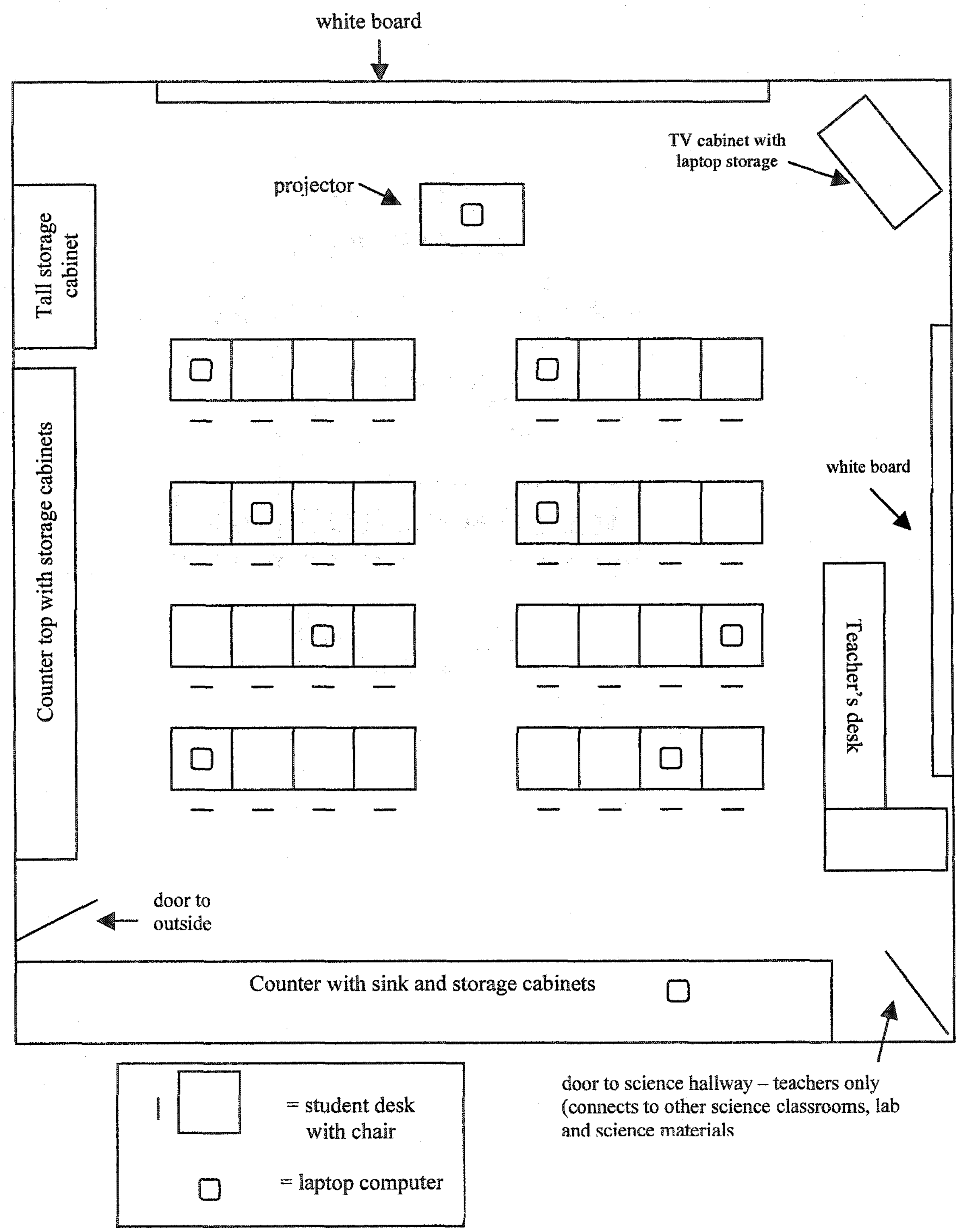


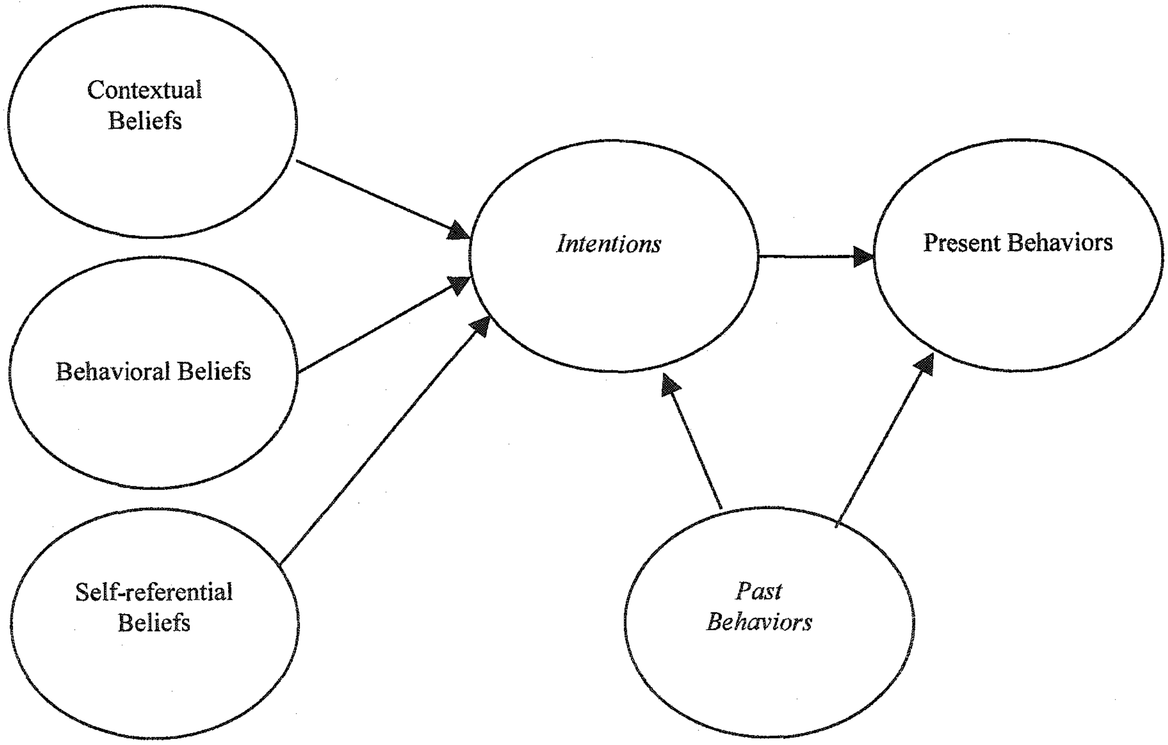
Figure 12: Barry's classroom arrangement from January 17, 2003 to end of study period (February 2003).



Conceptual Model for Data Analysis and Results

As introduced previously in the literature review section, the following conceptual model of the belief-behavior link was used to guide this entire study and will be used in this section as an organizational tool (Figure 13). I will focus specifically on the belief and present behavior constructs. I used the teachers' past behavior to help me choose my subjects, so I will not specifically address it again in this section except as it influences aspects of the teachers' beliefs and behaviors. I will also only discuss intentions as supporting or contradictory data (triangulation) to the beliefs and behavior data.

Figure 13: Conceptual model showing the major constructs that influence behavior. (Intentions and Past Behavior are italicized because they will not be addressed separately in this chapter.)



Contextual Beliefs of the Three Teachers

I will begin by presenting the contextual beliefs about teaching with computers for all three teachers. I will then briefly discuss the teachers' contextual beliefs about science teaching and general teaching.

All three teachers had mainly positive contextual beliefs about teaching with computers. They were very excited about the possibilities of using computers at a technology magnet school. The teachers recognized the importance of having such extensive access to computers. "Because we are a technology school, so we have computers….And that makes this job to…incorporate [the technology] much, much easier as compared to some other places….Here I can use them on a daily basis. That's the big difference" (Kiran, teaching with computers interview, quote #14). The teachers' descriptions of the school philosophy demonstrate the school's commitment to computer-based instruction. "It's how our school works. It's our vision for Fielding, of course, to use technology" (Julia, teaching with computers interview, quote #36).

> To be a science and technology magnet school, you know, [it] had to be total implementation. Where, you know, students were using the computers as much as possible in a way that, you know, they were driving their own learning as opposed to the teacher just standing at the front saying, "This is how you need to do it." (Barry, teaching with computers interview, quote #10)

> Basically that's how we set up our school. Our technology had to be interwoven along with space along with science, so it's just a natural order of things to have it every single day. So and most of the time, I would say 98%, we do use it every day. (Julia, teaching with computers interview, quote #33)

Since the school is a technology magnet school, administrative support for computers and other technology was expected. "Our administrators were very understanding due to the fact that we were a new technology school and that they expected to see technology being used in the lessons" (Julia, follow-up interview, quote #2). In fact, all three teachers felt a great deal of support for using computers from the principal. "Support from the principal is 100 percent, more than 100 percent. She encourages to use [the] computers on daily basis" (Kiran, follow-up interview, quote #1). The teachers felt she listened to their needs and made an effort to fulfill requests for help and equipment and solve problems.

> If you go to administration and say, you know, we need some more projectors, and if you give her a scenario like how we can raise money, to go to parent club, she's always definitely for that….If you really want something bad enough, if you show her the value of it, she'll find a way to make it happen. (Barry, follow-up interview, quote #4)

The district also supported the school in its use of technology by providing funds for equipment and for technological support. "The first two years it was incredible….[The district] knew that we had so much technology, and needed it first, that we had an overwhelming amount of support" (Barry, follow-up interview, quote #5).

> In fact, it was kind of embarrassing going to science committee meetings and listening to schools that didn't even have computers yet….And, our school was given so many….And, we did have the wireless on Internet access, which no other school had….That was part of the start up [funding from the district]. (Julia, follow-up interview, quote #8)

For the two years of this study, the district provided a full-time technology support person (a teacher on special assignment) who met regularly with the faculty to teach them about computers and to help solve technological problems.

> She did ongoing staff development with us, like once a week with each department working in how we can use this in science, and she would research good websites or activities…that worked pretty well. (Barry, follow-up interview, quote #6)

The district and school initially provided funding for between six and eight laptop computers for every teacher's classroom in the upper grades (5th and 6th grades). Full funding for computer equipment was never realized and the school was not able to fulfill its ambitious technology access plan. "We were expecting to get more computers from the District, thinking we'll have at least [one for two children] in the classroom, but we don't have that at this point" (Kiran, follow-up interview, quote #3).

The teachers felt the ratio of one computer to four students was not ideal, but realized they had many more resources than other schools. "We're spoiled here and sometimes we fail to, fail to see outside Fielding....So it can be frustrating, but it's a lot better than most schools have it" (Barry, follow-up interview, quote #12). To improve the ratio, teachers were sometimes able to share computers among classrooms.

> I've got six in my class right now that I can use at any time. But then like I'm, today I've borrowed next-door neighbors', math and science, so I've got an additional 12. And then there's almost a two to one ratio, and that way one student is working on something else while one has the computer and then they can kind of flip-flop and rotate that way. (Barry, teaching with computers interview, quote #20)

The sharing caused other problems, however, including miss-matched equipment, loss of files and changing of settings.

> That's been an issue with probably getting mixed up, all the computers. Since we've got more, some of the models aren't the same, like newer versions and then the plugs don't match up, so it's always an issue of find the right chargers, and where's this computer belong. I know we've got a labeling system, but it always seems like when you need them, there's one missing. It can be frustrating...but what a good problem to have. (Barry, follow-up interview, quote #8)

When asked what did not work well with the computer set-up in her classroom, Julia replied,

> The fact that we had to share computers to get the ratio of computers per students…and not being able to control what that class did to your set ups and everything. And, we often times had to backtrack and reload things because the computers were fooled with. That was a real pain having to loan out the computers. (Julia, follow-up interview, quote #5)

These complaints were not enough to keep the teachers from using computers.

The teachers felt another very important area of support was from each other. At school they often planned units and lessons together, discussed use of computers, and shared computers and lab equipment with each other.

> In the science department, we've had a really good team….So that [computer] sharing within our department isn't an issue, even if it's like, are you using your computers tomorrow? And we'd let the person know and sometimes the students would just come right in to be in class and then we'll get the laptops. So it's pretty easy, quick turnaround. (Barry, follow-up interview, quote #7)

When one teacher had a success or difficulty, he or she often shared that experience with the other teachers to help them be more successful. They also shared suggestions for interesting web sites and activities. The teachers felt strongly that this collaboration was encouraged and supported by the administration.

The teachers felt that parents were mostly supportive of their use of computers, although some did not like students needing to do homework on computers. One major area in which teachers felt a lack of support from parents was in supplying students with home computers. The school intended to have a large percentage of families purchase laptops that students would bring to school to supplement the school computers. Many parents, however, felt it was the school's obligation to provide computers and did not want to make the investment in a personal laptop.

> The parents were encouraged to buy their students a laptop to lower the computer/student ratio. And, I didn't feel that we had as much support on that as

> we needed. And, most parents wanted the school to buy the computers for the kids so that they wouldn't have to buy it themselves....They didn't really buy into what they had to contribute to be at [this] school. (Julia, follow-up interview, quote #3)

Even with these complaints, the teachers felt most parents were overwhelmingly supportive of the teachers' technology focus, especially since parents chose to send their children to this particular technology-rich school. "Some of the parents actually came to me and said, 'Ms. Malik, I have learned a lot from my son this year because my son is using all this technology'" (Kiran, follow-up interview, quote #4).

> I think [parents are] mostly supportive, especially when they see that almost all the written work is being done on the computer, and then it's either saved on a disc, it's turned in, or even e-mailed to the teacher, and then it's automatic feedback where you can just make your comments and send it right back to the student. And there's been success stories where parents have seen some students that have not been motivated, that the computer has kind of turned them around and it's really made a difference on their grade....So, I think overall, it's gotten better and better. (Barry, follow-up interview, quote #9)

Across the board, the teachers felt their students were supportive of computer use. "Oh, they loved it. Just their enthusiasm is support. I didn't really have any problems.... They were very enthusiastic about, they loved being on the Internet" (Julia, follow-up interview, quote #4). "Kids love the laptops. Kids love computers. They can sit at the computers all day" (Kiran, follow-up interview, quote #5). The teachers felt students were engaged in computer-based lessons and enjoyed doing work on computers. Most students liked doing research on the Internet and creating power point presentations.

> In general, they really like it. I mean, especially when they see that it's a day where we have the classroom computers out and we're planning an activity. I mean, the energy level just goes up because they're excited about using them. (Barry, follow-up interview, quote #10)

I have already discussed some of the issues the teachers had with the computer equipment at the school. For the most part, the teachers felt they were lucky to have the high level of access to computers. On the other hand, they were expecting to have even more computers and more technological support. They also complained of some technological difficulties with the computers they had. For instance, laptop batteries did not last very long, so the laptops had to be plugged in almost continuously. This somewhat defeated the purpose of having laptops, since the need to use the power cords created problems for student and teacher movement around the classrooms. I observed teachers constantly reminding students to be careful of cords and students tripping over cords and pulling them out of the computers or wall outlets (various observations). Barry commented that he wished there were plugs in the floor so kids wouldn't trip over the cords (informal conversation, 5/10/02). Students sometimes had to sit on the floor to use the computers near the electrical outlets. This caused other management problems.

> When you have kids working and sitting on the floors and stuff like that, you can't always see what they're doing because they're sitting by the wall and I can't go walk behind them and see what are they doing. (Kiran, follow-up interview, quote #6)

Even so, laptops were still easier to move around and allowed for more flexibility than desktop computers.

Another problem with the computer or other technology equipment was malfunction during lessons.

> Another piece that we have…a problem with computers, sometimes LCD projection doesn't work, sometimes they can't go to a website, the website doesn't work, or computer having problems, or they saved something on the server….So we have had those problems a lot….Or two of the computers aren't working. (Kiran, follow-up interview, quote #7)

When the students were using the Cal Alive! program specifically, there was usually at least one computer that could not load the program or had no sound.

> There sometimes seems to be no rhyme or reason why [on] one laptop it just works perfectly, and all of a sudden it just, there's a disc error. And I don't think it's necessarily the fault of Cal Alive…I think it was just some of these laptops that the drive wasn't working. So, they're just technology glitches that can be a little frustrating sometimes. (Barry, follow-up interview, quote #11)

> We have seemed to have a problem with the computers: lock up, wouldn't come on, and we would have [to] reboot a lot of times and reinstall the programs….I tended to have to do that a lot, just to run the programs up again. And the other thing was in the tutorials…when the kids were listening to the tutorials, the speech would cut out at the very end. (Julia, follow-up interview, quote #6)

Teachers and students were often distracted by trying to solve these technology problems, which sometimes kept them from focusing on the lesson. Students with afflicted computers would usually have to join other groups, resulting in five, or even six, students sharing one computer. Even with the equipment problems, the teachers felt they could still have students successfully use the computers. "I just kind of worked through them. It wasn't a big problem, like I said. If it was a huge problem, I wouldn't have used it" (Julia, follow-up interview, quote #7). For the most part the teachers were able to figure out how to either solve the problems or work around them.

> I try to fix it by myself whenever I can. If I can't then I go to our technology person and say this is what the problem is and these computers aren't working….It does waste time sometimes, that kind of is frustrating. But that does not stop me saying, "Wait, I'm using them."…Because that's part of life. Nothing works straight. You always have problems so you have to kind of go through them. (Kiran, follow-up interview, quote #8)

Barry was the only one of the three who felt some of these problems made it harder for him to use Cal Alive!. "Yeah, I think it kept me from using it. Well, it might have, especially early on. It might have deterred me from using it as much" (Barry, follow-up interview, quote #12).

Overall, the three teachers felt a great deal of support in teaching science and teaching in general. As can be seen from the layout of the science department building in the methodology section (Figure 4), the teachers had access to a large storage area filled with science supplies. The science lab room consisted of nine large lab tables, each with access to a sink. The shelves in the lab room contained microscopes and other equipment.

In addition, the administration supported their professional development with the K-12 Alliance and the methods taught in the program. Kiran described some of the ongoing support she was given through the school and the K-12 Alliance that really helped her.

> I mean, it's like a live connection right there. Because it's not like I'm isolated in my classroom and if I don't know what to do….Because of K-12 [Alliance]…people were able to come to my classroom and observe. That actually also reinforced me to look at my teaching, because I didn't want somebody to come here and me not doing a good job. So which is kind of cool….I get people like every week these days. Literally. So that's also kind of good because I can talk to them then see what kind of things they do. And I was able also actually…[to] go out, observe other teachers from other schools. (Kiran, science teaching interview, quote #19)

Barry also felt support for improving his teaching through meeting other teachers.

> The networking with people, and 'cause you do that at a school site, but if you do that at a either state or even national level with different teachers, you really have a tremendous base of ideas and knowledge that's out there. So it's really been a neat experience here. (Barry, science teaching interview, quote #19)

In addition, the teachers felt the administration supported their use of the 5E lesson plan model and cooperative planning in the science department.

Although she also felt supported by the administration, Kiran did express her belief that the structure of the school day (in 50 minute periods) and the amount of content she needed to cover made it difficult for her to give students the time to really dive deeply enough into topics and computer use. When describing the time constraints on her computer use, Kiran explained,

> By the time I give directions to students and say this is what we're doing today and have answered their questions and stuff like that, we only have about half an hour left, 45 minutes….And sometimes they need more time on doing the activity, answering questions from the activity, or reflecting on the activity, so if there's more time that definitely will help. (Kiran, follow-up interview, quote #9)

These same time constraints, and the amount of material that needed to be covered, made it more difficult to implement 5E lesson plans.

> Unfortunately because of time we always teach all the topics, teach all the standards. I always don't use the 5E model, but mostly we do….I just love, absolutely love how it works. The only thing that we have talked like as a team…that because we only have 45 minutes every single day, even to complete one activity, it's not realistic. It doesn't happen when you have to leave things in the middle, it's not as fun. (Kiran, science teaching interview, quote #18)

The three teachers' contextual beliefs were quite similar with one another, probably because they taught in the same school, were supervised by the same administrators, and had access to the same equipment. It was instructive to discuss the contextual beliefs of all three teachers together to highlight their commonalities. The teachers' behavioral beliefs, however, were significantly different from one another. In order to showcase the specifics of each teacher, I will present the results of his or her behavioral beliefs and teaching behaviors in a separate subsection. I will begin with Julia's subsection, continue with Kiran's, and conclude with Barry's.

Behavioral Beliefs and Behavior of the Three Teachers

In each of the next three subsections, I will detail findings about beliefs and behaviors from one of the teachers.

Emergent Themes and Subsection Organization

Four theme categories emerged as the teachers' belief and behavior data were analyzed. I will use these themes as a framework for presenting the results. The themes were:

A. *Behavioral Management*: Related to classroom discipline and student behavior
B. *Teacher Role*: Related to how the teacher sees him or herself as a teacher
C. *Teaching Strategies*: Related to actual instruction the teacher does and the reasons for doing it
D. *Learner Outcomes*: Related to teacher perceptions of outcomes the students should be getting from instruction

The subsection on each teacher will be organized in the following way (see Table 9). I will begin by presenting a table that gives an overview of the teacher's behavioral beliefs and corresponding behaviors, organized by the emergent themes. I will then elaborate on the details of the table by providing data from the Munby RGT interviews about the teacher's beliefs. I will continue by describing the teacher's actual teaching with computers behavior using my classroom observations and other behavior data I collected. I will end with a brief analysis of the correspondence between the teacher's beliefs and behaviors, with a discussion of his or her use of best practices in teaching with computers.

Table 9: Organization of teacher subsections.

1. Overview table of teacher's beliefs and behaviors
2. Details about teacher's behavioral beliefs
3. Details about teacher's teaching behaviors
4. Analysis of the correspondence between the teacher's beliefs and behaviors

Teacher 1: Mrs. Julia Wilson

Julia has been a teacher for 20 years, and has the most teaching experience of the three teachers in this study. Refer to Table 10 for a quick reference of background information about Julia.

Table 10: Julia's background information.

Gender	Female
Country of origin	U.S.A.
Years teaching	20
Grade levels taught prior to this study	K-6, self-contained classrooms and some pull-out science classes
Science background	No formal science background
Science major in college	Elementary Education
Science teaching background	Taught some science every year

Overview Tables of Julia's Beliefs and Teaching Behaviors

The following tables present Julia's behavioral beliefs about teaching with computers (Table 11), science teaching (Table 12), and general teaching (Table 13), with examples of her actual teaching behavior. These tables provide an overview of Julia's results. Note: I will not discuss every aspect of Julia's science and general teaching beliefs and behaviors, as this study focuses on her teaching with computers.

Table 11: Julia's Teaching with Computers Beliefs and Behavior.

Teaching with Computers Beliefs	Examples of Observed Teaching with Computers Behavior
A. Classroom Management • Computers help students stay on task because they get excited about what they're doing	• Plans computer-based activities • Uses computers to motivate and engage students
B. Teacher Role • Create varied opportunities for students to learn • Reduce the amount of lecture; use computers to take focus away from the teacher • Make sure students are on task at computers	• Uses Cal Alive and the Internet for different parts of her 5E lesson plans. They were used as an Engage, Explore, Explain, and Extend • Walks around during computer lessons to make sure students are on the right sites or not fooling around
C. Teaching Strategies • Computers motivate and engage students and can reach students with different learning modalities • Computers help cut down on the amount of lecturing or information coming directly from the teacher • Computers always have new information so they are more exciting to students	• Has students do research on the Internet and Cal Alive! instead of lecturing • Gives students a specific site, or a topic, to research • Uses computers in different parts of her 5E lesson plans
D. Learner outcomes • Computers allow students to have more control over their own learning • Computers allow students to work more independently from the teacher • Students are more motivated when they can find sites or information on their own	• Moves from group to group while students are working independently • Has students work on group projects that result from computer use • Allows students some exploration on the computer when researching

Table 12: Julia's Science Teaching Beliefs and Behavior.

Science Teaching Beliefs	Examples of Observed Science Teaching Behavior
A. Classroom Management • Students need structured lessons to understand activity and stay on task • Students need to be quiet so teacher can tell if they understand • No teaching unless there is good behavior in the room	• Writes out detailed directions and provides a structured protocol to follow • Stops activity in the classroom if students are noisy
B. Teacher Role • Provide structure so students can do the lesson • Make learning fun • Facilitate student learning • Asses if students are understanding concepts; if not, help them get there	• Walks around and assesses whether students are on task or having difficulty with procedures or concepts • Allows for fun experience at first, but then brings discussion back to the concept
C. Teaching Strategies • Students need many opportunities to explore and experience science concepts • Students must learn specific science concepts • Students need to have enough background in the subject before moving forward (assessment of prior knowledge important) • Students should learn life skills, like being able to follow directions and being responsible for learning	• Uses the 5E lesson plan to help student experience science concepts • Gives students clear directions so they understand what they are supposed to do in a lesson • Uses lecture when time is short • Walks around during lessons and ask students questions
D. Learner outcomes • Students should have responsibility over their own learning as much as possible • Students should learn to think critically and read and follow directions by themselves • Students should discover concepts instead of being told	• Gives clear, explicit directions for activities and expects students to be responsible for following them • Provides hands-on activities and time for computer-based research

Table 13: Julia's General Teaching Beliefs and Behavior.

General Teaching Beliefs	Examples of Observed General Teaching Behavior
A. Classroom Management	
• Noise means students are off-task • Paying attention is a big part of respect for peers and for teacher • Students need to show teacher they are listening • No teaching unless students are quiet and listening	• Stops classroom activity if noise level is too high • Students seated in rows with eyes to the front • Uses group work as a special incentive to keep students on task and motivated
B. Teacher Role	
• Help students stay disciplined by being organized • Provide an example of respect in order to expect respect in return	• Points out her mistakes to show how to learn from mistakes
C. Teaching Strategies	
• Teaching should be individualized for students with different learning modalities and different needs (e.g., gifted students) • It is important to teach thinking skills because it helps students with everything else	• Conducts brief question and answer sessions to remind students what they did previously and to introduce the activity of the day • Group work used during activities to make them more exciting and to teach life skills
D. Learner Outcomes	
• Students should learn life skills (e.g., team work, respect, self-esteem, responsibility) • Important for students to learn thinking skills (learn about consequences)	• Assigns roles to students during group work.

Julia's Behavioral Beliefs

Since my research question focuses on Julia's use of computers, it is instructive to highlight her behavioral beliefs about teaching with computers. I will present the results from her Munby RGT interviews, with an emphasis on beliefs related to teaching with computers. I will also provide results from her science teaching and general teaching interviews to showcase the complexity of Julia's belief system and how the beliefs compare with each other. For the specifics about Julia's elements, constructs, grid ratings, and factor labels from the Munby RGT interviews, see Appendix 6.

Beliefs about behavioral management.

Julia is very concerned about making sure her students are focused on her lessons in order for them to learn the science concepts she needs to teach. Among other things, Julia sees computers as a good tool to keep students on task.

> It's a real motivator and I think the more you can interact with computers and subject area, the more you have the kids with you. There's no opportunity to fool around cause we're always busy doing something. (teaching with computers interview, quote #1)

This view of computers fits in well with the behavioral management beliefs that appeared consistently in her general and science teaching Munby RGT interviews. For example, Julia believes students need to have a quiet atmosphere in order to learn. Noise means students are not paying attention and therefore not learning.

> I know all teachers have different tolerance for noise, and I let the kids talk while they are doing labs as long as I feel they are engaged in the activity…I teach respect, I teach the pillars. I demand respect. If someone is talking, regardless of the fact that the kid is not learning or not following directions and he'll be the first one to ask you again, you're wasting your time unless everyone is listening. And, you know, especially when you're trying to point out, "Look what this kid did over here, look what's happening in his experiment," if they're not listening, what's the point? They've missed the teaching moment. (general teaching interview, quote #7)

In addition to computers helping maintain good student behavior, Julia also discussed ways in which she believes computer technology has changed her teaching.

Whereas computers used to be disconnected from her core teaching, she has learned how to make them integral to her plans for student learning.

> Before I would have kids going back to our one or two computers, just rotating them in and out, maybe with a little Extend lesson that they needed to look up or practice spelling or something. And while I was teaching they would just be continually going back there. It wasn't related to my lesson plans at all. So now it is, everything is. (teaching with computers interview, quote #26)

In fact, Julia resisted incorporating computer technology in her teaching for many years. As she has gained more knowledge and access to professional development and equipment, she sees computers as powerful learning tools. "I'm finding that it's really a very important tool, because instead of going through a teacher, they're sitting there engaged in the information themselves" (teaching with computers interview, quote #29b).

Beliefs about the teacher's role.

Julia believes her role as a teacher is to provide experiences that allow her students to learn. She does not think students learn much from teachers giving them information, so she tries to avoid lecturing as much as possible.

> Oh yes, we waste a lot of time up in the front, unless you're standing on your head or kicking your heels....I've observed a lot of teachers and I notice what the kids are doing while a teacher is lecturing. So, they're not listening, maybe 2% of the class is listening. Or when I lecture, sometimes it IS necessary, and I'll lecture and very few kids can spit it back to me. So, what is the use of doing that? I try not to as much as I can because I'm concerned about what the kids are getting. We have to go through these standards and I don't have time to keep going over them. (teaching with computers interview, quote #30)

Computers help her meet her goal of limiting her lecturing by taking the focus away from the teacher.

> And it's more, you know, that "guide on the side" instead of the "sage on the stage," you know. You always want to get away from being the center. And again that's experience with kids. I always look at their eyes and I do not like that look

> of "oh, brother, is she boring." So I will go to any length to get it, a lesson interesting for the kids, because, you know, we're responsible to get the information out, and when you know you're standing up there yacking, and they don't listen, they're not listening, their eyes are glazed over…it's as good as not taking the time to do it, cause they're not listening, they're not getting anything out of it. And some kids won't even get anything out of the technology either, but for the most part, I think they really do. (teaching with computers interview, quote #4)

Julia characterizes herself as being able to understand instinctively what her students need in order to learn. She anticipates what will reach her students and adjusts her teaching according to their reactions. She believes that this is an important part of being an effective teacher and applies this consideration for her students to teaching with computers.

> I like to explore. I love having time to explore and when I don't have time I get frustrated. And you have to be a little empathetic with the kids and they like time to explore too. So I think it's more experience with kids and knowing what they like. And technology today is not what it was 15 years ago, so there are many more things out there for the kids. So you got to give them time. (teaching with computers interview, quote #3)

Beliefs about teaching strategies.

Planning.

Julia uses computers in every step of her teaching, from her own professional planning to her students' activities in class. "[W]hen I do lessons, I mean I use computers to do my lesson planning. I use computers as the, how would you say that, as the "what" I want kids to do as part of the lesson plan" (teaching with computers interview, quote #21). She explained the many ways she uses computers as a teacher.

> Well, of course that would encompass communication to the office, when we evaluate the kids we write down the scores and e-mail that in or put it on a spreadsheet, we do a lot of housekeeping for the school on computers. I do my lesson plans….So support for what I'm doing. I look up my lesson plans there, or

> we map, and do a lot of research on the Internet to get our curriculum mapped out. (teaching with computers interview, quote #34)

In terms of her team planning, Julia uses computers to work with other teachers to determine overall curricular goals for science teaching at the school. Using computers in all facets of teaching is relatively new for Julia.

> And that's something our science team has really been working hard on this year, is the mapping, the curriculum mapping. So I would say it's probably 80% this year, just doing it, just deciding that's how we're going to do it. This is the first year I've really used technology the way I'm using it. All new to me. (teaching with computers interview, quote #24)

Reaching all students.

Julia believes it is important to reach all children with her teaching. She believes that she can do this by using a variety of teaching methods to teach students with different learning modalities. It is the teacher's job to be aware of how different students learn and then teach accordingly.

> The first day of school I like to walk around the room and I notice all the kids whose eyes follow me are the visual learners. And then pretty soon you'll hear the pencils tapping. And the kids that don't realize they're tapping their knees against the desk, you know, those are the auditory learners. And, you know, it comes out really fast what style learning they do. And so you want it to be fun for every single group....It just make sense that, you know, not everyone learns the same way. (general teaching interview, quote #15)

Julia is especially concerned with challenging her above average students. She wants to make sure they are stimulated, and talks about giving them extra work during class or for homework. She uses the computer as a tool to make sure they are engaged.

> I've always been concerned about gifted kids. You need to challenge them. When they can design their own learning it's even better. So I've always been into the challenge part, going above and beyond the normal class activities for the gifted kids or the high achievers. (teaching with computers interview, quote #17)

> Or we like to go into the interactive sites where kids can, you know, kind of engage themselves....So and with the GATE kids, I give them that on the side so they can do it at home as well, because they need to be challenged a little better. I use the computers to extend the lesson if we're doing something and some of the brighter students get finished early. They go on the computers and look up a site, or I'll give them a topic and they need to search the Internet for something related. (teaching with computers interview, quote #6)

Motivating and empowering students.

Julia believes using computers is a great way to motivate all students because it is exciting for them to use the technology. "And since our program is really new with our technology, the kids are just loving it. Every second they can be on a computer, the better" (teaching with computers interview, quote # 31a). She shares their enthusiasm about the technology.

> They get so excited when they find a site. I can't get to all the kids in the same time. "Oh look what I found, look what I found!" And I'm still doing that [too] because the Internet is so great, I'm still doing that. (teaching with computers interview, quote #16a)

> And it's more personal for the kids. Kids have more choice, of course unless I write down a site I want them to research. So plus it's always new, there's always something different, you're not going to get a repeat. And right now it's brand new to the kids so any time they open up a computer they think they're "hot stuff." (teaching with computers interview, quote #10)

Julia sees this motivational factor applying to all subject areas, especially for her in teaching science.

> It's used to motivate kids in science definitely. It's an added dimension to science, to any teaching really, and I don't know what we did without it before. It just seems like such a short time ago when we didn't have it and we would come up with our own things or copy things that we'd see, or we have one computer in the classroom. (teaching with computers interview, quote #9)

Julia also believes computers can give students the opportunity to make their own choices and learn on their own. She believes this learning is more powerful than if a teacher always tells them what to do.

> Or I'll say, "You guys have got to see this site, it's so cool, there's good pictures." And then I find out even with that, if I direct them to a site that I found overnight or something, there's not quite the excitement as there would be...if they had just found it themselves...I just see a little difference. Even though they like the sites that I give them, they might think, "Oh, that's really cool." So, and even the ones I do give them there's always links and they go on. And there's choices. Kids are great at making their own choices. (teaching with computers interview, quote #16b)

> It empowers kids to learn on their own and I think that the greatest tool we have is kids' motivation to find out new things. They get tired of us telling them what to know and so anytime we have them explore, they're discovering. And they just, they remember it. Whatever they discover on their own I think they're going to remember much more than us telling them. (teaching with computers interview, quote #15)

Teaching concepts through discovery.

As a science teacher, Julia believes it is important to find the best ways for students to learn the science concepts. She believes they learn best by direct experience and discovering concepts on their own.

> "I want them to discover. If you tell them 'this is why it is' they remember it for maybe five minutes. But if they discover it themselves, they're going to remember a lot longer." (science teaching interview, quote #6)

> My principle when I was first came to [this town] had this thing about "as a teacher you should be the guide on the side instead of the sage on the stage" and I always had that motto on my desk because that's very true. Kids, if they can be in that discovery mode and instead of, you know, it's basically the kids doing things even though you're guiding them. If they don't know you're guiding them it's even better because they think they have control over their education. But this goes hand in hand with our 5E model where you back off and you let the kids explore and discover and discuss and explain the whiteboards. That's really what they're doing. They're not centering their attention on you, they're centering their

> attention on what they're doing, instead of listening to a lecture. (science teaching interview, quote #7)

Getting her students to think critically is another important goal for Julia. She believes that critical thinking will help students in any area of their lives and can help them discover how the world works, an essential part of science.

> I think that's one of the most important things that we can teach kids is how to critically think. And that has a lot to do with knowing consequences and cause and effect. Science is all about that so it just really plays hand in hand with that. So everything I have really done in the past 10 years at least, 12 years, has been along those lines; getting kids without, you can tell a kid this is why rocks fall to the earth, but you know they're not going to remember it if you just tell them. So I use a lot of critical thinking. (science teaching interview, quote #39)

> It could be a whole group where we're discussing something. Sometimes when they're explaining their whiteboards we end up in a discussion, a whole group discussion. And that's when I use critical thinking to get them to realize, "okay, what was the consequence of that? What was the effect? What caused this?" So you know I'm really leading it, but the kids are discussing among themselves. And hopefully they're discovering along the way. (science teaching interview, quote #36)

Julia believes computers allow students to guide their own learning and participate in the discovery and thinking processes.

> Sometimes we'll have a station that is just technology where they are researching something or doing an interactive site, depending on the lesson plan. And of course I would be supporting, you know walking around, but the kids are guiding their own learning. They're actually going from site to site, and "Oh, I want to find out more about this," so they click that. There are so many choices with the Internet that they are guiding their own learning and they are very engaged in it....And that's how they guide their own learning basically. When I give them free Internet time, I'll give them a topic, look something up and go to there, so they actually have...their own agenda as to where they want to go. And I just walk around making sure they're at the right, that they're engaged in science and not some game site or something. (teaching with computers interview, quote #11)

Computers also give Julia choices about how to help students learn information without her having to lecture.

> I'm using technology to carry out [the] lesson. Since I have technology integrated in what I'm teaching, it's a very important part of getting the concepts down....You don't want to stand up there and lecture, which is what we used to do. (teaching with computers interview, quote #28a)

Lesson implementation.

Julia believes computers are a natural fit with the 5E lesson plan. She described how she uses computers for the Engage, Extend, and Evaluation parts of the lesson (emphasis added in the quotes).

> Yeah, the technology is...[used] sometimes as a preview or like an **engagement**. We'll get on the net and see, you know, just different topics and then that brings up questions for discussion....We also use that as a springboard for science fair projects. There are so many sites on the Internet to show kids. (teaching with computers interview, quote #8)

> So and normally when we lay out our lessons, we always have an **Extend** with technology. So for instance, if we're studying geology and how mountains are formed, I would want them to look up what are the mountains on Mars and how big are they and, you know, something related to space because we're required to always tie in space with everything we do, which is easy to do. (teaching with computers interview, quote #7)

> When I use technology in a lesson, I'll have worksheets that they need to fill out...they look up, it's specific but they still need to get in there and research and then I can see how much they've gotten out of it by seeing what they write on their papers. So I am using technology as part of their **Evaluation**. (teaching with computers interview, quote #20)

Beliefs about learner outcomes.

Learning concepts.

One important outcome of Julia's teaching is for students to learn and understand the concepts she is trying to teach. As was mentioned previously, Julia believes that students learn best when they discover concepts on their own, and hands-on labs and computer-based activities can help them do that.

> You just kind of sit back and you kind of notice, oh I don't have to lecture at all. They're discovering things on their own. And then when you go to evaluate your lessons and you're looking for certain things like how much of the concept or the vocabulary that they remember, and it, you know, they spit it right back out because they experienced it hands-on. So and I love watching kids discover things. (science teaching interview, quote #8)

Life Skills.

Besides learning the science concepts, Julia believes it is important for her students to learn life skills that will help them in the future. She believes computer-based lessons can help students learn these skills. Some skills will help them in their future studies, like learning to follow directions.

> You have to read the directions yourself and that's what I'm finding the kids are really having problems with. They're not good direction readers. So I'm hoping with all of our technology and self-driven activities with technology that they'll be able to read directions better by themselves, which in turn I think will help their SAT scores, because I think we're gonna see a little better jump because they can learn, I mean if they're forced to read their own directions instead of having mom there or the teacher there, then they'll get used to it and they'll be able to do that for their SAT tests. (teaching with computers interview, quote #13)

Other skills will help them in their lives in general, such as being able to apply good thinking strategies.

> So often the problems that kids have are lack of thinking. "Why do you have detention?" "Because I hit a kid." "Why did you hit a kid?" "Well, I wasn't thinking." If they were to recognize what they are doing, and the consequences, even for a split second, maybe that could stop them from doing things that get them in trouble or their grades. Grades are a direct result of what you put into it. It's just good all around. Kids that really are strong in the thinking skills are the ones that are on the right path. They don't have to be the brainiest kids, but they're on the right path. (general teaching interview, quote #28)

Julia also sees her role as preparing her students to face challenges in their studies and careers. Group work is something Julia sees as a definite skill students need in the future.

> I know that in college now they do a lot of group work, you know, grades and projects. So they need to get used to it anyway. And in the working environment, that's how it's going to be in real life, so it's just kind of getting them ready for that. (general teaching interview, quote #37)

Julia also believes that by working together, students gain other important life skills that they will use throughout their lives.

> And they have fun building things together and it promotes good team work, good character building. They have to share. They have to be able to take, we normally have a monitor at each team, they have to be able to take orders or not get picked one day. I think it's good all around. They get leadership skills, the helping each other out I see as very valuable. (general teaching interview, quote #20)

> [I]t takes time for them to get used to each other and we talk a lot about not everyone is the same and some people have different qualities that make it easier to get along with them, sometimes harder, but you are a team. And I really stress teamwork and we have competitions in teams and everything. We go through the football analogy, the defense and the offense. The defense could have done great that day but if the offense doesn't score, you don't win the game. So you're all in the same boat. (general teaching interview, quote #29)

Summary of Julia's beliefs.

Julia has a well-formed and complex set of beliefs around teaching with computers, science teaching, and general teaching. She believes strongly in the need for order and quiet in her classroom, as well as in facilitating student discovery and student choice. She believes computers are useful in motivating students and in presenting information in an exciting way. Computers also help reduce the focus on the teacher and give students the opportunity to find information for themselves. How do these beliefs compare with her teaching behaviors? In the next section I will present examples of Julia's teaching from my observations of her classroom and from the other behavioral data I collected.

Julia's Teaching Behaviors

In this section, I will focus on examples that illustrate aspects of Julia's teaching with computers, but will also include some examples of her non-computer teaching to provide a fuller picture of Julia's teaching practice. I will use my observations as the main source of data, which will be supplemented by the more self-report behavioral data (e.g., lesson plans, reflections).

Behavioral management.

I was able to observe a great deal of correspondence between Julia's behavioral management beliefs and her behavior. She did not allow her students to get very noisy during the class period and would stop the class immediately if the noise level rose. A typical behavioral management exchange between Julia and her students would be something like this one (observation, 2/28/02):

> Julia: Listen carefully, I'm only going to say this one time.
> Students (SS): *noisy talking*
> Julia: Oops, I'm going to wait until it gets quiet.
> SS: *quiet and listening*
> Julia: If there is a problem do you run across the room and get me?
> SS: No.

Julia would also count down from five or use singing call and answer cues (e.g., Julia: "bum ba da bum bum..." SS: "bum bum") to get students to quiet down. Julia would make it clear to her students that their behavior had consequences. For example, she would say things like, "We're going to have a fun lab but I need to see that you're listening. I have all day to wait and we won't get to the fun stuff" (observation, 6/11/02). These techniques were usually very successful in getting students to give her their attention. She would also praise students when they were quiet and paying attention (e.g., "I really like the way you are being quiet today" [observation, 1/30/03]).

I only observed one class period in which Julia had a little bit of trouble getting her students to settle down at the beginning of the period (observation, 1/28/03). She made students repeat the arrival routine until they did it the way she wanted. The following exchange took place:

> SS: *entering classroom very noisily*
> Julia: 5, 4, 3, 2, 1, 0. (*waits*) Go outside and start over. Way too loud.
> SS: *leaving classroom and entering again*
> Julia: Go in quietly.
> SS: *entering classroom but still somewhat noisy*
> Julia: Kids, come out and try again. I need it quiet.
> SS: *leaving classroom for the second time*
> Julia: When I ask you to be quiet, I need everyone quiet. Try it again.
> SS: *entering classroom in silence*

On average during my observations, Julia only had to remind students to be quiet two to three times during a period and spent about two minutes waiting for quiet. Julia was able to use the rest of the period for instruction.

The computer set-up did cause some challenges for behavioral management. Julia complained to me while her students were using the laptops to do Internet research that, "This is not an ideal situation. I only have six or seven computers and four [students] to a computer" (informal conversation, 6/6/02). Right after that, one of the computers had technical problems and Julia had to send those students to join other groups. At one point there were seven students trying to share one laptop. Julia told me,

> This is way too many kids on a computer because this is what happens. Two kids are sitting back bored because they can't see the computer. That's when they get in trouble...Two or three to a computer is the most you should have.

Julia explained to me that initial hopes for buying more laptops or for being able to share them among classes were not being realized. “We were going to get more [laptops] but the money ran out, no more budget. Now we’ll have to use grants…We were borrowing computers but now everyone is using them everyday so we can’t borrow. We are encouraging kids to buy and bring computers” (informal conversation, 6/6/02)

The quantity of laptops in Julia’s classroom had not increased by the middle of the following year. She still had four or five students sharing each computer and it was sometimes difficult for Julia to make sure every student was engaged. On 1/28/03 Julia had to remind students, “I see some kids just standing around. You should be sharing jobs. Give everyone something to do” (observation).

Teaching strategies.

Reaching all students.

I did observe Julia incorporate different learning styles into her teaching. She would go over activity directions verbally and usually had a written directions as well (multiple observations and lesson plans). She would vary the type of student products to appeal to different learning styles. For example, although she often had students answer written questions or fill out worksheets (e.g., observations: 6/6/02, 1/10/03, 1/17/03), she might also have students make posters or booklets of drawings instead of just writing (observations: 2/28/02, 1/28/03; student artifacts, 9/30/02). I also observed her reading a brief story to her students as an Engage for an activity (observation, 1/17/03).

After attending a conference on brain research, Julia tried out some of the recommendations on 1/30/03. For example, to get her students to remember information about chemical elements, Julia had them move around and change their physical location before reviewing a list of questions with their partners. This could help kinesthetic learners. She told them to "take your sheets, bend over and go on the floor with your partner and ask each other one question to see if you know the answer" (observation). She then had them play an element symbol recognition game that could appeal to visual, auditory and kinesthetic learners. Each student received a card with two element symbols on it (e.g., card 1: Fe and Na, card 2: Na and He). The first student had to figure out which elements were on his card, stand up and say, "I have iron. Who has sodium?" The student with the Na symbol on her card would then stand up and say, "I have sodium. Who has helium?"

Group work.

As Julia discussed in her Munby RGT interviews, I did observe her have the students work in groups. She sometimes explicitly assigned roles for group members or gave them the responsibility of choosing roles. One method she used was to give each student in a group a different color. She would then assign roles by color. For example, during one class period she assigned the "reporter/controller" role to the green person (observation, 2/28/02). She called on the "materials" person to get markers and paper for a group project. When it came time for groups to share their work, Julia called for the reporters to raise their hands to speak. Another time Julia had students pick a recorder themselves (observation, 3/21/02). The recorders then went to the board to write up what their groups had found. During a lab on oil exploration (renewable and non-renewable resources), she reminded students to "take turns with your jobs" (observation, 6/11/02).

I also observed Julia refer to the idea of teamwork when her students were working in groups. In a lesson on experimental design, she told the students to "design an experiment as a team. Share ideas. You may have to give up your idea. You can't always have your idea in a team" (observation, 1/10/03).

As mentioned previously in the section on behavioral management, Julia had more trouble making sure every student had a role to play when working in groups on the computers (various observations: 2/28/02, 3/21/02, 6/6/02, 1/28/03). Usually in every group there would be at least two very involved students. One would be holding the mouse and in control of the computer and the other would be recording what the group found. Some students who did not have one of those two roles would still stay very involved, either reading the computer screen, discussing findings with their partners, or taking notes themselves. Other students would exhibit off-task behavior by staring off into space, reading, doing other work, or having side conversations. Julia did not seem to have a method for making sure all students had something productive to do during a group computer project.

Teaching concepts.

Critical thinking.

Julia spoke a lot about critical thinking in her Munby RGT interviews. I did observe her leading discussions in her classes, but they mostly consisted of her asking questions and the students answering. For instance, in a discussion of the daily news about space topics from MSNBC.com (observation, 6/6/02), the following exchange took place:

Julia: Daniel, please go to MSNBC.
Daniel: Shuttle launch after weeks of delays.
Julia: Why do you think it was delayed?
Student: Weather?
Julia: So another one?
Daniel: NASA develops radar for rescue
Julia: What do you think it would need a rescue for?
Student: Rough satellite.
Julia: So if you want to read about that you can go to the website.

On the same day, Julia led a discussion on how students should save their work on the computer. This was a good opportunity to have students think about the consequences of not saving their work or not doing it correctly, but she did that mostly by telling them about it.

Julia: You are going to walk me through saving. Suppose I had worked on my project for three weeks. How would you get it to me for a grade? Safeguard first. What is the first thing you need to do?
Student: on network
Julia: Ok, you could but…
Student: on a floppy
Julia: Yes, floppy. How do I do that?
(*A little later in the discussion*)
Julia: We were talking that often you don't know where you save because you don't pay attention…you need to bring a floppy all the time because someone might borrow the computers and we won't have these anymore and your work will be gone. Everyone bring a floppy because you don't have control over anyone else.
(*Students begin to do research on laptops with one group on Julia's computer*)
Julia: All the ones at my computer, don't touch my folders. Ms. ____ will come and talk to us about the danger of doing that. A student got in trouble for that.

Lesson implementation.

5E lesson planning.

It was clear from Julia's lesson plans that she attempted to organize much of her teaching according to a 5E lesson plan structure (various lesson plans) . She usually had a clear Engage, Explore, Explain, and Extend section in the written lesson plan. As her lessons often extended over several days, I usually observed only one part of each lesson plan and was not able to see how an entire lesson played out. I did observe an Engage, Explain, and Extend of a lesson on California climate and the rain-shadow effect that took place on two different days (observations 2/28/02 and 3/21/02). There was a large time lag between the initial Engage and Explore (which I did not observe) portions of the lesson and the subsequent Explain portion due to Julia being in and out of the classroom for a few weeks, so it was difficult for the students to remember what they had done previously. However, with a little prompting and visualizing from Julia, and a review of explanatory posters they had made, students were able to remember the basic concepts. I will come back to the details of this lesson shortly.

Specific uses of computers for 5E lessons

Julia spoke about using computers for different parts of the 5E lesson plan. She was able to do this, although I never observed her students using the computer to make presentations (both Kiran and Barry did have students make computer presentations). For a lesson on plate tectonics and faulting, Julia's lesson plan called for first giving student groups uncooked spaghetti and having them try bending it until it broke as an Engage activity. Then she planned to continue the Engage by showing them the Cal Alive! geology tutorial section on subduction (lesson plan, 9/26/01). This Cal Alive! section contains animations of different kinds of faults (e.g., normal faulting). For the Explore, Julia planned to set up six stations related to faults and four related to folds around the room. Three of the stations were to contain laptops displaying sections of the Cal Alive! geology tutorial ("subduction" and "faulting" for the faults stations and "folds and mountain building" for the folds station). After the student groups spent 20 minutes at one set of the stations, they were to explain what they had learned about either faults or folds on whiteboards for the Explain part of the activity. Julia planned to give them the choice to describe what they learned in the form of a "poem, art work, diagram, drawing, etc." The Extend was to research if mountains existed and behaved in the same way on other planets (connecting to the school's space theme). This research was to be done on the Internet and Julia assigned students several websites to use. This lesson was a good example of a 5E lesson plan incorporating computers. The only aspect that could have reduced the discovery aspect was showing the students the Cal Alive! subduction section as part of the Engage. The subduction section explains the different types of faulting that the students were going to Explore in the stations later in the activity.

As it turns out, Julia wrote in her reflection about that activity that her projector did not work during the activity so she was unable to show the Cal Alive! subduction section as part of the Engage. Instead, she had students go directly to the stations. She wrote, "They loved looking at the program and enjoyed the activities [during the stations]….The white boarding was especially enjoyable. The kids loved being creative! They went back into the Cal Alive! program, reinforcing their knowledge [of faults and folding] with pictures and facts, and described what they learned on white paper." Inadvertently Julia had maintained the more inquiry-based aspect of the 5E lesson plan because of technical difficulties.

As I introduced previously, on 2/28/02 Julia used the Cal Alive! program for a lesson on California weather and the rain-shadow effect (observation). She generally followed a lesson plan from the Cal Alive! Classroom Guide that was already organized in a 3-part learning cycle (Explore, Explain, Extend). She split the original Explore into an Engage and Explore. She also made a significant modification to the Engage from the original activity that ended up decreasing the "discovery" aspect of the activity.

For the Engage, Julia first had students read three pages in their textbook on California's climate. She then questioned the students about the definition of "rain-shadow effect" and the outcome of a rain-shadow (wetter on ocean side of mountains, drier on inland side of mountains). Then Julia went over directions for what she wanted students to do with Cal Alive! in the Explore section.

> Really quick, I want to show you. In your blue folder there are directions. I'm going to go over it first so you'll know what's going on. Go to the Cal Alive! icon [on the desktop] and double click. What do we call this in Cal Alive!? (Students answer, 'home base.') We're going to go on a field trip. You're going to start with Disk 2. The first thing I want you to do is slowly go over the mountain. I'm only going to assign you one.

Students then worked in groups to view a pre-assigned Cal Alive! animation flying over a transect in California from the coast, over a mountain range, to an inland destination. The 3-D animation shows, through changing colors and explanatory narration, how inland areas on the east side of a mountain range in California are drier than coastal areas on the west side. Originally, the activity called for students to explore the Cal Alive! transects before being introduced to the idea of a rain-shadow effect. After students observed differences between the coastal and inland sides of the mountains, students were supposed to come up with an explanation for why that might be happening. In Julia's version of the activity, the students already knew the phenomenon was caused by differential precipitation (and the reasons for that difference in precipitation).

After about eight minutes using the computers, Julia had students stop and draw a picture of the transect they observed. “I would like you to draw that mountain. Show me where it would be hot, cold, dry, wet…and any other information you found out.” In the last few minutes of the period, Julia led a question and answer session as students shared their drawings.

> Group 1: Our mountain was Mt. Shasta. The west side most likely rains. It precipitates there.
> Julia: And on this side? I have a question. Is there water on this [east] side?
> Group 1: No.
> Julia: Good, give them a hand. Who’s next? We only have a few minutes.
> Group 2: [Channel Islands to Death Valley transect] On the leeward side it was mostly hot. On this [west] side it was wet.
> Julia: Any questions?
> Student: How would it change so fast from green on one side to brown on the other?
> Julia: There is a different climate on the other side of the whole mountain range, not just one mountain.
> Group 3: [Pt. Reyes to Mono Lake transect] It is wet on this [west] side and dry on the [east] side.
> Julia: Explain why it got drier.
> Group 3: Mountains block all the moisture and rain so this [east] side is dry.
> Julia: Does the cloud run into the mountain or what happens?
> Group 3: The cloud poops out.
> Julia: Yes, the cloud poops out.

This discussion was somewhat typical of the Explain portion of the lesson plans. Often the Explore would take longer than expected and there would be very little time to allow the students to share their work. This caused the explanations and resulting discussions to be quite truncated.

In another example of Julia’s propensity for explaining the science concept in the Engage of a lesson, she had students read about interactions in their textbook before they explored the concept of interaction (lesson plan, 9/02). As part of the Explore, she had student groups look at four different types of interactions (e.g., competition, mutualism, predation) in the Cal Alive! program. Each student group was responsible for creating a poster to explain one interaction to the rest of the class.

In another lesson using Cal Alive!, Julia was preparing her students for a week-long science camp experience on the coast of California. Julia wanted to introduce students to the coastal habitats and organisms they would see at the camp. To do this, Julia had students view the rocky intertidal (tide pool) habitat in the Cal Alive! program and then draw pictures of some common organisms. Julia decided to make this a very prescribed lesson in which she told the students exactly which organisms to draw (observation and handout, 1/28/03) instead of allowing students to choose organisms. On the handout she created, Julia directed students to specifically "draw the goose barnacle, chiton, starfish, and marine snail." There was no reason that I could determine for structuring the lesson in this way, as Julia had no other plan for using those particular organisms in a later lesson.

This was not the only time that student choice was deliberately taken out of Cal Alive!-based lessons. Although the lesson I will describe was planned jointly with all three science teachers, Julia supported the decisions that were made and may have even been the originator of some of them. Julia also created the modified handout to go along with the lesson.

The lesson was created as part of the ongoing professional development provided by the K-12 Alliance, called the TLC (Teaching and Learning Collaborative). One of the regional directors of the organization met with the three science teachers to plan and implement a 5E lesson. The team decided to do a lesson on the weathering of rock. They chose to have students do a hands-on lab with rocks for the Explore part of the lesson and a section in the Cal Alive! program as the Extend (TLC planning session, 2/20/02).

The Explore activity consisted of a lab in which student groups attempted to break apart different kinds of rocks using various methods (e.g., using hand, hammer, nail, water). Instead of allowing them to choose which tools to use and in what order on which rock types, the teachers decided that the students should all follow the same sequence. When they implemented the lesson together, Barry was chosen to explain the directions to students in this section of the lesson. Following their plan, Barry explicitly directed the students to attempt to break apart each rock using the tools in the order they were listed on the data sheet. He told students to start with rock A and to "remember to go in order." Julia reinforced these directions by reminding students to stick to the order and "do everything with rock A, then rock B" (observation, 3/14/02).

In the Extend phase of the lesson, the teachers decided to have students use a soil-creating simulation in the Cal Alive! program to discover how physical and biological conditions affect the weathering of rock. In the simulation, students choose a rock type, temperature, moisture level, and presence or absence of vegetation. Then they run the simulation to find out how quickly and what type of soil is formed under the conditions they chose. The rocks featured in the simulation were the same as those used in the lab.

The teachers chose to modify an existing lesson in the Cal Alive! Classroom Guide for this part of their lesson. The original data sheet for the lesson allowed students to freely choose combinations of variables in the simulation until they begin to see patterns between their choices and the outcomes. Instead of allowing students to choose the variables, the teachers decided to redo the data sheet so students were told which variables to choose and when. For example, the teachers wanted students to try all the combinations with granite first. The data sheet directed students to "Choose granite, hot, dry, barren. Then choose granite, hot, *wet*, barren. Then choose granite, *cold*, *dry*, barren," etc. In addition, they simplified the number of variables by only allowing student to choose barren (not vegetated). All the students had to do was click the buttons in the order on the sheet and then record the outcome. The teachers cited time as the reason they needed to tell students what to do in the activity. In addition, the teachers didn't seem to think the students would be able to figure out the patterns in the data if they were allowed to do the experiment in whichever order they wanted.

Analysis of Julia's Belief and Behavior Correspondence

Correspondence between beliefs and behavior.

After teaching for 20 years, Julia has developed a rich and complex system of beliefs about teaching. Her beliefs are infused with notions of respect and responsibility, and she takes her role as a shaper of young lives very seriously. She has constructed an approach to teaching that is both satisfying to her and fun for her students. It is clear that Julia has been able to incorporate teaching with computers into her teaching practice.

For the most part, Julia was able to use computers in general, and the Cal Alive! program specifically, in ways that were consistent with her teaching with computer beliefs. She believes computers are a good teaching and learning tool because they motivate students to learn, teach them technological and other life skills for the future, and help students stay on task. I observed her having students use the computers to do research, distill information, and learn about science concepts and science news. Her emphasis on using the computer for information retrieval fits with her beliefs about the utility of computers. She believes computers are great sources of current information and they present information in a way that is more interesting to students. According to Julia, it is hard for students to get bored when they have access to the Internet and exciting software programs.

> This would be more of a way to get out information to the kids in a unique way, and a fun way for the kids. I try to do as much hands-on as I can, but the information part gets really dry....And now the kids, you know, we can be at the computers, we have Cal Alive!, where they're still getting the information, but they're doing on their own basically. (teaching with computers interview, quote #28b)

These uses of the computer are also consistent with Julia's beliefs that there should be less emphasis on the teacher as the keeper of knowledge. The computer takes the focus away from her as the teacher and gives her students a way to find things out for themselves.

Correspondence between behavior and best practice.

Julia has some beliefs and behaviors that are consistent with the best practices in teaching with computers that are cited in the literature and emphasized in the K-12 Alliance professional development program. At first glance, Julia seemed to embrace the philosophy and methods associated with inquiry-based learning (e.g., discovery learning and conceptual understanding). Julia had very explicit science teaching beliefs about allowing students to discover concepts on their own. Why did she sometimes modify computer-based lessons so that they did not coincide with her student discovery beliefs?

One possible reason is that student discovery was not as much a part of her computer teaching beliefs as it was her science teaching beliefs. Although she mentioned student discovery in her computer teaching beliefs, especially if she specifically allowed students to explore freely, she talked more about computers as a motivator and as a means to transmit information in an interesting way. Perhaps it was this view of computers that dominated at the times she decreased the amount of student discovery in a lesson.

Another possible explanation has to do with Julia's competing beliefs about important outcomes of a lesson. As a part of Julia's science teaching beliefs, she had a strong belief that it was important for students to learn discrete science concepts. She was very concerned with exactly what science content students were learning in her lessons, as can be seen in the following quotes.

> I want them to discover the concepts. It's not vocabulary work, it's not reading, it's not testing. It's basically the kids learning. What in the lessons do I need to do to get them to learn the concepts? (science teaching interview, quote #40)

> As they're exploring, I just walk around and I listen. I'm evaluating what they're knowing by what they're saying….I can see if they're even understanding the concept I want them to understand, just by walking around. And then I can also see if they've gotten what I wanted them to get out of the experiment or whatever we're doing. (science teaching interview, quote #28)

Perhaps Julia's beliefs about making sure students learn specific content are more dominant than her beliefs about the importance of having students discover concepts on their own. Julia does talk about her belief that students will remember things longer if they discover them on their own. However, it is possible that she can be more certain that they will be able to answer questions correctly in the short term if she introduces the concepts explicitly. Therefore, her science teaching beliefs about learning science concepts might supersede her beliefs about students discovering concepts on their own.

Julia did develop the majority of her lessons using the parts of the 5E lesson plan, which is a recommended method for facilitating inquiry-based learning. For example, she believed in the importance of the Engage to assess students' prior knowledge and get them ready for exposure to new experiences. She also took naturally to the idea of the ongoing Evaluation to monitor students for understanding, or lack thereof, and adjusting the lesson accordingly. She felt the Evaluation in the 5E lesson plan was something that captured a strategy she had already been using in her teaching.

> When people would ask, 'how do you teach this or that?' then it's kind of, I never had a way to tell them. 'Well you just kind of have to look at their eyes or listen to them, and if they don't get it then you go back and you do another…' So it was really cool. I really got into that. (science teaching interview, quote #38b)

Even though she used the 5E lesson plan, she would sometimes modify it and thereby reduce its effectiveness. It is even possible that she misunderstood some of the purposes of the different parts of the 5E lesson plan. The most obvious instance of this type of modification was when Julia used the Engage of a lesson to have students find out about a science concept from the computer or textbook before doing a hands-on or computer-based activity to explore the concept. Although this did serve to introduce the students to the lesson (one purpose of the Engage), it basically took away their ability to discover the concept through their own explorations.

One other contributing factor to why she might have had some trouble using the 5E lesson plan could be that she was attempting to fit this new teaching method into her existing beliefs about, and experiences with, teaching. She commented several times about how she had already been teaching according to the 5E lesson plan and that it was just a way to name what she already did. Julia told me, "I just really, really enjoy seeing the formula, the 5E lesson plan, because that's what I've been doing but I've never had a formula for it" (science teaching interview, quote #38a). She was pleased with many of the strategies she was learning at the professional development program for this reason. "I found, you know, when I went to K-12 (Alliance), I thought, 'That's how I teach. That's it, that's it!'" (science teaching interview, quote #37)

The other area in which Julia was not as successful in implementing best practices, or even in acting in accordance with some of her own stated beliefs, was in providing opportunities for student to guide their learning by making choices. This is interesting because of her specific computer teaching beliefs about how computers allow students to have more choice. Why might she then specifically take out student choice in these lessons? The previous explanation about the primacy of Julia's beliefs about learning content might apply here as well. Perhaps Julia is so concerned that students be able to demonstrate that they've learned concepts that she fears they will miss the cognitive goal of her lesson if she allows them to make more choices.

Another contributing factor could be the consistently strong ideas about behavioral management that Julia had in both her general and her science teaching beliefs. Julia was very clear about her need for quiet and order in her classroom.

> I like to see their eyes, and I know that not all kids have to show me they're listening by having their eyes on me, but it's an indication…I've already always told them, you know, 'so I know that you are paying attention, hands on your desk and eyes up in the front.' (science teaching interview, quote #1)

It is possible that Julia's belief in maintaining a quiet classroom is stronger than her belief about the importance of student choice. Having students make more choices might also necessitate allowing them to have more discussion as they make those choices, and therefore make the class seem more out of control.

In addition, since Julia is relatively new to teaching with computers, her self-referential beliefs might play a role here. She may not be as confident about her skills in keeping the students under control while they are using this unfamiliar tool. She spoke about computers being new to her and even of initially resisting integrating computers in her teaching.

> I used to think, it's a few years ago when technology first became popular in school, how much time we could just be doing this or this or this and then we're, to use technology it takes a lot more time to get the same concept across. Of course things were different a few years ago, but I balked at using it really, outside of, you know, the overheads and the Internet sites that I scanned, or whatever. (teaching with computers interview, quote #29a)

If she feels a little insecure when introducing computer use to her lessons, she might think students will also be more out of control while using the computers. Therefore, reducing student choice might be a way for Julia to feel confident that she can still preserve control over the classroom when computers are being used.

Hierarchy of beliefs.

Julia held extremely strong behavioral management beliefs in both categories of science and general teaching. Her need for an ordered and quiet classroom may have dominated the other, more student-centered beliefs, in her science teaching belief system. The consistency of her behavioral management beliefs in those two belief systems might help explain why these particular beliefs were more dominant. In addition, her science teaching beliefs about important outcomes of teaching science, namely that students learn specific concepts, also seemed to be driving her behavior towards somewhat reduced student choice and less opportunity for discovery. Her teaching with computers beliefs seemed to support Julia's management beliefs more than her inquiry-oriented beliefs, in that she believed computers were useful to keep students engaged and on task, partially because they presented information in a more interesting way than a teacher could or should.

Teacher 2: Ms. Kiran Malik

Kiran has a science background and taught high school science before moving to Fielding to teach 5th and 6th grade science. Refer to Table 14 for a quick reference of background information about Kiran.

Table 14: Kiran's background information.

Gender	Female
Country of origin	India
Years teaching	9
Grade levels taught prior to this study	High school science
Science background	Science major in college
Major in college	Home economics, minor in science
Science teaching background	Food science, home economics, and science

This subsection on Kiran's results will be organized in the same way as the subsection on Julia (see Table 15). I will begin Kiran's subsection by presenting tables that give examples of her behavioral beliefs and corresponding behaviors (see Tables 16, 17, and 18). After presenting these tables, I will give details about Kiran's beliefs using data from my interviews with her. I will then focus on Kiran's actual teaching with computers, using my observations of her teaching and other behavior data I collected. I will end with an analysis of the correspondence between Kiran's beliefs and behaviors, with a discussion of her use of best practices in teaching with computers.

Table 15: Organization of Kiran's subsection.

1. Overview table of Kiran's beliefs and behaviors
2. Details about Kiran's behavioral beliefs
3. Details about Kiran's teaching behaviors
4. Analysis of the correspondence between Kiran's beliefs and behaviors

Overview Tables of Kiran's Beliefs and Teaching Behaviors

The beliefs and behaviors presented in the following tables are associated with Kiran's teaching with computers (Table 16), science teaching (Table 17), and general teaching (Table 18), and are organized by the four emergent themes described on page 124 (behavioral management, teacher role, teaching strategies, and learner outcomes).

Table 16: Kiran's Teaching with Computers Beliefs and Behavior

Teaching with Computers Beliefs	Examples of Teaching with Computers Behavior
A. Classroom Management • None stated	• Has students work in small groups on computers • Demonstrates what students need to do before activity begins (explicit directions)
B. Teacher Role • Model interest in and use of computers for students • Provide structure for students; tell students exactly what they need to do	• Gives explicit directions about what students should do during a computer-based activity (e.g., answer specific questions, research specific information)
C. Teaching Strategies • Computers are useful in helping students to work independently and not always relying on the teacher for information • Well-structured and directed activities make learning possible and are needed to keep students focused • Students will learn more when they do something themselves (e.g., hands-on experience, Internet research) • Computers are useful in helping students demonstrate what they have learned	• Has students work in small groups on computers to complete research or activities (circulates around to the groups providing assistance) • Gives explicit directions about what students should do during a computer-based activity (e.g., answer specific questions, research specific information) • Haves students create computer-based presentations after conducting research or doing an activity
D. Learner outcomes • Computers give students opportunities to make choices in their learning process, which in turn builds confidence • Students need to stay current with society and technological advances and know-how • Students connect with people outside their limited experience and learn about the broader world through the Internet	• Sometimes allows students to choose the form of presentation style, including options of making computer-based presentations • Has students use the Internet to find up-to-date information

Table 17: Kiran's Science Teaching Beliefs and Behavior

Science Teaching Beliefs	Examples of Observed Science Teaching Behavior
A. Classroom Management • Students must be ready before they can learn • Students are ready to begin the learning process when quiet and paying attention • Personal acknowledgment from the teacher sets the foundation for good student behavior	• Personally greets each student as they enter the classroom every day • Makes it clear to students how much time they have to sit down, get settled, and get to work on their beginning activity
B. Teacher Role • Support students' emotional needs so they are able to learn • Provide structure for students; tell students exactly what they need to do	• Personally greets each student as they enter the classroom every day • Gives explicit directions about what students should do and asks them to verbally acknowledge that they understand or ask questions if they don't
C. Teaching Strategies • Instructional models are good ways for students to learn science content • Well-structured and directed activities make learning possible and are needed to keep students focused	• Organizes lessons according to the 5E lesson plan • Makes it very clear to students what the activity is and what they should do
D. Learner outcomes • Students must learn foundational concepts in order to be able to build their knowledge in subsequent lessons • Students need to learn to follow directions to be successful in life	• Reminds students of what they have learned or done in past lessons (e.g., through discussion or PowerPoint presentations with digital pictures) • Has students repeat lesson directions in several ways before beginning their work (e.g., listen to directions, explain directions to partner, summarize directions to whole class)

Table 18: Kiran's General Teaching Beliefs and Behavior

General Teaching Beliefs	Examples of Observed General Teaching Behavior
A. Classroom Management • Personal acknowledgment and a caring attitude from the teacher sets the foundation for good student behavior	• Personally greets each student as they enter the classroom every day • Makes it clear to students how much time they have to sit down, get settled, and get to work on their beginning activity
B. Teacher Role • Support students' emotional needs so they are able to learn	• Personally greets each student as they enter the classroom every day
C. Teaching Strategies • Routines and structure allow students to learn • Students should have opportunities to be more in charge of their learning process (e.g., make choices, ask questions) • Hands-on activities and first-hand experiences are the best ways for students to learn • Instructional models, like the scientific method and 5E lesson plan, are good ways for students to learn science content • Constant and ongoing evaluation of student understanding is key to adjusting instruction so that students learn	• Organizes lessons according to the 5E lesson plan • Makes it very clear to students what the activity is and what they should do • Gives students opportunities for hands-on activities and for small group research. • Sometimes allows students to make choices about how to present the results of their research or activities (e.g., do a poster, skit, computer-based presentation)
D. Learner Outcomes • Students need to learn to follow directions to be successful in life	• Has students repeat lesson directions in several ways before beginning their work (e.g., listen to directions, explain directions to partner, summarize directions to whole class)

Kiran's Behavioral Beliefs

As the purpose of this study was to examine teaching with computers, I will emphasize the beliefs associated with Kiran's teaching with computers. I will also provide results from her science teaching and general teaching interviews to showcase the complexity of Kiran's belief system and how the beliefs compare with each other. For the specifics about Kiran's elements, constructs, grid ratings, and factor labels from the Munby RGT interviews, see Appendix 7.

Beliefs about behavioral management.

Kiran did not specifically discuss behavioral management in relation to teaching with computers. As I mentioned before, however, she did elaborate her beliefs about how to maintain order in her classroom in both the general and science teaching interviews. Her belief is that if the teacher sets the behavioral foundation for the day by personally acknowledging each student at the beginning of the period, then students are more likely to behave and be productive.

> It doesn't matter what kind of wonderful lab you have planned, what kind of wonderful activities you have planned, if your class doesn't settle down and they aren't listening to you, they aren't behaving, nothing is going to work then....And the reason I have to, I can't just stand by my desk and say, "Yes, hi kids, come on in and do this," because I know that...if I'm away from [them] physically, they have more tendency to talk or goof off or take more...time to sit down or settle down. If I'm physically right there they know Ms. Malik is watching us. She's right there.... They put their backpacks away quickly and go right to work. It makes a big difference. Otherwise we'll be wasting time. (general teaching interview, quote #2)

Kiran believes her greeting ritual shows students that she expects them to learn in the class.

So if I'm greeting outside and acknowledging, "Yes, I see you coming," instead of sitting by my desk, that is a big thing in classroom management too. If I ever have to tell a teacher or tell myself what is one thing I can do to make my class [a] pleasure is greet the kids when they come in. Because they know Ms. Malik is looking at us, they know she's going to give us only 30 seconds to sit down and go to work. If I would give them 15 minutes, they'll take 15 minutes to sit down. (science teaching interview, quote #1a)

In addition, it reassures students that the teacher cares about them as individuals.

So they acknowledge and they say, "Ms. Malik knows that I'm here." And that's why I try to say good morning, just "Good morning, Johnny. Good morning, Kyle," and so on. So I say their name. I look in their eyes and they say good morning back to me. Because it shows them that I care about them. That's very, very important part of their education. Very important. (general teaching interview, quote #4)

This is the time when I ask them, "How are you feeling? Are you okay now?"...I mean, those kind of things, like making connection, making them feel special, kind of. For some kids, like from research has shown this too....that some kids if you say hello to them, they feel so good. Just...that I said, "How are you?" or just "Hello." It's a big thing for them....The kind of life they have these days, some of them don't get that from anywhere else. So it's like a very big thing for them, and it's like making...connections with the kids, making them feel comfortable. (science teaching interview, quote #2)

When students feel that personal attention, they are more likely to want to perform.

It's a very, very important part of the school culture, though. I mean if your children are feeling comfortable with you they'll actually learn. I know that many high school students say that out loud. "I'll work for this teacher. I won't work for this teacher." And I'm pretty sure the [little] kids don't say it but they do the same thing. (general teaching interview, quote #13b)

Kiran has even experimented with not greeting her students at the beginning of the period, just to see what would happen. The results reinforced her belief in students' need for structure and direction.

I have actually done on purpose...when I just stood right here by my computer [instead of by the door] and see how their performance [is] different. And...some

> of them won't even see me standing right here....And, I have actually seen,...and it's just for my experimenting portion, that how long will it take for them to settle down if I don't stand over there and reinforce you have 30 seconds to sit down...I have seen that's been taking 5 minutes....It's not that they're doing it on purpose, they just don't realize....Because they really want directions. They really want somebody to tell them what to do. And if you don't, then they don't do it. They really don't know what to do. (science teaching interview, quote #7)

Beliefs about the teacher's role.

Kiran believes it is important to support the emotional needs of her students. The greeting ritual is one way she can do that. In comparison to the high school students she used to teach, Kiran sees her 5th and 6th graders as being much more emotionally sensitive.

> Children have to feel comfortable with you. You have to get their level and think like them. And only then you can relate to them and stuff like that....It's a touchy kind of feeling....And you know what? Sixth graders, fifth graders they are so sensitive. You never know....I used to teach high school before and never realized that sometimes little tiny kids that when you say something simple, I mean not with me, but with each other. They care what goes on, those little tiny things, so much. "Oh Ms. Malik, she looked at me." "Oh Ms. Malik, she took my pencil." I mean those little tiny things....Yeah, they're so important to them. It's interesting how their psychology works. (general teaching interview, quote #13a)

In addition to providing emotional support to her students, Kiran also sees her role as being a good example to them in terms of organization and technology use. She believes she must keep up to date with technology so she can help her students do the same. She made a conscious decision to begin teaching at Fielding School and learn how to use computers for this purpose.

> I remember as coming from a student from India,...I used computers over there a little,...just like Word or something basic. But just see the need...of the society and move on with it. That's how I kind of feel that I got the idea....I saw, "Okay, this is where I am right now. I'm a teacher and I have a choice...if I want to move to this technology school. If I do, then I need to start using these computers"....But I think it's just the need as we move into society we want to

> keep up with society, keep up with the whole thing. (teaching with computers interview, quote #20)

Beliefs about teaching strategies.

Students guiding their learning.

Kiran believes the computer gives students the opportunity to be more in charge of their education. When they are using a computer, they have more responsibility over what they are doing. "When they're using the computer, they actually are doing the work by themselves" (teaching with computers interview, quote #2).

Likewise, Kiran believes it is important to let students have some freedom to decide things on their own, and computers can facilitate this as well. For example, she explains that she does not always prescribe every part of a lesson. In some cases, she leaves parts of it open to let the students make choices. She believes this not only builds their confidence (see Learner Outcomes), but it also allows her to see how they are progressing in their skills. In a lesson on erosion, she left computer use up to the students. Many of the groups decided to make PowerPoint presentations for their final reports even though it wasn't required.

> [Computer use] was optional for them….And so that's why that when we said the students drive computer use, they actually are the one who is enhancing it much more that I do, because sometimes…I make some things required….[and other times] I make it optional. And I have seen that out of eight groups, I had six groups which had PowerPoint presentations….I want to kind of see exactly where they are, what do they feel comfortable with….But my main focus wasn't the PowerPoint. My main focus was the content. And they chose the media to be PowerPoint. That was fine with me. So I think it is pretty important, the way they use it. (teaching with computers interview, quote #6)

Kiran pointed to her experiences in the K-12 Alliance professional development institutes as helping her incorporate more student-directed exploration in her teaching.

During one specific activity in the institute that Kiran refers to, teachers created "ecocolumns" out of empty 2-liter soda bottles and populated them with plants, insects, spiders, and fish. The teachers determined what questions they were going to investigate about their ecocolumns over a two-week period. Each day they had time to observe and collect data to answer their questions.

> Like when we made ecocolumns, we had to come up with the questions, we had to create the whole thing. That was neat because the things I had in mind I really had to think…And I had to decide do I want to make holes in there….[And then] I was so glad to see my fish alive, that the reason was because…I made the holes in here. Maybe that's why it's still alive. So you kind of apply all those things…as a teacher,…how to teach this to my students….Everything I learn I think, "How can I tweak it or change it to…apply it to my own classroom?" (general teaching interview, quote #21)

After her own experiences, Kiran hoped to incorporate more activities in which students asked their own questions during experiments.

Teacher-directed strategies.

Kiran also believes it is important for the teacher to provide structure for the students so they know exactly what they are supposed to be doing. With computers, she might spend a small part of each day projecting her computer screen to the class to explain directions for a lesson.

> When I'm using computers to teach the kids, they are actually listening to me instead of actually having them using computers. And that is the time when I am showing them a PowerPoint that I have made. I'm, where they have to follow some things or learning what the concept, take notes and stuff like that, are, I'm using Cal Alive!. That is the time when I use computers sometimes, just as a tutorial that I want them to learn what something basic before they actually start working on the activity. (teaching with computers interview, quote #1)

She might also give them explicit directions in a lesson.

> There are also certain times when I ask them, "Okay, this is what I exactly want you to do. I need a PowerPoint presentation with this many slides on it, with this much stuff on it. And this is what the first slide should look like, this is the second." I mean exactly what I want. And then...when I do something like this I usually have a sample...in front of me...to show to them this is what I'm looking for. So then they kind of relate to and say, "Okay, this is what she is looking for exactly." (teaching with computers interview, quote #12)

She believes that this is because students need help to focus when they are learning. Without this focus, they would spend too much time on a project.

> If I say, okay, I want you to go explore rivers now...there are millions of things and they can spend days and months on rivers if they want to. But so this keeps them focused mainly, and focus on the standard that we're working on, focus on the concept that we're working on, so I have to tell them exactly what are they looking for....'Cause if I would have just said, go ahead find about rivers, they would have spent days and months. And now what are they looking for? They wouldn't have known. So it's very important I think, even like within an Explore activity, for them to know exactly what are they looking for, and maybe where they can find it from. (science teaching interview, quote #15)

These teacher-centered ideas might make it hard for Kiran to incorporate the interests of the student into her lessons.

Teaching concepts through first-hand experiences.

Kiran believes that one of the most important things for her as a teacher is for her students to understand science concepts. She must make sure they understand each concept as she teaches it so they will be able to understand future concepts.

> If they're not getting the concepts...if they don't understand the foundation one then it will be hard for them to go and understand the next higher level concept....But it is very important for them to understand the concept....Ok, this is what I'm looking for...this is what the actual question is. This is what I want the kids to answer and...if they answer that question, and they have the understanding and they know the process, then they'll understand the next concept too. Otherwise they won't be able to understand and build their knowledge on top of that. (general teaching interview, quote #23)

Kiran believes students learn best by doing things themselves. These experiences help them remember better than they would if they were just told the concept. She explained, "Because if we just go to some of the traditional ways that people have been doing things before, then you usually study just to get at the idea and get a grade and then you forget" (general teaching interview, quote #24). She likened this experiential learning to her own process of learning to drive. The instructor told her what to do, but it wasn't until she did it herself that she really understood.

> I had to practice again and again in order for me to learn how to drive. And the same thing for the kids. I mean if they understand one time, I'll definitely have them do an extension activity. Can you show me, can you apply this in a different situation, this knowledge you just learned?...They had to actually apply their knowledge or use it in somehow...related to real life examples. So that I can actually really understand, ok now they really got it. It went in their brain. (general teaching interview, quote #25)

Kiran has seen this apply in her own life as a teacher too. She described an experience she had when teaching another teacher about the 5E lesson plan.

> I had one teacher one morning, she said I need to do a 5E lesson, how do I do it? Then I was able to go back and remind her, remember the plan lesson that we did [in staff development]?...So I said, "You know that's why we always say hands on activities really help because you weren't able to remember." Because we did so many staff development things for the teachers, they just forget...but she was able to remember that....When I said, "Do you remember those cans, Coca Cola can and Diet Coke [from a lesson on density]?" And so she said, "Yeah." "You know what," I said, "That's why your kids do remember with the hands on activities. That's why we should have hands on activities, do the labs and experiments." (science teaching interview, quote #14)

Kiran was able to confirm that the other teacher's first-hand experience helped her remember the needed information, which gave her evidence that supported her existing belief.

Lesson implementation.

Kiran believes the scientific method is the best tool for students to get the first-hand experiences to learn concepts. In the Munby RGT interviews, she talked a great deal about how she has students do investigations beginning with questions and hypotheses, moving through hands-on experiments or computer research, continuing with summaries and conclusions and ending with communication and feedback. She keeps a poster on the experimental design/scientific process on her wall to remind students of the steps to take when investigating. "That [poster] says…observation in the beginning, then the questioning, then the hypothesis, and…so on. All of those processes for the scientific process" (general teaching interview, quote #7). She emphasized the importance of the initial questions in the process.

> The inquiry, the questioning process, which comes before [the rest], is actually much before the research. It comes [with] the things like the observation, the question in their mind, them setting up the stage, posing a question to themselves, "Ok, what am I trying to find right here? And where will I go from here? How can I find it?" (general teaching interview, quote #26)

Kiran sees the 5E lesson plan as a natural fit for the scientific method. She believes that the 5E lesson plan helps her organize her lessons to help students conduct experiments and learn concepts.

> We say, "Ok, in order for you to do this activity you have to do research, you have to summarize this, and you have to make the visual and you have to explain." Even with the…5E model…that's what they do. So…like a step within the Explore activity…because then they have to kind of follow, okay, this is what we're supposed to first. Because they can't explain anything unless they do the research, unless they summarize their findings then and make a visual so everybody else can see it. (science teaching interview, quote #13)

Computers can be used in many parts of the 5E lesson plan. For example, Kiran believes computers are particularly useful in the Explain portion of the lesson.

> Now, so, and then they use computers instead of just taking, just explain…actually they were doing presentations. Instead of just doing their [regular presentations], they had made PowerPoint presentations. I said, "That's great, okay that's wonderful." So they're using actually the technology to explain things to their peers because they were doing the presentations to their peers, teaching something that they got expert, became experts on, to their peers. (teaching with computers interview, quote #4)

Evaluation.

Kiran had two factors in her general teaching belief interview that looked very similar. She struggled for a long while to determine how they were different from each other and how they were important to her teaching. Ultimately she felt they both had to do with evaluation and assessment of student behavior and learning. The evaluation of behaviors and emotions is important in her behavioral management beliefs, as I have already discussed. In addition, Kiran believes it is important to continually evaluate how her students are doing so she can adjust her teaching to help them learn the concepts. She spoke about two types of evaluation she does, one is formative and the other summative. The formative evaluation has to do with students' ability to carry out the process of the activity and fits in with the Evaluation part of the 5E lesson plan.

> When I'm doing [ongoing] evaluation…it's mainly like, yes they're working together, they're doing cooperative work. Yes they're following directions, I evaluate them on that. Ok, yes they're going in the right way, they're following the right path. They're following the procedures, they're writing the procedures down. So that is more like ongoing assessment, ongoing kind of evaluation that we always do. I mean evaluation is something that we always do from the beginning, right from the beginning, as the kids are walking in the line, that is the time I start evaluating them and until the end. (general teaching interview, quote #10b)

The summative evaluation is what Kiran uses to determine the success of her lessons. She uses answers, worksheets, final reports, and quizzes to decide on future lessons.

> But this actually gives me physical evidence to look at, to at least look at, okay this is where the kids are. And actually this will also help me, let's say by the end of this activity, one activity with them…I'll look at their actual sheets, what did they write down about that,…so that gave me an idea, okay where the kids are from right here. And then I might find out that then one class I have to do another activity with the same concept or a different kind of activity. (general teaching interview, quote #11)

Beliefs about learner outcomes.

Life skills.

Kiran believes it is important for students to learn life skills from her teaching.

> Being a teacher, and my relationship with them is to teach them about certain things, and it's not only teaching science, also teaching the life skills. I always talk to them about those….I think the key is just to make them successful. (science teaching interview, quote #16)

Kiran believes computers can facilitate the learning of life skills. For example, she believes computers give students the opportunity to make choices in their learning. When students are allowed to make choices, they also learn important life skills, such as responsibility and respect, as she describes in the following quote.

> There are many times when I'll just leave things open and say, "You get to choose. You get to make your right decision and see…what kind of choices you make"…I mean even sometimes I let them choose their own groups, once in awhile I do that….That's part of the…teaching them how to become good individuals with personalities and "character counts." And those ["character counts"] come in their being responsible and respectful and because they can't say, "We don't want you in our group, we don't want you." (teaching with computers interview, quote #11)

Giving students choices also builds their confidence. When they know they won't be penalized for trying something new, they feel empowered to stretch their skills.

> I have also seen is that if I once in awhile leave them a little open, say, "You have a choice of choosing a media. You can make a poster, you can make a PowerPoint, you can make a web page." Then they actually get to explore more too and try more things out and say, "Let me try if I can do that." Because then they don't have that phobia, kind of, "Oh my god, if I don't get this done I will be losing 60, 50 points." Because then they kind of sit back and relax and that is when they produce the most work, when they are relaxing and focusing on the work than sort of like getting scared and stuff like that. (teaching with computers interview, quote #13)

Kiran discussed another important life skill in her science teaching interview, the ability to follow written directions. This ability will help them succeed in future areas of their lives.

> I also want them to read, follow directions just by reading…because when they take any standardized test or anything I cannot explain direction to them, so they have to learn how to read directions and follow them….That's one of my goals to work on from next year on with all of my classes is have them learn more directions, and like to do the whole experimenting method….Have them read the directions and follow them. Because, many times when I explain, I do a demonstration up there, they can do it easily. But when it comes to reading and then applying it and doing it, then I have seen it sometimes becomes a problem. (science teaching interview, quote #8)

Keeping current with society.

Kiran believes computer technology is the wave of the future and students will fall behind if they do not understand how to use it. When students use computers while learning science content, they are getting an extra learning experience.

> And technology is like, like they're learning one more thing along with learning science. Because like for example they were learning about erosion – wave erosion, wind erosion and glaciers and those kinds of things – that was the thing that they were teaching each other. But some of them, and all of them did do research during class, but some of them chose to do PowerPoints and that's great. (teaching with computers interview, quote #7)

Kiran explained how using computers now will help students function in our society.

> [Technology is] also a good thing for students to learn and use....Because in the society they are going to now, from now on if they don't know these things, they'll be falling behind. They'll see other people who already know how to use this stuff....If they don't know how to do those things then they are either going to fall behind or suffer or...have to work harder. They'll have like some roadblocks right there. So just to kind of carry on, go on with our current or new technology and go on with the society, you have to teach the kids how to use computers and how to do all that. It's good. (teaching with computers interview, quote #15)

Kiran believes the Internet is an especially important computer-based tool because it can also give students up-to-date scientific information.

> It is very important because that...keeps them up to date with the whole world. For example when we're doing weather and I was having them checking the weather every single day....So...keeping them up to date with things, I mean we can use encyclopedias too, but they're old. And with the Internet we can get that information on a daily basis. So I think it's very important to keep them up to date with technology and with content about science and any of the subjects you can do this. (teaching with computers interview, quote #19)

The Internet also connects students to the outside world.

> The *why* [italics added] we do it is to keep them current with the whole environment. And when they do the Internet research, part of the thing also is they get to connect and see what is happening in the rest of the world. (teaching with computers interview, quote #16)

Broadening horizons.

Kiran believes it is important to connect her students with what other people, and especially other children, are doing in the world. She believes this broadens her students' experience and allows them to connect what they are doing in school with others.

> Here with the Internet you can connect with outside world and actually get to see what is happening out there....And for example, when we're doing science fair projects, they were able to go on the Internet and look at the projects as examples

> from other schools. Look at the projects who won prizes before,...look at what kind of project ideas are there, look at the whole process and whole steps. So they can actually connect to what [other students are] doing and compare their work with them or relate to what they're doing and where they kind of stand in that area. So they can do a lot of different things with that. (teaching with computers interview, quote #18)

> And we actually as a school we're working a project that is called International Project or International Study Project, something like that, where we are thinking that eventually our kids like they do...science fair projects. Maybe they can, like one of our kids and...one child from another country, like from Japan or China or some other country, they can actually work on the same project together, and which will be kind of cool to see because they can use their knowledge from here...and they can combine both of them. (teaching with computers interview, quote #17)

Summary of Kiran's beliefs.

Like Julia, Kiran has very strong behavioral management beliefs. She also believes students must be paying close attention and learning to follow directions. In addition, Kiran has beliefs about the need for routines and structures to facilitate student learning. On the other hand, she also has beliefs about giving students the opportunity for making choices in more open-ended activities. These beliefs in providing both structure and choice opportunities are present in her teaching with computers, science teaching, and general teaching belief systems. She believes computers facilitate student choice, help students work independently from the teacher, and help students organize information through presentation programs. How do these beliefs compare with Kiran's teaching behaviors?

Kiran's Teaching Behaviors

In this section, I will provide examples of Kiran's teaching behavior from my observations of her classroom and from the other behavioral data I collected. I will focus on examples that illustrate aspects of Kiran's teaching with computers, but will also include some examples of her non-computer teaching to provide a fuller picture of Kiran's teaching practice. I will use my observations as the main source of data, which will be supplemented by the more self-report behavioral data (e.g., lesson plans, reflections).

Behavioral management.

In each observation of Kiran's class, I watched her do the greeting routine with her students as she had described. She would stand at the door and greet each student personally as they walked in the classroom. She would remind them that they had 30 seconds to sit down with their agendas open. The students would go quietly to their seats and start to copy the agenda off the board. Kiran would use other methods of quieting students during her class periods, but usually only had to ask for quiet once before students would respond. Like Julia, Kiran would use methods such as "clap once if you can hear me" and counting backwards from five to remind students that it was time to listen to her. She would also reinforce when they were behaving well. She might say, "You are doing an excellent job everyone, right now" (observation, 3/21/02) and "You have been doing a great job of listening. That is a good skill to learn at this age" (observation, 6/11/02).

Kiran had some of the same issues as Julia did in terms of management of computer-based activities with the students. Due to the number of laptops available, she would usually have at least four students per computer, and sometimes more if a computer had technical problems. It was difficult to make sure every student was involved in the activity when only one person could control the mouse and not everyone was close enough to the screen to see what was happening. Kiran acknowledged these difficulties to me, "If I have four students working on one computer, it doesn't work" (science teaching interview, quote #6).

On several occasions I observed students were working with the computers on the floor so the cords would not cause people to trip. The students were all crowded around the outlets with groups sitting very close together, making it difficult for Kiran to monitor what they were all doing. I observed on 12/6/02 that many students were not on task and were talking about non-activity related things. Kiran also noticed this happening, so on my next visit on 12/10/02, she reminded students that I was tape-recording the classes and that I had picked up their off task conversations. She reiterated to them that they shouldn't be wasting time. Although embarrassing me, it did keep students more focused on that day's activities.

Teaching strategies.

Following directions.

Kiran also followed structured routines when it came to imparting directions for a lesson. I observed her use several versions of the routine each time I visited her classroom (various observations). For example, during a Cal Alive!-based lesson on the rain-shadow effect, she had students read the directions first, then she went over the directions verbally, and finally she had students explain the directions to each other in pairs (observation, 3/7/02). In another section of the lesson, she had different students repeat her directions to the whole class (observation 2, 3/7/02).

Student choice.

As with Julia, I observed instances in which Kiran gave her students more choice and others in which she was more directive. For example, sometimes she would allow students to choose how to present their research, and other times she would require certain forms of presentation. For a report on natural resources, all student groups were required to make a PowerPoint presentation that answered the same questions (observation, 6/11/02). Some of the questions (or directions) were more open-ended than others (e.g., "How can we conserve natural resources?" vs. "Draw and explain the step by step process of coal formation"). Although there were some more open-ended questions, the students' presentations seemed to duplicate each other. Kiran did not seem surprised by this, explaining to the students, "We are doing these presentations over and over because we're doing a quiz. By the end, you should know it." Although I did not observe this myself, I'm wondering if she directed them more as she helped each group individually.

In contrast, as part of a research project on chemical elements, Kiran gave students the choice of ways to report their research (observation, 12/6/02). She told them they were to become the "master of your element and you will teach it to the others." The report was to be in the form of a commercial to advertise their element, and she gave them a choice of how to present it. For example, she talked about possibilities like a journal, a poster, a skit, or PowerPoint presentation. She did not, however, give them the choice of what element to research. She also gave them a list of specific information they had to include in their commercial (e.g., element's name, symbol, atomic number, atomic mass, color, texture, hardness, boiling point, modern uses), with almost no open-ended questions.

Kiran had students do another project on glaciers that included a final presentation (lesson plan and handout, 6/02). In the directions for this project, students were to research glaciers in pairs. Kiran gave students the choice of how they would do their research (e.g., Internet, textbook, library books). In contrast with the two previous examples, Kiran only gave the students broad topics to research and left the details up to them (e.g., types of glaciers, movement of glaciers). The directions also gave students the choice of how to present their research. They could choose from a PowerPoint presentation or a written report with a visual aide. She did give them parameters for their presentations (e.g., PowerPoint presentations should have a minimum of six slides).

As I described in the section on Julia, Kiran also participated in the jointly developed lesson on rock weathering that included the Cal Alive! soil creation activity. I observed her doing that part of the Extend with her students (observation, 3/21/02). She also used the data sheet that was agreed upon by the teachers; the one that directed students on every choice (e.g., choose granite, hot, wet, barren). She reinforced the directions with her students.

> Kiran: You will do four trials with each type of rock on Cal Alive!. (*Indicating data sheet*) Choose wet or dry, cold or hot. Choose barren. What are you going to choose?
> Students: Barren.

I don't know, of course, whether she would have done this activity differently if she had planned it herself. Like Julia, however, she did not object to the prescriptive nature of the activity when they were planning it, nor did she modify it for her own class.

Teaching concepts.

Although Kiran did provide a great deal of structure in her lessons, sometimes in the form of reducing possibilities for student choice, she seemed to be able to allow students to discover concepts through the activity instead of giving them the concept prior to exploration. In using Cal Alive!, sometimes Kiran followed a pre-made lesson in the Cal Alive! Classroom Guide, and other times she modified the activity to fit better with her lessons. In her implementation of the Cal Alive! lesson on the rain-shadow effect, Kiran followed the pre-made lesson plan in which all choices in the activity were prescribed (students were assigned a California mountain range to study and were assigned two habitats on either side of the mountain range to compare and contrast). Students were also given set questions to answer (observation and handout, 3/7/02). Within that limited-choice structure, however, Kiran allowed her students to discover the connections between the location of habitats on the west or east side of the mountain range and the characteristics of the habitat (e.g., more vs. less moist). Unlike Julia, Kiran did not have students read about or study the definition of the rain-shadow effect before doing the activity. As they conducted the activity, Kiran asked her students guiding questions to help them focus on the differences they were seeing.

In a lesson on plate tectonics and faulting, Kiran used Cal Alive! as part of the Extend in a 5E lesson (lesson plan, 10/18/01). There was no pre-made lesson to accompany this part of the geology tutorial, so Kiran developed her own lesson. Her use of Cal Alive! consisted of projecting the faulting section of the Cal Alive! geology tutorial for the whole class in order for them to review what they had already learned through hands-on activities on plate motions using graham crackers and honey. After showing one type of fault, Kiran had students recreate it using pieces of sponges. Although many parts of this activity were a review of the types of faults they had already learned about, Kiran was able to include several hands-on experiences for her students. It wasn't until after these hands-on activities and computer use that Kiran had students read the textbook section on the relationship between faults and earthquakes.

Kiran also used Cal Alive! to help students with an activity on habitats and adaptations. The activity was called "Design a Dragon Project." In the activity, each student group created a dragon, including its habitat, adaptations to that habitat, and its relationship to other dragons (e.g., classification "tree"). In order to help students pick realistic environments for the dragons, Kiran gave them the option of researching habitats using Cal Alive!. It was up to the students to take what they learned about habitats from Cal Alive! and invent their own habitats. Kiran had her students make a three-column graphic organizer to help them keep track of their research (e.g., with columns for "source," "facts," and "application to your project"). This use of Cal Alive! contained many opportunities for students to discover concepts and make connections, as well as allowing students to make free choices.

In a non-Cal Alive! lesson, Kiran had her students use an Internet-based activity as an Extend for a unit on density (handout, 11/15/02). She used an activity directly from the K-12 Alliance professional development institute as the Engage. The activity involved predicting what would happen when submerging regular and diet coke cans in water, and then watching the result (the diet coke can floats). Then she had her students conduct two Explore activities, one with mixing oil, molasses, and water, and the other with adding salt in different concentrations to water. For the Extend activity at the end of the unit, she had her students do virtual density experiments on a website in which they could manipulate mass, volume, and density of objects, such as logs, to find out if they would float or sink. Students then had to answer questions about the outcome of changing a variable while holding the others constant (e.g., If you increase the mass of the log, but its volume stays the same, how will it affect the log's density and ability to sink or float?). Although I did not observe the Engage or Explore sections of this unit, there seemed to be many opportunities for students to discover and make connections among concepts relating to density. There was nothing in Kiran's lesson plan to suggest that she told them what density was before allowing them to explore and discover the phenomenon on their own.

Analysis of Kiran's Belief and Behavior Correspondence

Correspondence between beliefs and behavior.

After teaching science for nine years, Kiran has developed a very structured belief system, as can be seen in the similarities between her science and general teaching beliefs. Even her teaching with computers beliefs contain some of these common elements, including the need for teacher-imposed structure to focus student learning and the importance of allowing some student choice. Given the consistency in her belief systems, it is not surprising that she was able to use Cal Alive! and other computer-based activities in ways that corresponded with these beliefs. She was able to follow the routines that were important to her, like structured repetition of directions, while still allowing students to work in groups and have the responsibility of learning concepts through hands-on activity and guiding questioning. Even when she limited student choice, she allowed the students room to discover.

Her most common uses of computers were for student research and presentations. I observed her using computers more frequently than Julia, who I did not observe having students make any computer-based presentations. Like Julia, however, she did have some difficulty with keeping all students engaged as they used the computer. Although she had strong behavioral management beliefs in her science and general teaching belief systems, she did not have any clear behavioral management beliefs in relation to teaching with computers. This may have made it more difficult for her to devise strategies to promote equal engagement for all of her students. She did express, when she first got six classroom laptops, some misgivings about her ability and her students' ability to work in groups on a limited number of computers. "We only had six computers and I wasn't sure that with the six computers in the class they can do [presentations]" (teaching with computers interview, quote #9).

Correspondence between behavior and best practice.

Kiran had some beliefs that seemed to support best practice in teaching with computers. She had consistent beliefs that students should be allowed to make choices in their learning and that computers can facilitate student choice. She was able to give her students opportunities for choice. For example, she often allowed them to choose how to do presentations, with computer use as one of the options. To a lesser extent, she allowed them choices about how to use the Internet to do research, and sometimes gave them somewhat open-ended assignments for their research. These teaching behaviors correspond to best practices of giving students more control over how they do activities and find information.

On the other hand, some of her computer-based activities were much more directive. She might limit student choice to the extent of telling students exactly what to research and how to present it. In terms of best practice, these lessons were extremely teacher-centered rather than student-centered.

The fact that Kiran designed some lessons in a more teacher-centered manner and others in more student-centered manner is supported by her beliefs. Kiran had strong beliefs in both allowing student choice and providing explicit teacher-imposed structure to keep students focused. These beliefs could cause somewhat contradictory behavior, but Kiran seemed to be able to implement each of them at different times. She had strong beliefs at both ends of the student choice continuum, and therefore could employ either teaching strategy depending on the circumstances. As Kiran explained,

> There are certain times when I do require them to do certain kinds of presentations.... There are some times I leave it open just to see where they're comfortable zone is, where they're standing right now, where can they exactly do right now...because that is very cool for me to see. (teaching with computers interview, quote #10)

This ability to vary her teaching practice shows a level of balance in these beliefs in that one did not always dominate the other.

Kiran also had beliefs that supported students learning things on their own rather than being told by the teacher. In contrast with Julia, Kiran's beliefs focused more on the hands-on aspect of both student-centered and inquiry-based learning, rather than the discovery aspect. Nevertheless, Kiran seemed to be more consistently successful than Julia in facilitating student discovery of concepts. She seemed more comfortable with allowing students to truly experience concepts during the Explore of a lesson, rather than precede the exploration with an explanation of the concept. Why was Kiran able to do this?

Kiran may have been more comfortable with inquiry because of her strong science and general teaching beliefs in the value of the scientific method and the utility of the 5E lesson plan structure to facilitate student learning. "Because it's like the key right here. It doesn't matter what you do in science, it's always...like you have a question, you...go through all that science, scientific process" (general teaching interview, quote #8). Kiran sees the scientific process as a structured plan to follow in doing experiments. The 5E lesson plan gives Kiran another structure that complements the scientific process.

> It's like one activity but these are the different steps for that activity....The first step was...actually listening to directions, following them, then researching, summarizing, and focusing on what they were looking for. And then drawing and writing, making the visual, and then explaining....These are the steps to do that. Because if they skip one of them they wouldn't be able to come up with the exact final statement that they had to come. (science teaching interview, quote #12)

It is possible that using these teaching models give Kiran the structure she feels is necessary for students to stay focused on the lesson. Since student inquiry is a specific aspect of both models, Kiran may feel comfortable allowing the discovery of concepts to occur within the overall structure.

Hierarchy of beliefs.

Kiran's beliefs in regards to teaching with computers, science teaching, and general teaching were quite uniform. She did not have any major conflicts in her beliefs across these categories that kept her from behaving in ways that were consistent with those beliefs. The one area of potential conflict was in her dualistic beliefs about the importance of student choice (more student-centered), as well as the importance of teacher-direction. Rather than one of these beliefs taking precedence over the other in her behavior, Kiran was able to teach in ways that accommodated both beliefs. Even though her teaching with computers beliefs were probably more recently-acquired, they were consistent enough with her science and general teaching beliefs that she was able to act in accordance with them while teaching with computers.

Teacher 3: Mr. Barry Foster

Barry is the teacher with the least experience of the three in this study. Refer to Table 19 for a quick reference of background information about Barry.

Table 19: Barry's background information.

Gender	Male
Country of Origin	U.S.A.
Years teaching	5
Grade levels taught prior to this study	6th and 8th grade integrated science
Science background	Science major in college
Major in college	Pre-dental
Science teaching background	Science teacher

The subsection on Barry will be organized in the same way as the subsections on Julia and Kiran (see Table 20). I will begin Barry's subsection by presenting tables that give examples of Barry's behavioral beliefs and corresponding behaviors (see Tables 21, 22, and 23). After presenting Barry's belief and behavior tables, I will give details about Barry's beliefs using data from my interviews with him. I will then focus on Barry's actual teaching with computers, using my observations of his teaching and other behavior data I collected. I will end with an analysis of the correspondence between his beliefs and behaviors, with a discussion of his use of best practices in teaching with computers.

Table 20: Organization of Barry's subsection.

1. Overview table of Barry's beliefs and behaviors
2. Details about Barry's behavioral beliefs
3. Details about Barry's teaching behaviors
4. Analysis of the correspondence between Barry's beliefs and behaviors

Overview Tables of Barry's Beliefs and Teaching Behaviors

The beliefs and behaviors presented in the following tables are associated with Barry's teaching with computers (Table 21), science teaching (Table 22), and general teaching (Table 23), and are organized by the four emergent themes described on page 124 (behavioral management, teacher role, teaching strategies, and learner outcomes).

Table 21: Barry's Teaching with Computers Beliefs and Behavior.

Teaching with Computers Beliefs	Examples of Observed Teaching with Computers Behavior
A. Behavioral Management • Computers help keep students on task because they are motivated by computers	• Plans computer-based activities • Lets students use computers when they are done with scheduled activities
B. Teacher Role • Model life-long learning with technology • Get students oriented and then let them discover on their own	• Shows how to use technology first in front of whole class, then lets students try
C. Teaching Strategies • Some direct instruction needed to orient kids to the technology • Students can work at their own pace on the computer • Students learn best if they do it themselves	• Uses the LCD projector to show kids how to use the technology (whole class instruction) • Students do research projects on the Internet
D. Learner Outcomes • It is important for students to learn to extract information and put it in their own words • Students can be more independent learners when they use computers • Life skills, such as knowing how to find information, are very important for future	• Students do research projects on the Internet and Cal Alive! and then write up research or do presentations • Students work in small groups on the computer • Students practice information retrieval through Internet and other computer-based research

Table 22: Barry's Science Teaching Beliefs and Behavior.

Science Teaching Beliefs	Examples of Observed Science Teaching Behavior
A. Behavioral Management • None stated	
B. Teacher Role • Should not just tell students the answers, let them discover • Facilitator • Lifelong learner (be example to students)	• Does sometimes end up giving students the answers
C. Teaching Strategies • Hands-on experiences, in the form of laboratory experiments, are the best way for students to learn • Student-centered = hands-on • If science is relevant to students they will remember it more • Writing and putting the science concepts in their own words, will help students learn • Students will do better if they're shown first (e.g., how to use technology)	• Tries to make science concepts relevant to students • Has students write up research or make presentations • Shows how to use technology first in front of whole class, then lets students try
D. Learner Outcomes • Students learn science best by doing things themselves • Students perform better when responsible to their peers (not just teacher)	• Has students conduct labs and hands-on activities • Has students research science topics on the Internet and write about it • Has students work in groups and do presentations

Table 23: Barry's General Teaching Beliefs and Behavior.

General Teaching Beliefs	Examples of Observed General Teaching Behavior
A. Behavioral Management • Students will behave themselves better when given clear roles (monitor themselves in group work) • Noise means students are working (some level of noise is okay)	• Uses group work with assigned roles • Allows students to talk somewhat noisily in their groups and during transitions
B. Teacher Role • Allow students to discover on their own • Show how disciplines are interconnected (e.g., science & writing)	• Has students choose topics for Space News articles
C. Teaching Strategies • Teaching should include lots of research and writing • Students should be given opportunities to discover things on their own and go at their own pace	• Has students write biweekly Space News articles • Gives students some physical control over computers and lab equipment
D. Learner Outcomes • Students should be responsible for paying attention and learning • Students should be learning life skills	• Has students work in groups and assigns roles • Has students do presentations to the class • Has students learn to use technology

Barry's Behavioral Beliefs

In this section, I will emphasize the beliefs associated with Barry's teaching with computers, as well as provide results from his science teaching and general teaching interviews that are similar to or different from those beliefs. For the specifics about

Barry's elements, constructs, grid ratings, and factor labels from the Munby RGT interviews, see Appendix 8.

Beliefs about behavioral management.

Barry did not speak a great deal about behavioral management in any of his interviews. He admitted that he did not learn very much about classroom management in his teaching credential program.

> [My methods teacher] was almost to the extreme end to where we didn't get a lot of core stuff on like, you know, how to develop a behavioral management plan or lesson plans, 'cause it was all about these are great activities you can do in science. Which is wonderful, but there's more to teaching than just all these great activities. (teaching with computers interview, quote #6)

As I mentioned previously, Barry is much more tolerant of louder noise levels during the class period than either Julia or Kiran. He believes that when students are interacting, they are learning. "I tell them it's okay to talk. 'You guys are talking to each other. That tells me you're engaged and involved in the learning'" (general teaching interview, quote #10c). He does use some management techniques to try to keep students on task.

> We work on noise levels too. Like I rate them from one to five and if they get above a three, then I kind of let them know that that's a signal to me that maybe you're not doing what you're supposed to, maybe you're just playing around too much. (general teaching interview, quote #10b)

Barry also believes computers help keep students focused on the lesson. When students use computers, he does not have to focus on behavior as much and is freer to help individual students.

> With students using the computers for word processing…you can maybe work more individually with one student at a time and not have to like worry about all

> the students because they're really on task there. (teaching with computers interview, quote #13)

Barry also uses the technique of assigning roles to different students to help with classroom management issues. He believes this helps keep the classroom running smoothly.

> I don't know if it's finely tuned, but we like it to be. That's the goal anyway....For example, like there are group jobs where the kids come in and we're using the textbooks today. So "Number twos, let's go get the textbooks and take them back to our table groups." So that way instead of having 32 kids get up and the mad rush for textbooks,...it's just eight students getting that. So it just becomes more organized. (general teaching interview, quote #4)

Beliefs about the teacher's role.

Barry believes that the teacher should model good learning behavior. If the goal is to have students be lifelong learners, then the teacher should be one too. Part of being a good teacher in general, and good science teacher specifically, is to be willing to try new things.

> To be the best teacher you can be, you can't just keep doing the same things. I mean you really have to be able to be flexible and change your methods. And professional development, going to workshops and just becoming a lifelong learner yourself. I mean that's what you want your students to become, the teacher also has to do that, to continue to build a knowledge base, to be the best teacher that you can possibly be for your kids. (science teaching interview, quote #2)

When it comes to technology, Barry believes students are also a great resource for knowledge. "I learn a lot from my students too....[They teach] me a lot too, so it's kind of neat" (teaching with computers interview, quote #9).

One area that has been a little difficult for Barry in teaching younger grades is in the emotional aspects of his students. He is not used to this facet of the teacher role.

> We're treating our 5th graders like middle schoolers as far as having to rotate and change classes and that's a tough transition for them. So I mean it's frustrating because you're adjusting a bit, not being around that age group very much, you have to be more of a nurturer and, you know, really look out for them. (science teaching interview, quote #18a)

He believes it is important for this age group that you deal with their emotional and social issues, but he also feels it detracts from his teaching.

> "Mr. Foster, I'm not feeling very well today," and "So-and-so did this to me." And so that kind of takes away from your instruction time and that time that kids are having the best, the optimal learning experience. But that's part of the age group, so it's, you adjust and make it the best you can. (science teaching interview, quote #18b)

Beliefs about teaching strategies.

Reaching all students.

Barry believes computers can be used to help him individualize his teaching so he can reach more of his students.

> You're trying to bring in all different background levels in science and you want to challenge every student in different ways. And I think that's what's nice about technology, to where it can be more differentiated that way. I mean you can do some independent learning over here with the laptop while someone else is doing this. (science teaching interview, quote #12)

He does not believe that all students respond to the technology in the same way (e.g., boys vs. girls), but computers can be put to good use in conjunction with other teaching strategies. In this way he can appeal to students with different learning styles and preferences.

> You want them to enjoy their learning experiences, and that isn't always possible. It's not always fun and games. But, and some students don't respond to it as well. I mean if you want to stereotype 5th and 6th grade, boys vs. girls, it seems that at this age that in general boys like the hands-on more. And I think there's more girls that do, but they're probably a little more afraid to show that because of peer pressure and that sort of thing. And there's different, I mean some students enjoy

> the computers more than others….So I mean it's multiple learning styles. So you don't always want to teach the same way, so you can reach as many kids as possible. (science teaching interview, quote #9)

Teaching skills and concepts through hands-on experiences.

Barry believes that the best way for students to learn how to do something, like using computers, is through hands-on experiences.

> If they're going to learn it, just like anything, you have to try it for yourself. Like with the driving test, I mean if you don't actually get to drive the car then you can't just get the written test and say, "Ok, you're ready, you're qualified." (teaching with computers interview, quote #3a)

He might do a lesson with the purpose of teaching students how to use computers instead of learning certain science content. "Like we just did stories where they wrote stories in like a rough draft. Then I corrected them and gave them back to them….And the main purpose of doing that was to have them learn how to save documents" (teaching with computers interview, quote #15).

Barry believes students must have opportunities to use the equipment and software themselves to really learn how to use it.

> So for me just to show them on the projector and not ever give them a chance to try it, that's a lot to remember….I mean you really need to have a computer in front of you to try it for yourself as you are being taught. (teaching with computers interview, quote #3b)

Barry has the same belief about hands-on experience when it comes to learning science concepts. Students will learn science concepts when they can do experiments and see the science happening themselves. "It's very important for science too. And there's different catch phrases, you know, 'hands-on, minds-on'" (teaching with computers interview, quote #4a).

> The students learn best by doing it for themselves....You just remember better by doing. And if you work with labs or ways they can try it for themselves, it becomes easier for them to learn how to do it or remember things. It sticks better and you can show how science is all around us. And if you're standing up there and you're telling them about it, they're not as likely to remember it. (science teaching interview, quote #3)

Barry also believes making science relevant to students, in addition to giving them first-hand experience, helps them learn.

> Research shows that if you're going to commit something to long-term memory, you have to have what they call the "hook." And if you're going to have students remember scientific information, that's the best way to do it, to [show] them how it would relate in their life....We just came back from science camp, I mean that was just a great example, that those kids are never going to forget that because they were out there looking at it for themselves instead of reading about it in a book. And I mean that's definitely a great way to hook kids in science and the information that's there. (science teaching interview, quote #6)

Barry describes an example of student-centeredness in his own teaching. It is apparent in this example that he is equating student-centeredness with students having physical control over computer equipment.

> When they're doing those activities, they're trying that for themselves too. I mean it's student-centered because they do get the chance to use the Internet for research and for word processing....With the use of the Internet, thus far it's been research and I'm roaming throughout the classroom giving them ideas or maybe putting up websites to try. And of course you have to monitor and make sure they're not going to sites they're not supposed to. (teaching with computers interview, quote #12)

He does struggle a little with the definition of "hands-on" and whether students using computers really provide the same experiences as science labs.

> I mean you could say, "Ok, are computers really hands-on?" And well, yes, the students are using computers, but computers do not replace labs and student actually performing...experiments. They can simulate. There's programs out there with a lab setup and you can click on, you know, the different equipment and become more familiar...but it's just a simulation, it's not the real thing. (science teaching interview, quote #14)

Barry concludes that although student-led research on computers is beneficial, in order for students to really learn something in the long term, they should actually be doing science in laboratory experiments.

> You can research a topic and learn a lot more about it, but if you're really going to remember the information and show how it's related to real life, the students really need to do, have the lab experience where their hands are actually on the equipment doing the science. (science teaching interview, quote #15)

Teacher-led instruction.

Although Barry does not feel he learned as much himself when being taught by transmission-oriented teachers, he believes there are times when he must lecture to his students. Even so, he acknowledges how the role of the teacher might change when students are doing hands-on activities.

> So it's so important that students have both methods, where they get some direct instruction and they're doing the science for themselves too....So you're not going to get rid of the teacher. The teacher is more of a facilitator than probably it used to be. (science teaching interview, quote #16b)

Barry does acknowledge that he needs to limit the amount of talking he does due to the developmental level of his students. He felt he could do more lecturing to 8th graders, but 5th and 6th graders aren't able to focus on lectures for very long.

> As an 8th grade science teacher I was able to, I hate to call it lecturing, but I mean it's kind of what you're doing, direct instruction probably a little bit more because they have a greater attention span....Whereas 5th and 6th graders, the attention span's a lot shorter...you also have to have a variety of activities, where it's, you know, it's not all just giving them information. You might present a little bit and then have them do another activity so that you keep their interest stimulated. (science teaching interview, quote #17)

Barry explains how he has adjusted his teaching for the younger students.

> What I found out is with 5th and 6th grades, what I'm teaching now, that it just doesn't work. I mean they, about five to ten minutes of direct instruction is pretty

> much all they can take....And then if we're going to lab we'll explain the lab and then they get in their groups and then it becomes a student-centered, where they're actually working with the materials. Hands-on science. (general teaching interview, quote #2)

Barry believes the best use of his direct instruction time with 5th and 6th graders is to explain directions for the day's activities or to model something students will get to try during the class period. He often uses his laptop and projector to show students what they will be doing.

> As part of the training it's nice to have the LCD at the beginning for like some direct instruction, like showing them where to click and "save as" and that sort of thing. So that's a good way to start off the class, especially if they haven't tried it for themselves at all. (teaching with computers interview, quote #1)

He also might use the projector to show students websites and make connections to what they're doing in science class.

> And then use of the Internet has been pretty much limited to research and we're doing projects like that. And then like it might be a good way to start the class for warm up, like if we're talking about a certain topic in the news, in the science news, you know, that you could pull up and say, "Ok, this is what's going on and this is how it relates to what we're studying." (teaching with computers interview, quote #2)

Lesson implementation.

Barry believes one of the main uses for computers and the Internet in a lesson is for information retrieval and presentation. The majority of his description of his teaching with computers involves having students do research on a science topic and then having them write up a report on that research.

> So the use of the Internet would come first to do research....We're doing reports,...something where you have to have relevant information to back up a topic. And they use the Internet first to do research, you know, jot down some information and then interpret it in your own words to create a report and then word process it to turn in. (teaching with computers interview, quote #16)

He also talks about having students do computer-based presentations on their research.

> We're going to do things like group PowerPoint presentations where they can't just put something down inside, they have to have information that backs it up. So if I give them a topic, you know, they'll have to look for information to share on the slide where it's more like a presentation for the students. (teaching with computers interview, quote #14)

His goal for these activities is "to show that they can extract information that's important and compile it…and share that information" (teaching with computers interview, quote #17b). Sometimes he assigns them a topic, and other times he lets them choose their own.

> About every two weeks I have them research, a lot of times it's on their own. And it can be kind of on the current space news article or any science article. And then reading that and then writing a summary about it…deciphering the information and then putting it in their own words. (science teaching interview, quote #5a)

He uses their research on current topics in science to show them how science connects to their lives.

> And sometimes we share those with the class and there's always, generates some interesting conversation about what's out there now in science and they can see the relevance to their lives. Makes it more real to them. (science teaching interview, quote #5b)

When asked how this use of computers may have changed the way students do research, Barry points to the ease of finding varied information from multiple sources on the Internet. He does not emphasize the possibilities of student control and interest-driven research.

> If we didn't have computers we still could have researched, but it wouldn't be with the Internet. It would be with reference books from the library….I mean [computers] change what you do because…it's enhanced the way we can research and the amount of information that we're available to get. And it's worldwide and

> it's at the click of a button as opposed to just whatever reference materials you have available in your school library or maybe the public library. (teaching with computers interview, quote #18)

Barry did not specifically mention the 5E lesson plan in his interviews. He did however, talk about uses of computers that would fit in well with a 5E lesson plan or group work situation, such as in stations. Barry believes computers work well in stations where they can be used to help students extend what they are learning by quickly looking up information or trying a related activity in the Cal Alive! program.

> What we found works good as a science team, we share ideas, and stations seem to work really well….So if you do it in stations, you can do a multitude of activities. Plus with the stations, you can maybe have one laptop at each one, the one you want to research in. This is how I plan to use Cal Alive!, where they can first try something out with, you know, the standard lab equipment and then go to the computer and say, "Ok, so this is the way it relates." And that might be the research or that might be the activity with Cal Alive!. (science teaching interview, quote #4)

Evaluation.

Barry talked a little about the different ways he might evaluate his students. His beliefs were somewhat like Kiran's, in that ongoing evaluation was valuable in determining how students were doing, but they were not as in-depth as hers.

> And we talked about how then you can assess. It might not be written questions. It may just be, you know, walking around and kind of the teacher asking questions or even stopping the lab and saying, "Ok, this group, kind of summarize what you've learned so far." (general teaching interview, quote #3a)

Barry does believe it is important to try to get students involved in the evaluation process instead of leaving it all to the teacher. He feels ongoing assessment through questioning could encourage students to interact more with each other.

> And then you actually get to the point where the students are questioning each other. And it's pretty neat when you see that happen. It's tough sometimes to spur

> that, but once they get the hang of that, they're actually assessing themselves. And that's a good way to teach. (general teaching interview, quote #3b)

Beliefs about learner outcomes.

Life Skills.

Barry believes students learn important life skills from his teaching. By having students participate in hands-on learning experiences, he puts the responsibility of learning on them, rather than on the teacher.

> With the responsibility, too much of it is left up to the student when it's direct instruction. I mean they're kind of at free will to choose, do I want to pay attention or do I not want to? I mean they can kind of sit there and just kind of nod their heads but you don't really know if they're getting across what you want them to get. (general teaching interview, quote #5)

This helps students to be more actively involved in their own learning process. In addition, Barry believes the research he has students do will help them in the future in terms of knowing how to find information by themselves.

> [Research] allows them to become independent learners….Eventually they're either going to be more independent in college or when they're out of college. You don't ever stop learning and your ability to find out information becomes very important as you get older in life, I think, where you don't have someone saying, "Ok, you might want to look up this answer." You have to find it for yourself. (teaching with computers interview, quote #19)

When students do presentations on their research, they are becoming experts in a certain area and have the responsibility of teaching their peers.

> They can use the PowerPoint to then use the projector to show it to the students. That way, everyone kind of benefits from different topics. Instead of just teacher reading all about it,…it puts more of the onus on them, like they're responsible to not just the teacher, but their peers. (science teaching interview, quote #10)

In addition, doing presentations helps students gain speaking skills and confidence.

> [When I give them the opportunity to go up in front of the class and do a presentation, as much as they're learning content, they're also learning other things.] Like how to present themselves, group speaking, that sort of thing. And PowerPoints, with the technology, has been a great tool to do that. And even if it's just presenting their space news article…where I've even noticed that this year they've become less nervous about it. And they're almost, if I don't do it every other week and if I don't ask them to share, then it's like, "Well Mr. Foster, can I talk about an article?" So it's, they really enjoy it. (general teaching interview, quote #8)

Barry also talked about how computers in general can help give students another avenue to gain confidence.

> I've got a 5^{th} grade student that…was one of the first to bring his [personal computer] from home and he's grown so much in the past five weeks with is confidence. Because other kids now look to him as a leader like, "Oh, he knows how to do this." (teaching with computers interview, quote #8)

In terms of group work, Barry believes that students are also learning to be more responsible to each other. Students who know more can help other students.

> There's some [students] right now that can definitely take right off and do this. They can hook their own laptop up to the [projector] and develop a PowerPoint and do that. And that's what's nice about group work because then the students can kind of teach each other instead of just the teacher. (science teaching interview, quote #11)

They also learn what it means to take responsibility for different aspects of the work that is done in groups. When Barry assigns group members roles, he believes they are learning to take turns and take each role seriously.

> So there's different roles that each one can do. And then instead of just having the same person do the same role, you know they all want to be group leaders, to kind of rotate around and let them know group leader is a big responsibility. So if you don't do a good job you're going to have to reassign that. (general teaching interview, quote #7)

Barry also believes that part of the responsibility they are learning is to make sure the group is working well together.

> When it's group work and it's student-centered, the student[s]...they kind of police themselves. They kind of monitor each other's progress and everyone is participating equally. And if they're not...they may point it out to me. (general teaching interview, quote #6)

Summary of Barry's beliefs.

Barry does not have well-formed beliefs, or is not able to articulate his beliefs, about behavioral management. Unlike both Julia and Kiran, however, he believes a noisy classroom means students are learning. Barry believes students learn best when they have physical control over computers or science equipment (hands-on experience). He also believes there is a role for more teacher-centered instruction, which has roots in his own experiences as a student. Barry believes computers are used best for researching information, organizing it, and presenting it. He also believes computers allow students to make choices and learn on their own. How do these beliefs compare with Barry's teaching behaviors?

Barry's Teaching Behaviors

In this section, I will provide examples of Barry's teaching behavior from my observations of his classroom and from the other behavioral data I collected. I will focus on examples that illustrate aspects of Barry's teaching with computers, but will also include some examples of his non-computer teaching to provide a fuller picture of Barry's teaching practice. I will use my observations as the main source of data, which will be supplemented by the more self-report behavioral data (e.g., lesson plans, reflections).

Behavioral management.

Barry's classroom was noticeably noisier than either Julia's or Kiran's. A typical class would begin with at least five minutes of Barry trying to get his students to quiet down. The following exchange took place on a day when students were going to use computers (observation, 5/10/02).

> Students (SS): *coming in the room loudly, some running and shouting*
> Barry: Get in your math groups.
> Student 1: I got this chair!
> Student 2: You can't sit there!
> Student 3: I'm sitting here already!
> Barry: If you can hear my voice, clap three times.
> SS: *clap, clap, clap*
> Barry: Please don't touch the computers right now.
> SS: *still noisy*
> Barry: We don't have to do this, even though there is a guest here.
> SS: *getting quieter, but still talking*
> Barry: You're embarrassing me. (*Barry continues with lesson even though some students are still talking quietly.*)

At the end of the period, students started to talk loudly, walk around the classroom, and even try to leave before they were dismissed. Barry spent the last five minutes trying to get students to sit down again, and he even had to go outside to retrieve the students who had left prematurely. After the students left that day, Barry commented that they wear him out, although he felt the lesson went "very well" (informal conversation, 5/10/02).

Transitions during the class periods were also times in which Barry would have to spend several minutes getting students to be quiet and pay attention so he could give further directions (various observations). He would often ask for quiet several times and then, failing to get students to settle down, continue when the noise level had diminished but before students were completely quiet.

This pattern of behavioral management repeated throughout the time I observed Barry. On another day more than six months later, Barry also had difficulty getting students to settle down at the beginning of the period (observation, 12/19/02).

> Students (SS): *Coming in noisily, milling around.*
> Barry: Everyone take your seats please.
> SS: *No response. They continue talking and walking around.*
> Barry: Take your seats.
> SS: *Some start to sit down, but still noisy.*
> Barry: If you can hear my voice, clap one time.
> SS: *Clap, but still talking.*
> Barry: If you can hear my voice, clap two times.
> SS: *Clap, clap. Students are quieter but still talking.*
> Barry: *Begins the class even though students are still talking quietly.*

Barry was obviously not as bothered by noise in the classroom as either Julia or Kiran. This was probably because he thought some noise meant students were engaged in an activity. These examples, however, show that Barry was not able to fully control, or even may have tolerated, off task noise as well. This may have affected his ability to implement certain aspects of his lessons.

Teaching Strategies

Group work.

Barry had not used much group work as an 8th grade teacher. It was one of new strategies that he was trying out with his 5th and 6th graders.

> And, you know, this is my fifth year teaching and just try new things each year and find out what works better. I think it just takes a couple of years and then you start figuring out that, you know, this is a great way to teach with the group work. (general teaching interview, quote #9b)

Barry made an attempt to be sure all students had a chance to take an active role when using the computer in groups. One strategy I saw him use was to have students take turns having control of the mouse during a lesson. I observed him employ this strategy when he implemented the jointly planned TLC lesson with his students (the same one that Julia and Kiran did). As a reminder, part of the lesson involved students using the Soil Creator in the Cal Alive! program to create different kinds of soils by choosing various starting materials (e.g., different kinds of rocks) and conditions (e.g., high vs. low moisture). Barry told his students, who were working in groups of four, to "make sure everyone has a chance, so each do three trials. There are 12 total trials, so everyone has a chance to use the computer. Work in pairs to fill out the data sheet" (observation, 5/10/02).

While most students were on task and engaged with the activity, some students still had trouble figuring out how to work out their group roles. One group couldn't figure out whose turn it was to use the computer. One of the students got frustrated and said, "Ok then, I'll write!" Another said, "You tell me what to do!" The other two group members were not even facing the computer. They were sitting behind the screen writing on their data sheets. Another group also had members who were not watching the experiment on the computer screen.

Student choice.

One aspect of the TLC lesson I discussed in the sections on Julia and Kiran was the way the teachers decreased the amount of choice in the lesson. As a reminder, the teachers decided to modify the pre-made data sheet to prescribe the combinations of materials and conditions that students should choose in making their soil. They also decided, in order to save time, to only allow the students to choose an absence of vegetation ("barren" vs. "vegetated") when running the simulation. Neither Julia nor Kiran changed these aspects of the lesson when they implemented it in their classrooms. Barry did not attempt to change them either, but during the lesson he commented to me, "Did we decide to just have them do 'barren?' They are using 'vegetated' and realizing that [the soil] is forming faster. That's good." Barry was open to the students straying from the lesson format and therefore discovering something new. I also noticed some students getting in a competition to see which group could find the combination of variables that would cause the soil to form the fastest.

Barry also used the same lesson with his 6th grade students that Julia used with her students to prepare them for going to science camp (observation, 1/30/03). This was the lesson in which students used Cal Alive! to research and draw organisms in the rocky intertidal (tide pool) habitat, a habitat they would encounter at the science camp. Barry spent the first 30 minutes of the period going over a science fair checklist with the students because it was due the next day. For the last 15 minutes of the period, Barry had students get in groups of four on the computers to use Cal Alive!. He gave them the handout Julia had made in which students were to draw specific organisms from the rocky intertidal habitat. As with Julia, this lesson seemed more prescribed than necessary.

Discussions.

During a lesson on the characteristics of the Earth and people's view of the Earth over time (e.g., flat vs. spherical nature), Barry had students answer questions individually on a worksheet (observation and handout, 12/10/02). Then he passed out blow-up globes to each group and had them go over their answers on the worksheet together. One of the questions had to do with historical ideas that the Earth was flat. The question presented two pictures, one of a horizon and one of the Earth from space. The following discussion about that question took place. Notice that Barry begins by reminding students that he wants them to come up with the answers and he will just act as a guide for the discussion.

> Barry: Discuss your answers with your group. Come to a consensus. What does that mean?
> SS: Agree. *Students examine globes and discuss answers.*
> Barry: I'm not going to give you the answers. Raise your hands if you changed at least one question.
> SS: *Many raise their hands.*
> Barry: I'll ask questions but I won't give the answers. Question one?
> SS: D
> Barry: Explanation? How is picture two different than picture three? How are they different?
> Student: Latitude and longitude.
> Barry: Yes, but would you see those from space?
> Student 1: Picture number one looks flat and picture number two looks round.
> Barry: Why?
> Student 1: Some places look flat but they are really slanted.
> Student 2: Because our eyes can't see far enough to see the curvature.
> Barry: If you could see further, what would you see?
> Student 3: If you see a ship in the distance, it looks like it slowly disappears.
> Barry: What I was trying to get you guys to come up with was that it depends on how close you are to it. It's called "perspective."

Barry set up the discussion to focus on student participation rather than teacher transmitting the answers. Barry did use guiding questions during the discussion, but in the end was looking for one specific answer. Although he told them he would not provide the answers, he ended up doing just that. He did not notice that the students were really getting the concept of perspective without actually using the specific term. Nevertheless, he did let the student discussion continue for a while before he stepped in with what he felt was the correct answer.

Teacher-led instruction.

I observed several class periods in which Barry spent the entire session on individual work accompanied by whole class discussion. For example, one period was dedicated to reviewing for a quiz on matter (e.g., concepts such as mass, volume, buoyancy). Barry had students read out loud from the textbook and then had students explain what they just read (observation, 12/10/02). Students then filled out a practice quiz sheet on their own. When they were done they were allowed to check their answers with their own notes.

Another period was reviewing for a quiz on parts of the atom and then taking the quiz (observation, 1/17/03). Barry spent the first part of the class in a question-answer session that reviewed all the concepts that would be on the quiz. Barry had the students look at their periodic tables and review the names of the elements and the meanings of the numbers and symbols on the table. He also reviewed how to figure out an element's atomic and mass number of neutrons. Then he passed out the quiz and students filled it out. At first Barry did not have anything for students to do as they finished. Then he told them, "If you are done you can sit quietly at your desk and read a book." Instead, some students took a laptop out of the cabinet and plugged it in on the side of the room. Other students followed their lead. At one point I noticed that two girls were looking at a Hamtaro website (a toy/movie tie-in site). Barry noticed as well and reminded the students that, "Those of you on computers have to be on educational games or science fair sites." The girls moved to a lunar landing game site.

Another day was spent on teaching students how to use PowerPoint to make presentations about chemical elements (observations, 1/28/03). It was the first time Barry's 5th graders were going to create presentations. The written directions for the activity were for students to create a four-slide presentation (handout, 1/28/03). Slides one through three had specific information students had to include, such as the symbol of their element, the atomic number, atomic mass, and physical properties. The fourth slide was to be comprised of, "What other interesting information did you learn about your element? For example, who discovered it and when? What are some uses for that element?" Barry spent the first part of the period projecting a computer screen for the whole class. He had students take notes as he explained the steps for turning on the computer, logging on, and using PowerPoint. He led a question-answer session in which he asked students what he should do next and they answered. For example:

> Barry: How do I turn on PowerPoint?
> Student 1: "Start," then "Programs."
> Barry: *Clicks "Start" then "Programs" and then clicks the PowerPoint icon.* Right now it's a blank slide and you can add info. Put name of element. Focus on getting information on four slides....Where do I go if I'm ready for a new slide?
> Student 2: The button called "new slide."
> Student 3: If you need pictures you can click "insert."
> Barry: Where can I get clip art?
> Student 3: "Insert," then "picture," then "clip art."

After he finished going over the directions for using PowerPoint, he had students pick partners, choose an element for their presentation, and get out computers to do Internet research on those elements. Although the presentation structure was quite prescribed, the point of the lesson may have been to give students practice in using the PowerPoint program instead of learning the specific content. Barry did allow students to choose which element they wanted to research.

Analysis of Barry's Belief and Behavior Correspondence

Correspondence between beliefs and behavior.

Barry is a relatively new teacher, and his belief system about teaching is not as complex and structured as either Julia's or Kiran's. He does believe that students learn better by doing than by getting information from the teacher. Barry believes that computers facilitate student learning because students are in charge of getting information from the computer. This motivates students to learn because they are finding things out on their own. Students can then use computers to organize and summarize the information they have found. For these reasons, Barry believes computers are best used as a teaching tool for information retrieval, word processing, and presentations. He also believes students learn best when they are in physical control over computers and science equipment. He equates this "hands-on" quality with student-centeredness.

Much of Barry's teaching with computers behavior does correspond with these beliefs. He has students research topics on the Internet or on Cal Alive!, then write up reports, fill out worksheets, draw pictures, or make PowerPoint presentations.

Correspondence between behavior and best practice.

Although Barry talked about student-centeredness in his interviews, his narrow belief about the meaning of student-centeredness influenced his behavior. As I mentioned before, his understanding of student-centeredness focused mainly on the hands-on aspect, and did not include much about the student driving the direction and process of learning. Even when referring to the school philosophy about open-ended, discovery-oriented learning, Barry defines that as students having hands-on experiences.

> What we're trying to strive here for the school is "inquiry-based," where it's, you know, it's open-ended and the students discover for themselves. And the best way to do that is to let them *do* the science, not just read about it in the book and answer questions [italics added]. (teaching with computers interview, quote #4b)

He may have thought he was creating student-centered lessons, when in fact he was only creating hands-on lessons. Although he allowed his students to physically use the computers, which fulfilled his idea of student-centeredness, many of his lessons were really teacher-centered. In the lessons I observed, Barry directed students in very specific ways. For example, in the soil creation activity with Cal Alive!, Barry reduced students' ability to freely experiment. When students were making PowerPoint presentations, he told them exactly what information to research and include on each slide.

On the other hand, there were moments when Barry was able to give his students a little more ability to choose. For instance, he did allow students to choose a chemical element to research for the PowerPoint presentations. This choice could have increased motivation for students to learn the material. He also tried to make sure student access to computers while they worked in groups was equitable.

Even though Barry held the belief that hands-on experience was best for students, a considerable number of lessons I observed consisted mostly of either individual desk work, students reading aloud from the textbook, or teacher-led, whole class discussions. I observed more of this in Barry's classroom than in either Julia's or Kiran's.

Barry is a relatively new teacher who seems to be struggling with his experiences as a student, the ways he taught in the past, and the new ways he was expected to teach at Fielding. Barry's own experiences as a student were very much in teacher-directed classrooms. He often compared and contrasted his current teaching style to the styles of his teachers throughout his education.

> Because I'm a science teacher, we do a lot of lab work. And that student-centered is important because, like in the past the way I was taught, and just education in general, was more teacher-led or direct instruction. (general teaching interview, quote #1)

Although he believes in hands-on learning, Barry recognized that he sometimes ends up using the teacher-directed styles that made up the majority of his educational experiences.

> Ideally you'd want to do [hands-on labs] everyday in some fashion, but at some point the students, I mean kind of go back to how you were taught…where there's always the lecture where you have to get the core information that you need and then you do the lab setting. (science teaching interview, quote #16a)

Barry also had more difficulty with managing his students' behavior in the classroom then either Julia or Kiran. He did not have well-formed beliefs about behavioral management, and he did not have a strong foundation for good classroom management from either his teacher credential program or his past teaching experiences. Barry's classroom was noticeably more chaotic than Julia's or Kiran's from my observations. It almost seemed like Barry did not distinguish noise of students being off-task from noise representing on-task engagement. By implying to students that he would tolerate off-task behavior, as seen in his pattern of almost pleading for quiet but continuing with the class despite not getting it, he often had to spend a more significant portion of a period on behavior issues. Since students often need extra time when doing open-ended, student-controlled computer activities, losing critical minutes may have hindered his ability to implement student-centered lessons with the computer. When time runs low, many teachers fall back on more time-efficient, directive methods of teaching.

Barry also talked about how it has been difficult for him to really embrace student-centeredness in his teaching. Even with good examples in his teacher credential program, he acknowledged the strong influence he feels from his past experiences as a student and his struggles with classroom management as a new teacher.

> With my cooperating teacher, with student teaching…she did a good job of getting the students involved in the learning process and not just the teacher-led instruction like I grew up with pretty much for the most part….And then first year teacher, you know, I wanted to do it but you're so focused on your classroom management. It's hard to do and it's hard to give the students that power, so to speak. (general teaching interview, quote #9a)

Barry's self-referential beliefs also seemed to be influencing his ability to successfully implement best practices with computers. He did not feel totally confident in his own use of computers, as he explained what happened in his previous teaching experience.

> And when you're a younger teacher, the older staff kind of looks to you like, "Oh well, you're more comfortable with technology than I am," type of thing. So you're expected to [know] more, but we didn't have the resources and I didn't have the knowledge and I think I just picked up a lot of this just by the hands-on approach and just trying it yourself. (teaching with computers interview, quote #7)

These competing impacts of past experience, self-referential beliefs, and being a new teacher seemed to be affecting Barry's ability to implement best practice in teaching with computers. His behavioral beliefs seem to be in a period of transition in which he has beliefs that support teacher-centered practices, but also harbors some nascent beliefs that are student-centered. He has some promising teaching behaviors, but he often falls back on teacher-centered instruction. Barry himself acknowledged that his teaching style is changing and he is always striving to learn more about how best to teach.

> This is my fifth year as a classroom teacher, and the first couple of years you're really in the survival mode….So you just kind of find your groove and find out what works….But yet I'm more confident to try things and that's the way you find the best method….It's almost like a progression. You know, it's exciting to think about, "Ok, I've been able to do these new things in five years." And you just keep that trend going and you just get better and better every year. And that's what keeps you motivated. (science teaching interview, quote #1)

CHAPTER 5: FINDINGS AND IMPLICATIONS

I designed this study to delve deeply into the teachers' beliefs on many levels in order to gain a better understanding of how the multitude of beliefs a teacher holds can either complement or dominate each other and ultimately affect that teachers' behavior. I will discuss the importance of this degree of understanding of teachers in the section on implications.

I will now share the findings as they answer my research questions. In the previous chapter (Results and Analysis), I presented details about each teachers' beliefs and behaviors, and analyzed the relationship between them, in order to give a full view of how and why the teachers teach the way they do. In the Findings section, I will summarize and discuss some of the outcomes from the last chapter in order to show how they align with my research questions.

The first two research sub-questions asked about the complexity of beliefs about teaching with computers, science teaching, and general teaching. I will summarize my findings about the teachers' contextual, self-referential, and behavioral beliefs in each of the belief categories (teaching with computers, science teaching, and general teaching). The third research sub-question asked how these beliefs interacted with each other to affect the teachers' use of computers with students. I will discuss the role that the teachers' complexity of beliefs played in their ultimate teaching with computers behavior and then present other findings that came out of the study. I will conclude with the implications and limitations of this study, as well as recommendations for further research.

As background for the belief and behavior findings, I will first discuss the overall frequency of the teachers' computer use to demonstrate that these teachers were using computers often. The fact that these teachers actually used computers, instead of just intended to use them, allowed for a deeper look at the role their beliefs played in that use.

Overall Computer Use by Teachers

In this study, I observed the teachers over two periods (February to June 2002 and December 2002 to February 2003). Within these observation periods, I observed each teacher at least twice a month. In addition, I was able to collect around 70% of the unit lesson plans they developed over those time periods, in addition to some other computer-related lessons from other times during the year. I also collected the teachers' lesson planning books, teacher handouts, and related student artifacts. The teachers also filled out a daily activity log for a period of 20-25 days. Although some of these data are self-reported, they offer supporting evidence for the observational data.

From my observations and the teachers' lesson plans, I found that the teachers used computers in their lessons about 50% of the time throughout the observational period. The teachers filled out the daily logs in the spring of 2003 (after I had finished my observations), and their self-report data indicated a similar pattern of use. Over the period in which they filled out the logs, Julia used computers in 39% and Barry in 36% of their lessons, while Kiran used them in 68% her lessons. It is interesting that Kiran actually increased her frequency of use of computers over the observation period.

Findings

Belief Findings

Contextual Beliefs

All three teachers had positive contextual beliefs in terms of teaching with computers. They believed they were fully supported in incorporating computers into their instruction by their school administration and district. They also believed their computer use received the support of the majority of students and their parents. Although all three teachers cited some technological difficulties and a desire to have more computer equipment, they believed they were unusually fortunate to enjoy such a high level of computer access and technological support. Only Barry stated that, when his classroom was first given the laptops, some of the technological problems might have kept him from using the computers as frequently. Both Julia and Kiran denied that technological problems ever kept them from using the computers. They saw these issues as a normal part of working with technology and, although an inconvenience, the problems always had a solution.

The teachers also had positive contextual beliefs in regards to science teaching and general teaching. They believed their administrators fully supported their teaching of science and teaching in general. The principal was so supportive of the idea of best practices in teaching that she found funding for all three teachers to participate in the K-12 Alliance Professional Development Program for two years in a row. The teachers believed the principal encouraged their use of the methods and strategies they learned through the K-12 Alliance and also the leadership role they were trained to take. In addition, the teachers believed they had the resources they needed to teach in general and to teach science specifically. They had a science lab room and science materials at their disposal. The only area in which one of the teachers was less than positive was Kiran's feeling that she had too much content and too many standards to cover, sometimes hindering her ability to spend as much time on each lesson as she would have liked.

Behavioral Beliefs

All three teachers had a rich set of behavioral beliefs about teaching with computers, science teaching, and general teaching. Often the teachers held similar beliefs in more than one of the belief categories. For example, Julia and Kiran both held strong beliefs about the great importance of classroom order in both their science teaching and general teaching. In other cases, some of the beliefs in one category seemed to contradict those in other categories, or even those in the same category. Kiran held some possibly contradictory beliefs about teacher-centeredness and student-centeredness in her general teaching beliefs. For example, she felt that teacher-centered structure was necessary for students to learn, as well as that students needed opportunities to guide their own learning. Barry also held the science teaching and general teaching belief that students learn best when they do things on their own, but this might have conflicted with his teaching with computers belief that teacher-direction is a big part of getting students comfortable with technology. The teachers were able to hold these seemingly contradictory beliefs, and I will summarize my findings about the roles these beliefs played in the teachers' behavior in the next section.

Self-referential beliefs

All three teachers talked about how they had used computers in the past, both in their personal and teaching lives. Prior to teaching at Fielding, they had the most experience using computers professionally to support themselves as teachers, rather than using computers with students. For instance, they used computers to search for information and lesson ideas on the Internet, write their lesson plans, and keep track of grades. Part of this had to do with the lack of computer access at their previous schools. For example, Julia had one computer in her classroom, and she only had students use it in ways unrelated to the current lesson she was teaching (e.g., writing up work from a previous lesson). Kiran had access to a school computer lab, but she cited problems with access due to sharing the lab with the rest of the school. Barry had one computer in his classroom and no computer lab at his school in Houston, and three computers in his classroom and a computer lab at his school in Nebraska. Even though he had more access to equipment in Nebraska, he said the work he had students do was mostly word processing and some research that was not integrated with the rest of his teaching. Although the teachers had positive beliefs about the benefits of teaching with computers, they all expressed some confidence issues about their ability to incorporate computers in their teaching. This questioning of abilities was relatively slight, but it is worth mentioning as it might have affected their teaching with computers in some ways.

Both Julia and Barry expressed a great deal of confidence in teaching science. Barry had a background in science and believed he was able to teach it to his students. Although Julia did not have a formal science background, she had taught elementary science in some capacity for so many years that she believed she was fully capable of teaching science to her students at Fielding. For the most part Kiran was confident in teaching science. She did express some minor insecurity about her science content knowledge, although she had minored in science in college.

Barry was the only one of the three who expressed some uncertainty about his general teaching abilities, and this was only in the area of behavioral management. He did not always feel confident in his ability to maintain control over his students, and cited the lack of focus on classroom management in his preparation has a teacher. Both Julia and Kiran were quite confident in their general teaching abilities.

Findings About the Role of Beliefs in the Teachers' Behavior

Some researchers contend that the longer one holds a belief, the stronger that belief is (Pajares, 1992; Rokeach, 1970). More newly-acquired beliefs will often be overruled by older beliefs. In all three cases, the teachers had more experience as both teachers in general and science teachers specifically than they had as computer-using teachers. It is not surprising that their beliefs about teaching with computers were less complex than their beliefs about either science or general teaching. For example, none of the teachers had well-defined beliefs about behavioral management for teaching with computers. Kiran held no specific beliefs in this area, while the extent of Julia's and Barry's beliefs were that computers motivated students to stay on task. This is in sharp contrast to the extremely rich and complex beliefs about behavioral management held by both Julia and Kiran. Barry, on the other hand, did not have well-formed behavioral management beliefs in any of the three belief categories.

All three teachers had some difficulty managing their students during computer-based activities. Even after they experienced two years of teaching with the laptops at Fielding, I did not observe any major change their predominant strategy of having groups of four students sharing a laptop. They continued to complain of this causing off task behavior. It is possible that their lack of clear behavioral management beliefs related to teaching with computers hindered their ability to create systems that would equally engage all students in the lessons.

On the other hand, Julia's strong behavioral management beliefs related to her science and general teaching seemed to affect her teaching with computers in profound ways. For Julia, making sure students were always quiet and on task may have kept her from having more opportunities for free exploration and student-driven research on the computers. Although she had science teaching beliefs about the importance of student discovery of concepts and student choice, she often reduced the discovery and choice aspects of computer-based lessons.

It is clear that some beliefs are more dominant than others for each of the teachers. In all cases, the teachers' general teaching and science teaching were more dominant than their teaching with computers beliefs, probably because the latter beliefs were the most newly-acquired. Certain aspects within a category of beliefs were also more dominant than others.

Ability to Incorporate Best Practices

All three teachers were able to incorporate some best practices in their teaching. They all adopted the 5E lesson plan as a model for a good portion of their lessons. The majority of class periods I observed were a section of a 5E lesson plan design. On the daily logs, Julia reported using the 5E lesson plan in 78% of her lessons, Barry in 77%, and Kiran in 98% (note: these logs show the percentage of time the teachers *believed* they were using the 5E lesson plan).

Although they designed lessons according to the 5E lesson plan, this did not always mean their lessons turned out to be student-centered or inquiry-based, two important best practices in teaching with computers and science education (as well as math education). Within the model, teachers were able to be quite teacher-centered in directing exactly what their students should do and how they should do it. Both Barry and Julia had some trouble allowing students opportunity for discovery and choice. While Kiran was also teacher-centered in how she designed her lessons, she was able to give students room for discovery of science concepts. She did not usually tell them the concept before they had a chance to explore for themselves. Her strong belief in routines and established structures may have influenced her in this respect. Using the scientific process and 5E lesson plan model gave her the structure she needed, and perhaps because of this, she was able to follow them with more fidelity than Barry or Julia.

In terms of computers, most of the teachers' use was relatively consistent. They used both the Internet and Cal Alive! as research tools, much like books. They had students use computers as word processors in writing reports. Julia did not have students use computers to create presentations (she preferred whiteboards, posters, or written reports). Barry and Kiran, on the other hand, also had their students create computer-based presentations with PowerPoint. In some cases teachers had students use computers to do virtual science experiments, such as with some pre-made Cal Alive! lessons or with Internet-based science websites. None of teachers had students use the computer for communication or data collection and analysis.

Several researchers have described frameworks for computer integration in teaching as I described in the literature review section. Based on ideas of best practices, these frameworks assert that lower levels of integration correspond more with traditional, teacher-centered uses, while higher levels of integration correspond with more student-centered uses (Apple, 1995; Hooper & Reiber, 1995; Reinking et al., 2000). A middle level of computer integration usually involves a teacher using computers in ways that support their existing teacher-centered beliefs (the lowest levels are when teachers don't use computers at all). The researchers contend that as teachers use computers more and discover new uses, their beliefs and behaviors are transformed to being more student-centered.

According to these frameworks, I would place these teachers in my study at a middle level of computer integration. They are clearly using computers a great deal, but are using them to ways that could be considered more teacher-centered. Kiran was probably using computers in more ways that resemble best practice (e.g., giving students choices of when and how to use computers). They all used computers as tools for research, information organization, writing, and presentations, but did not fully exploit their potential for communication and higher-order thinking skills (e.g., analysis).

Other Findings

There were several other interesting findings that came out of this study (see Table 24).

Table 24: Other study findings.

Finding	Explanation
External barriers	Although teachers had extremely positive contextual beliefs, some external barriers were still cited by teachers as influencing their use of computers. For example, time and coverage of standards.
Misunderstandings of methods and definitions	Teachers seemed to have alternate conceptions of some aspects of best practices, such as student-centeredness and the subtleties of the parts of the 5E lesson plan model.
Availability of model lesson plans	Teachers were more successful at best practices when using pre-made activities that incorporated them. In addition, they were more successful if they had experienced the lesson themselves, such as through professional development.
Methodological issues	The Conceptual Model provided a useful guide to framing the research, including data collection and analysis. The Munby RGT provided rich belief data.

As I reviewed in the literature review section, teacher beliefs are only one of the barriers cited that keep teachers from integrating computers in their teaching. There are many external barriers, such as lack of equipment and training, that researchers cite as prevalent (Fabry & Higgs, 1997; P. L. Rogers, 2000; Willis & Mehlinger, 1996). One purpose of this study was to attempt to reduce the impact of these external barriers in order to highlight the influence of beliefs on teachers' behavior. Nevertheless, the teachers in this study still found some contextual issues that they believed kept them from using computers the way they wanted to. For example, I already mentioned that technological difficulties affected Barry's use of computers in some ways. In addition, Kiran talked about how the 50-minute periods and breadth of subject matter made it difficult for her to go into sufficient depth with computer-based and 5E lessons.

Some science education reformers suggest restructuring the school day and decreasing the breadth of science content to accommodate more best practices in science teaching (Benton-Kuepper, 1999; Cuban, 1982; National Research Council, 1996; Semb, Ellis, & Araujo, 1993). In the present political climate of more accountability measured by standardized tests, it is unlikely that these changes will be made in the near future.

Not only did these external barriers possibly make it more difficult for these teachers to fully implement best practices, some misunderstandings or misconceptions about aspects of the best practices might have made it harder for the teachers. Both Kiran and Barry seemed to equate student-centeredness with hands-on activities. If they were providing opportunities for students to manipulate objects or physically touch the computer, they were potentially fulfilling their idea of student-centered teaching. In reality, hands-on activities have the capability of promoting student-centeredness, but as can be seen clearly in Barry's practice, they can also be extremely teacher-centered when the teacher dictates exactly what students should do with materials or on the computers.

In a similar way, Julia seemed to misunderstand certain important aspects of the 5E model, namely the importance of allowing students to discover phenomena and concepts through the Explore section of the lesson. Several researchers studied the importance of the sequence of the learning cycle and found that the most learning took place when the concept was not explained until after the exploration phase of the model (Abraham, 1989; Renner, Abraham, & Birnie, 1985).

These misconceptions about best practices may also have hindered the teachers' ability to use them. It is also possible, however, that the teachers modified the best practices so they would better conform to their existing belief systems.

Another finding from this study is that the teachers were sometimes better able to employ best practices if they used a lesson that was either pre-made to incorporate best practices or was modeled to them in the professional development program. For example, Kiran did the rain-shadow activity from the Cal Alive! Classroom Guide. She was able to follow the activity and allow students to make the connections about the phenomenon through their exploration. In addition, the Cal Alive! program was often used in the professional development institutes as part of stations in which the teachers discovered related concepts through comparison of different parts of the program. Julia was able to model this approach in one of her lessons. This finding mirrors a finding from an outside evaluation that was conducted on a SPAN professional development institute, a precursor the K-12 Alliance program (Young, 2001). In that study, teachers were observed using their regular lessons and then using lessons from the SPAN program. When using SPAN activities, teachers used more best practices when using lessons taken from the SPAN institutes.

Finally, some of the methodological tools I used allowed for a deep exploration of the constructs important in this study. The conceptual model employed in this study proved to be a useful guide. It consolidated the major findings from studies of several prominent belief-behavior theories. While many of these belief-behavior theories have been used in quantitative studies, the conceptual model provided a framework of important constructs for qualitative studies. These qualitative studies can provide the rich, individual teacher-focused data that can help the research community understand the subtleties of teacher beliefs. In addition, the Munby RGT provided a structured process that allowed me to get detailed information about teacher beliefs, something that is not easy or trivial. I would recommend other researchers use both the conceptual model and Munby RGT for future studies of teacher beliefs.

Implications

One implication from this study is how difficult it can be for teachers to implement best practice teaching methods with computers. The teachers in this study were in an exemplary environment in terms of access to computer equipment, professional development, and administrative support. Yet they were still unable to be fully successful in using computers in student-centered and inquiry-based ways with their students. Their beliefs played a major role in their ultimate computer use. If this happens under the best of circumstances, how would teachers in less than exemplary computer-related situations fare? How might teachers with more negative contextual beliefs be able to incorporate computers into their teaching? How would their other beliefs influence their use of computers? These questions are important for the education community to think about and address in order to assist teachers in their ability to teach according to best practices.

Implications for Professional Development

If beliefs have such a strong impact on how teachers incorporate computers in their teaching, as well as their teaching in general, then the research and teacher education community cannot afford to ignore teacher beliefs. If we truly wish to make an impact on how teachers use computers to help students learn, then we must address teacher beliefs in a explicit ways.

This research has implications for the professional development of teachers on many levels. It has implications for the individual professional development that occurs as most conscientious teachers move over time from being inexperienced to experienced and hopefully novice to master (expert) and also for the more formal professional development programs that takes place in schools and through large-scale, systemic reform efforts.

It is clear from this study that these teachers' beliefs did play a role in their teaching with computers behavior. It was not trivial to uncover the complex interplay of their beliefs, but doing so, or at least understanding the important role of those beliefs, may be one of the keys to helping teachers grow and change in their profession.

The Professional Growth of Teachers

Every person comes to teaching with a wealth of experiences and personal beliefs that affect the teacher he or she will become (Kagen, 1992a; Pajares, 1992). The short period of teacher preparation is only the beginning of that teacher's professional journey. As teachers gain experience and years in the profession, they form a set of practices that most likely fits with their beliefs and allows them to perform within the school structure. More often, the practices teachers utilize will be similar to those they experienced during the long formative period as a student (Feimen-Nemser & Buchman, 1987; Tabachnick & Zeichner, 1984; Weinstein, 1989). Because of the power of these beliefs and the educational and life experiences that helped shape them, it is extremely difficult for teachers to change their teaching practices (Kagen, 1992a; Pajares, 1992). This is of the utmost importance if teachers are being asked to change by teacher educators, policy makers, parents, and the public at large. How does this affect teachers' ability to incorporate research-based best practices in their teaching?

It is illustrative to look at the case of Julia in this study. Since she is the teacher with the most experience of the three, it would make sense to assume that it would be hardest for her to change her teaching practice. Her beliefs are well-formed and seemingly stable, given the parallels between her science and general teaching beliefs. Interestingly enough, she does try to base her teaching on the example she got from her own third grade teacher. In terms of best practices, Julia tries to emulate the student-oriented strategies she saw her teacher use. Clearly this model from the past has impressed her enough that she still thinks about it 30 years later. Providing other models for her, such as through peer teaching or coaching, may be a way to help Julia change her teaching.

Julia does have beliefs that could support best practices of inquiry-based teaching with computers (e.g., allowing student to discover concepts) and aspects of student-centeredness (e.g., students being able to guide aspects of their own learning). I have already discussed, however, how she holds other beliefs that may be hindering her ability to be completely successful in these areas.

Knowledge of these competing beliefs by a professional developer (e.g., principal, teacher educator) or awareness of them by Julia herself, could help her make progress.

Julia clearly wants to allow her students to discover concepts on their own and to make meaningful choices in their learning process. She is not even aware that she is not fulfilling her own beliefs. This is where a professional developer could have the most impact on Julia's behavior.

In a similar way, Barry has beliefs that could support some of the research-based best practices in teaching with computers, primarily student-centered and inquiry-based teaching. One could hypothesize that it would be even easier for Barry to change his behaviors since his belief system is less mature than Julia's because he is much newer to the teaching profession. Barry is obviously having conflicts between his beliefs and his past and present teaching experiences, and is even aware of the conflicts on some level. He pointed out how he often ends up teaching in a didactic manner, even though he believes students learn best when they find things out on their own. Confronting the conflicts in his belief system could help Barry make the necessary changes to his behavior. Armed with an understanding of possible conflicts in a teacher's belief system and the reality of his or her current teaching practices, a professional developer could assist the teacher with awareness about the situation.

Kiran is an interesting case because she was able to get closer to ideals of inquiry in her lessons, even though she has some strong teacher-centered beliefs. She did not allow a great deal of open-ended discovery, but she did allow her students to make connections and discover concepts within a very structured lesson. She also allowed her students more opportunities to choose when and how to use computers. How might Kiran be helped to incorporate even more student-centeredness and other best practices in her teaching?

How might professional development have to be designed in order to truly target teacher beliefs and assist with this type of teacher change? I propose some ideas that may help professional developers assist teachers in becoming aware of their beliefs and using that awareness to move closer to incorporating best practices in their teaching. I recommend that these ideas be part of a long-term (three to five year) effort of professional development.

1. Outline the general relationship between beliefs and behavior and how this relationship can impact teaching.
2. Give teachers support and strategies to help them become more aware of the reasons (beliefs) behind why they teach the way they do. For example, strategies for belief awareness could include reflective writing and group discussions. Support for teaching behavior could consist of cycles of observation, feedback, discussion, and re-teaching.
3. Assist teachers in strengthening beliefs that support teaching best practices by helping them discover strategies to make those best practices more comfortable for them. For example, since behavioral management beliefs may be a driving force for most teachers, help teachers find explicit ways to manage the classroom to support both the behavioral management beliefs and the best practice teaching method. This may include helping teachers make incremental changes in their practice so they can keep control over the

classroom. At the same time, modeling entirely new (to the teachers) classroom management practices that are more conducive to best practice teaching methods might help teachers see that control is possible even when students are given more choice opportunities and allowed to conduct inquiry-based activities.

4. Do not attempt to force teachers to change their beliefs. More success is possible if teachers can be helped to use their existing beliefs to make progress towards best practice.
5. Make the correct execution of best practice methods explicit to teachers. If they do not understand the important subtleties of the methods, they are less likely to be able to implement them successfully. This could be done through supportive methods such as modeling, peer coaching, observations of teaching, feedback, re-teaching, and reflection.

Systemic Professional Development

These findings also have implications for the way we conduct reform-oriented professional development programs in schools, districts, and on even larger scales. If current and future teaching behaviors cannot be truly affected without addressing teacher beliefs, then professional development efforts must themselves make some fundamental changes. Incorporating belief awareness into professional development could be difficult, but the alternative may be the familiar cycle of traditional teaching models that don't take into account what we have learned about how students learn best. I will now outline some ideas that could help make addressing beliefs possible.

Long-term process.

At this point in time, even long-term professional development programs last for one or possibly a few years. When funding changes, teachers are usually left on their own again. The belief awareness professional development process should be ongoing and might need to last for three to five (to even ten) years, depending on the progress of the teacher. Remember, it is extremely difficult to fundamentally change beliefs, so a long-term commitment is necessary if we want to affect the kind of changes that will truly impact student learning.

Dissemination.

Conducting in-depth belief awareness professional development on a large scale is a daunting idea. How could it be done in a streamlined and cost-effective manner? A look at the professional development literature gives some recommendations for more effective programs. With the addition of the belief-awareness focus outlined previously, these recommendations could also allow this type program to be done. Table 25 highlights some of the components of best practice in professional development.

In addition to these recommendations, the strategy of educating Teacher Leaders, as done by the K-12 Alliance, could be a good model of targeting numerous school sites with less need for special professional developers. If Teacher Leaders were educated on how to help other teachers identify their beliefs, reflect on their own practice, and begin to support their beliefs that align with desired practice, much of the real work of this type of professional development could take place at the school site. This would need a great deal of support from the administration of the site.

Table 25: Recommendations for effective professional development programs. Recommendations taken from the following sources (Garet, Porter, Desimone, Birman, & Yoon, 2001; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Supovitz & Turner, 2000)

Category	Description
Structure	Critical mass of participation from one school site
	Onsite location
	Long-term support (contact hours and duration)
	Participation by teachers and administrators
Content	Focus on science content (specifically content that teachers will actually teach)
	Focus on ways students learn science
	Active engagement in discussion, planning, presenting, practice and reflection
	Collaborative learning
	Opportunities for evaluation of practice
	Observations and feedback
	Reviewing student work for understanding
	Opportunities for leadership Aligns with local, state and national standards
	Opportunities for ongoing communication

Content of professional development.

Much of professional development today consists of a focus on science content. Although there is a need for teachers to get more knowledge about science, if beliefs are not addressed, they may still not be able to teach that content according to best practices. Therefore, it may be more important to focus on beliefs and pedagogy in professional development if we hope to cause any kind of meaningful change.

Dealing with transient nature of teaching.

Teachers often move to new schools and districts, making continuity difficult. If a long-term, systemic view is taken, then the movement of teachers may not as much of a problem. If a similar culture of professional development is present on a large scale, namely always focusing on beliefs when doing professional development, then the teacher can continue with the process at the new school site. If a teacher has not experienced the belief-awareness type of professional development before, they would just start with the first stage of the process.

Limitations of Study and Recommendations for Future Research

Limited Observations of Actual Behavior

It would always be good to get more observations of actual behavior in order to firmly establish patterns of teaching. I would recommend standardizing the types of behaviors the researcher is hoping to see or create an observation form that lists behaviors for ease of data collection and comparison. It might also be a good idea to video and/or audio tape all observations to allow the researcher to pay closer attention without having to take copious notes during the observation.

Teacher Reflections and Lesson Plans Were Not Always Detailed Enough

Sometimes it was difficult to determine what teachers meant to do by reading their written lesson plans or reflections. I would recommend following up with teachers on their lesson plans and doing face-to-face reflections after each observation. Use video and audio tapes to assist teacher with reflections. It is often easier for a teacher to give more details while talking rather than while writing, and the interviewer can always prompt the teacher to give more information.

Relatively Short Study Period

Data were collected over two trimesters, one at the very beginning of computer integration. If possible, I would recommend studying the teachers over one or more full years. A longitudinal study would also allow the researcher to look for changes in beliefs and practices if they occur.

Small Number of Subjects in Best Case Scenario Setting

While this study allowed a greater focus on beliefs affecting behavior, most teachers do not teach in this type of setting. The next step would be to repeat the study with teachers in various settings and with different backgrounds. One caution is that if researcher is interested in computer use, some level of positive contextual beliefs is probably mandatory for this type of research.

Next Steps for this Research

It has become more clear as research is done on teacher beliefs how crucial they are to how teachers teach. With further evidence provided by this study and other recent belief-behavior studies (e.g., O'Hara, 2000), it is time for the education community to fully embrace the implications this has for the incorporation of computer technology into teaching and, more generally, for the professional development of teachers. Access to computers and professional development may not be capable of causing true change in teaching behavior unless teachers are treated as individuals and their individual beliefs and behavior are addressed.

To help highlight this issue, I plan to publish pieces of this work in different venues. First of all, this research speaks most directly to the community concerned with computers in education. Not only does this research show how teachers' individual beliefs can play a fundamental role in how they use computers, it has implications for how teachers could be assisted in their quest to incorporate computers using strategies that enrich student learning. Even teachers who have beliefs that could support best practice with computers may have other, more dominant, beliefs that keep them from being fully successful. In this study, behavioral or classroom management beliefs were a strong mediator for all three teachers. Beliefs like these need to be addressed in explicit ways, such as helping teachers form a concrete plan to maintain good classroom management while using computers. These findings could also apply to any kind of classroom innovation, whether it is a form of technology, new teaching method, or new curriculum.

Because this study was focused on teaching behaviors having to do with computers, I did not fully report on all of the data collected during the study. I would like to return to these data to explore how the teachers' beliefs played a role in their science teaching. I predict I would find a similar interplay among the teachers' science teaching and general teaching beliefs that influenced their science teaching behavior. This type of analysis of these data would be useful for the science education community.

More generally though, this study provides important information for the professional development community, be it in incorporating technology, science education, or other discipline. Addressing beliefs is important on any level of professional development, from individual professional growth of teachers to large-scale programs. I would like to work with professional developers and teachers at many stages of development (e.g., preservice, novice, inservice) to begin to determine how teachers could best be assisted in making progress towards awareness of how their beliefs influence their behavior and ultimately to being able to make changes in behavior, and even beliefs, to improve their teaching practices. If this is specifically with adopting and incorporating computer technology, I would also like to work with teachers in many different contexts to determine how to best help them make progress towards best practices in teaching with computers.

In terms of the teachers in my study, I would like to continue working with them (although this may not be possible given their changed circumstances – see Post Script). As these teachers may be at beginning stage of adoption of computers in teaching, a treatment study would be a logical next step. How would a professional development program designed to confront the teachers' beliefs and practice cause changes in these three teachers? Would the teachers move to a later stage of adoption of computer technology? What would their behaviors look like at the end of the treatment period? Would I ultimately see changes in their belief systems?

Post Script

What has happened with the teachers in the study and the program at Fielding School?

1. Kiran is the only teacher still teaching at Fielding.
2. Barry transferred to teach high school science in the same school district.
3. Julia moved to Southern California after her husband got a new job. She decided to take a break from teaching and is opening a business that sells bird-feeding equipment. As part of the business, Julia will be educating teachers, schoolchildren, and the public about birds and habitat. She also volunteers with a nature society and is helping to develop a docent program.

4. At Fielding, fifth graders were put in self-contained classrooms instead of rotating in a middle school-like manner. The upper-grade science teachers are now teaching 6^{th}-8^{th} grades.
5. Block scheduling with math and science was attempted. I don't know if it has been successful.

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APPENDICES

Appendix 1

Learner-Centered Psychological Principles

By the APA Work Group of the Board of Educational Affairs. (1997). Learner-centered psychological principles: A framework for school reform and redesign. (Rev. Ed.) Washington, D.C.: American Psychological Association. http://www.apa.org/ed/lcp.html#The%2014%20Learner

The following 14 psychological principles pertain to the learner and the learning process. They focus on psychological factors that are primarily internal to and under the control of the learner rather than conditioned habits or physiological factors. However, the principles also attempt to acknowledge external environment or contextual factors that interact with these internal factors.

The principles are intended to deal holistically with learners in the context of real-world learning situations. Thus, they are best understood as an organized set of principles; no principle should be viewed in isolation. The 14 principles are divided into those referring to cognitive and metacognitive, motivational and affective, developmental and social, and individual difference factors influencing learners and learning. Finally, the principles are intended to apply to all learners -- from children, to teachers, to administrators, to parents, and to community members involved in our educational system.

Cognitive and Metacognitive Factors

1. Nature of the learning process: The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience.

There are different types of learning processes, for example, habit formation in motor learning; and learning that involves the generation of knowledge, or cognitive skills and learning strategies. Learning in schools emphasizes the use of intentional processes that students can use to construct meaning from information, experiences, and their own thoughts and beliefs. Successful learners are active, goal-directed, self-regulating, and assume personal responsibility for contributing to their own learning. The principles set forth in this document focus on this type of learning.

2. Goals of the learning process: The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge.

The strategic nature of learning requires students to be goal directed. To construct useful representations of knowledge and to acquire the thinking and learning strategies necessary for continued learning success across the life span, students must generate and pursue personally relevant goals. Initially, students' short-term goals and learning may be sketchy in an area, but over time their understanding can be refined by filling gaps, resolving inconsistencies, and deepening their understanding of the subject matter so that they can reach longer-term goals. Educators can assist learners in creating meaningful learning goals that are consistent with both personal and educational aspirations and interests.

3. Construction of knowledge: The successful learner can link new information with existing knowledge in meaningful ways.

Knowledge widens and deepens as students continue to build links between new information and experiences and their existing knowledge base. The nature of these links can take a variety of forms, such as adding to, modifying, or reorganizing existing knowledge or skills. How these links are made or develop may vary in different subject areas, and among students with varying talents, interests, and abilities. However, unless new knowledge becomes integrated with the learner's prior knowledge and understanding, this new knowledge remains isolated, cannot be used most effectively in new tasks, and does not transfer readily to new situations. Educators can assist learners in acquiring and integrating knowledge by a number of strategies that have been shown to be effective with learners of varying abilities, such as concept mapping and thematic organization or categorizing.

4. Strategic thinking: The successful learner can create and use a repertoire of thinking and reasoning strategies to achieve complex learning goals.

Successful learners use strategic thinking in their approach to learning, reasoning, problem solving, and concept learning. They understand and can use a variety of strategies to help them reach learning and performance goals, and to apply their knowledge in novel situations. They also continue to expand their repertoire of strategies by reflecting on the methods they use to see which work well for them, by receiving guided instruction and feedback, and by observing or interacting with appropriate models. Learning outcomes can be enhanced if educators assist learners in developing, applying, and assessing their strategic learning skills.

5. Thinking about thinking: Higher order strategies for selecting and monitoring mental operations facilitate creative and critical thinking.

Successful learners can reflect on how they think and learn, set reasonable learning or performance goals, select potentially appropriate learning strategies or methods, and monitor their progress toward these goals. In addition, successful learners know what to do if a problem occurs or if they are not making sufficient or timely progress toward a goal. They can generate alternative methods to reach their goal (or reassess the appropriateness and utility of the goal). Instructional methods that focus on helping learners develop these higher order (metacognitive) strategies can enhance student learning and personal responsibility for learning.

6. Context of learning: Learning is influenced by environmental factors, including culture, technology, and instructional practices.

Learning does not occur in a vacuum. Teachers play a major interactive role with both the learner and the learning environment. Cultural or group influences on students can impact many educationally relevant variables, such as motivation, orientation toward learning, and ways of thinking. Technologies and instructional practices must be appropriate for learners' level of prior knowledge, cognitive abilities, and their learning and thinking strategies. The classroom environment, particularly the degree to which it is nurturing or not, can also have significant impacts on student learning.

Motivational and Affective Factors

7. Motivational and emotional influences on learning: What and how much is learned is influenced by the learner's motivation. Motivation to learn, in turn, is influenced by the individual's emotional states, beliefs, interests and goals, and habits of thinking.

The rich internal world of thoughts, beliefs, goals, and expectations for success or failure can enhance or interfere with the learner's quality of thinking and information processing. Students' beliefs about themselves as learners and the nature of learning have a marked influence on motivation. Motivational and emotional factors also influence both the quality of thinking and information processing as well as an individual's motivation to learn. Positive emotions, such as curiosity, generally enhance motivation and facilitate learning and performance. Mild anxiety can also enhance learning and performance by focusing the learner's attention on a particular task. However, intense negative emotions (e.g., anxiety, panic, rage, insecurity) and related thoughts (e.g., worrying about competence, ruminating about failure, fearing punishment, ridicule, or stigmatizing labels) generally detract from motivation, interfere with learning, and contribute to low performance.

8. Intrinsic motivation to learn: The learner's creativity, higher order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty, relevant to personal interests, and providing for personal choice and control.

Curiosity, flexible and insightful thinking, and creativity are major indicators of the learners' intrinsic motivation to learn, which is in large part a function of meeting basic needs to be competent and to exercise personal control. Intrinsic motivation is facilitated on tasks that learners perceive as interesting and personally relevant and meaningful, appropriate in complexity and difficulty to the learners' abilities, and on which they believe they can succeed. Intrinsic motivation is also facilitated on tasks that are comparable to real-world situations and meet needs for choice and control. Educators can encourage and support learners' natural curiosity and motivation to learn by attending to individual differences in learners' perceptions of optimal novelty and difficulty, relevance, and personal choice and control.

9. Effects of motivation on effort: Acquisition of complex knowledge and skills requires extended learner effort and guided practice. Without learners' motivation to learn, the willingness to exert this effort is unlikely without coercion.

Effort is another major indicator of motivation to learn. The acquisition of complex knowledge and skills demands the investment of considerable learner energy and strategic effort, along with persistence over time. Educators need to be concerned with facilitating motivation by strategies that enhance learner effort and commitment to learning and to achieving high standards of comprehension and understanding. Effective strategies include purposeful learning activities, guided by practices that enhance positive emotions and intrinsic motivation to learn, and methods that increase learners' perceptions that a task is interesting and personally relevant.

Developmental and Social Factors

10. Developmental influences on learning: As individuals develop, there are different opportunities and constraints for learning. Learning is most effective when differential development within and across physical, intellectual, emotional, and social domains is taken into account.

Individuals learn best when material is appropriate to their developmental level and is presented in an enjoyable and interesting way. Because individual development varies across intellectual, social, emotional, and physical domains, achievement in different instructional domains may also vary. Overemphasis on one type of developmental readiness--such as reading readiness, for example--may preclude learners from demonstrating that they are more capable in other areas of performance. The cognitive, emotional, and social development of individual learners and how they interpret life experiences are affected by prior schooling, home, culture, and community factors. Early and continuing parental involvement in schooling, and the quality of language interactions and two-way communications between adults and children can influence these developmental areas. Awareness and understanding of developmental differences among children with and without emotional, physical, or intellectual disabilities, can facilitate the creation of optimal learning contexts.

11. Social influences on learning: Learning is influenced by social interactions, interpersonal relations, and communication with others.

Learning can be enhanced when the learner has an opportunity to interact and to collaborate with others on instructional tasks. Learning settings that allow for social interactions, and that respect diversity, encourage flexible thinking and social competence. In interactive and collaborative instructional contexts, individuals have an opportunity for perspective taking and reflective thinking that may lead to higher levels of cognitive, social, and moral development, as well as self-esteem. Quality personal relationships that provide stability, trust, and caring can increase learners' sense of belonging, self-respect and self-acceptance, and provide a positive climate for learning. Family influences, positive interpersonal support and instruction in self-motivation strategies can offset factors that interfere with optimal learning such as negative beliefs about competence in a particular subject, high levels of test anxiety, negative sex role expectations, and undue pressure to perform well. Positive learning climates can also help to establish the context for healthier levels of thinking, feeling, and behaving. Such contexts help learners feel safe to share ideas, actively participate in the learning process, and create a learning community.

Individual Differences

12. Individual differences in learning: Learners have different strategies, approaches, and capabilities for learning that are a function of prior experience and heredity.

Individuals are born with and develop their own capabilities and talents. In addition, through learning and social acculturation, they have acquired their own preferences for how they like to learn and the pace at which they learn. However, these preferences are not always useful in helping learners reach their learning goals. Educators need to help students examine their learning preferences and expand or modify them, if necessary. The interaction between learner differences and curricular and environmental conditions is another key factor affecting learning outcomes. Educators need to be sensitive to individual differences, in general. They also need to attend to learner perceptions of the degree to which these differences are accepted and adapted to by varying instructional methods and materials.

13. Learning and diversity: Learning is most effective when differences in learners' linguistic, cultural, and social backgrounds are taken into account.

The same basic principles of learning, motivation, and effective instruction apply to all learners. However, language, ethnicity, race, beliefs, and socioeconomic status all can influence learning. Careful attention to these factors in the instructional setting enhances the possibilities for designing and implementing appropriate learning environments. When learners perceive that their individual differences in abilities, backgrounds, cultures, and experiences are valued, respected, and accommodated in learning tasks and contexts, levels of motivation and achievement are enhanced.

14. Standards and assessment: Setting appropriately high and challenging standards and assessing the learner as well as learning progress -- including diagnostic, process, and outcome assessment -- are integral parts of the learning process.

Assessment provides important information to both the learner and teacher at all stages of the learning process. Effective learning takes place when learners feel challenged to work towards appropriately high goals; therefore, appraisal of the learner's cognitive strengths and weaknesses, as well as current knowledge and skills, is important for the selection of instructional materials of an optimal degree of difficulty. Ongoing assessment of the learner's understanding of the curricular material can provide valuable feedback to both learners and teachers about progress toward the learning goals. Standardized assessment of learner progress and outcomes assessment provides one type of information about achievement levels both within and across individuals that can inform various types of programmatic decisions. Performance assessments can provide other sources of information about the attainment of learning outcomes. Self-assessments of learning progress can also improve students self appraisal skills and enhance motivation and self-directed learning.

Appendix 2

The ten background surveys that were administered during the professional development institute and used to choose subjects for the case studies: 1) Background information (Figure 14), 2) Classroom set-up drawing (Figure 15), 3) Personal computer use (Figure 16), 4) Professional computer use (Figure 17), 5) Use of computers with students (Figure 18), 6) General teaching methods (Figure 19), 7) Science teaching methods (Figure 20), 8) Technology teaching methods (Figure 21), 9) Administrative support (Figure 22), and 10) Future participation (Figure 23).

Figure 14: Survey 1 – Background information.

Please answer the following questions:

How long have you participated in K-12 Alliance Professional Development programs? (check one)
- ❑ First year
- ❑ Second year
- ❑ Third year
- ❑ Over three years

What was your major in college? ________________________________

How many upper division science courses did you take? ______

Did you take a computer technology course in your credential program?
- ❑ Yes
- ❑ No

If you answered yes to #4, please briefly describe the content of your computer technology course (e.g., how to use computers in general, how to integrate computers into classroom instruction).

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____

Figure 15: Survey 2 – Classroom set-up drawing.

Please draw a picture of your classroom. Note the position of the teacher's desk, student desks and chairs, and other furniture. Include any computers and indicate if they are for student or teacher access.

Figure 16: Survey 3 – Personal computer use.

How many computers do you have at home?
☐ 0 computers
☐ 1 computer
☐ 2+ computers

Is your home computer connected to a printer?	☐ Yes	☐ No
Is your home computer connected to the Internet?	☐ Yes	☐ No
Do you own a digital camera?	☐ Yes	☐ No

Please check all of the following items that describe ways you use a computer in your personal life (not in relation to your professional teaching). The computer you use does not have to be a home computer.

☐ e-mail
☐ Internet searching
☐ word processing
☐ spreadsheets
☐ databases
☐ paying bills
☐ making purchases
☐ creating web sites
☐ chat rooms
☐ video conferencing
☐ playing solitaire
☐ trading stocks
☐ organizing personal finances
☐ online banking
☐ making travel arrangements
☐ doing taxes
☐ printing color photos
☐ getting/storing information
☐ storing addresses
☐ daily/weekly calendar
☐ instant messenger
☐ downloading programs
☐ playing fantasy games (e.g., Myth)
☐ drawing programs
☐ downloading music
☐ ordering books
☐ reading news
☐ checking weather reports
☐ getting driving directions
☐ doing research
☐ using CD-ROMs
☐ online auctions/trading
☐ creating presentations
☐ other ________________
☐ other ________________

Please check the boxes that describe how often you do the following activities.

		Daily	2-3 times per week	2-3 times per month	Less than 1 time per month	Never
6.	I use a computer for personal reasons…					
7.	I check my e-mail…					
8.	I log onto the Internet for personal reasons…					
9.	I use word processing programs…					
10.	I use a digital camera…					

Figure 17: Survey 4 – Professional computer use.

Does your school provide a computer for your use as a teacher in your classroom (separate from student computers)?

☐ Yes ☐ No

If you answered no to the previous question, is there are computer provided for your use anywhere in your school?

☐ Yes ☐ No

Please check all of the following items that describe ways you use a computer ***as a teacher*** (not with students). The computer you use does not have to be a school computer.

☐ e-mail
☐ Internet searching
☐ word processing
☐ spreadsheets
☐ databases
☐ recording grades
☐ contacting parents
☐ creating web sites
☐ taking roll
☐ video conferencing
☐ keeping up with current educational policies
☐ posting homework on a web site
☐ searching Internet for lesson plans
☐ signing up for classroom space
☐ communicating with colleagues
☐ ordering classroom supplies
☐ ordering school-related books
☐ keeping up on current events
☐ daily/weekly professional calendar
☐ evaluating instructional materials
☐ using teaching-related CD-ROMs
☐ doing research
☐ creating rubrics
☐ creating presentations
☐ writing lesson plans
☐ other ______________
☐ other ______________
☐ other ______________
☐ other ______________
☐ other ______________

Please check the boxes that describe how often you do the following activities.

	Daily	2-3 times per week	2-3 times per month	Less than 1 time per month	Never
I use a computer for professional reasons…					
I log-on to the Internet for professional reasons…					
I use word processing programs to create teaching-related materials…					
I use a digital camera for teaching-related reasons…					

Figure 18: Survey 5 – Use of computers with students.

How many student-accessible computers do you have in your classroom?
☐ 0 computers
☐ 1 computer
☐ 2 computers
☐ 3-4 computers
☐ 5+ computers

How many of those computers are connected to the Internet? ______
Are any of those computers connected to a printer? ☐ Yes ☐ No
How many of your classroom computers are able to run CD-ROMs? ______
Does your school have a computer lab? ☐ Yes ☐ No
If yes, how many student-accessible computers does the computer lab contain? ______
How many computers in the lab are able to run CD-ROMs? ______

Please check all of the following items that describe ways you have your students use a computer, either in your classroom or in the school computer lab.

☐ e-mail
☐ Internet searching
☐ word processing
☐ spreadsheets
☐ databases
☐ writing reports
☐ doing homework
☐ creating web sites
☐ writing stories
☐ video conferencing
☐ playing games
☐ using educational software
☐ looking up information
☐ creating multimedia presentations
☐ communicating with classmates
☐ communicating with scientists
☐ creating graphs
☐ learning science content
☐ doing skill-building exercises
☐ taking multiple-choice exams
☐ self-evaluation
☐ turning in homework
☐ doing research
☐ using drawing programs
☐ digital photos
☐ practicing keyboard skills
☐ free time activity
☐ as a station
☐ collecting data
☐ analyzing data
☐ other ______________
☐ other ______________
☐ other ______________
☐ communicating with students at other schools/in other countries

Please check the boxes that describe how often you do the following activities.

	Daily	2-3 times per week	2-3 times per month	Less than 1 time per month	Never
I have my students use a computer…					
I have my students log-on to the Internet…					
I have my students use word processing programs…					
I have my students use a digital camera…					

Figure 19: Survey 6 – General teaching methods.

Certainly, we know your teaching changes all the time, from day to day....minute to minute. But, please consider the following in terms of your overall patterns of teaching and classroom instruction.

	On an **average** day in your classroom, please rate the percentage of time spent on:	Please circle the closest approximation.					
1	Administrative duties (taking roll, collecting homework, etc.)	0%	10%	25%	50%	75%	100%
2	Direct teacher instruction	0%	10%	25%	50%	75%	100%
3	Project-based instruction	0%	10%	25%	50%	75%	100%
4	Small-group work	0%	10%	25%	50%	75%	100%
5	Sharing out of small-group work	0%	10%	25%	50%	75%	100%
6	Individual desk work	0%	10%	25%	50%	75%	100%
7	Whole class instruction	0%	10%	25%	50%	75%	100%
8	Teacher-led discussion	0%	10%	25%	50%	75%	100%
9	Student-led discussion	0%	10%	25%	50%	75%	100%
10	Student-choice activities	0%	10%	25%	50%	75%	100%
11	Students completing worksheets	0%	10%	25%	50%	75%	100%
12	Preparation for taking standardized tests	0%	10%	25%	50%	75%	100%
13	Teacher-student question-answer sessions	0%	10%	25%	50%	75%	100%
14	Teacher-student individual interaction (tutorial style)	0%	10%	25%	50%	75%	100%

Figure 20: Survey 7 – Science teaching methods.

We know most of you do not teach science every day. We want to ask you, however, to answer the following questions based on an average day when you are doing science in your classroom.

	On an average day in your classroom, please rate the percentage of time spent on:	Please circle the closest approximation.					
1	Teaching science content	0%	10%	25%	50%	75%	100%
2	Teaching science processes	0%	10%	25%	50%	75%	100%
3	Reading about science content	0%	10%	25%	50%	75%	100%
4	Writing about science content	0%	10%	25%	50%	75%	100%
5	Teacher-generated investigations/experiments	0%	10%	25%	50%	75%	100%
6	Student-generated investigations/experiments	0%	10%	25%	50%	75%	100%
7	Small-group work in science	0%	10%	25%	50%	75%	100%
8	Whole-class instruction in science	0%	10%	25%	50%	75%	100%
9	Project-based instruction	0%	10%	25%	50%	75%	100%
10	Inquiry-oriented activities	0%	10%	25%	50%	75%	100%
11	Directed activities	0%	10%	25%	50%	75%	100%
12	Library or Internet information gathering work on science topics	0%	10%	25%	50%	75%	100%
13	Discussing or studying about scientists	0%	10%	25%	50%	75%	100%
14	Discussing or studying about science careers	0%	10%	25%	50%	75%	100%

Figure 21: Survey 8 – Teaching with technology methods.

We know you are all in different situations and have differing amounts of access to computers. These questions are not asked to make any judgments, we simply are trying to understand all the different issues in education that help or hinder teachers in integrating technology into their general teaching.

	In an **average week** in your classroom, please rate the percentage of time spent on:	Please circle the closest approximation.					
1	Using computers for administrative purposes (recording grades, taking roll, etc.)	0%	10%	25%	50%	75%	100%
2	Using computers to prepare for teaching (e.g., accessing info on the Internet, writing lesson plans)	0%	10%	25%	50%	75%	100%
3	Projecting the computer screen for whole class instruction	0%	10%	25%	50%	75%	100%
4	Teaching how to use computers	0%	10%	25%	50%	75%	100%
5	Students using educational software alone	0%	10%	25%	50%	75%	100%
6	Students using educational software in groups	0%	10%	25%	50%	75%	100%
7	Students using computers as a resource tool **in any way** they please during the instructional day	0%	10%	25%	50%	75%	100%
8	Students using computers as a resource tool **at any time** they please during the instructional day	0%	10%	25%	50%	75%	100%
9	Students using computers as a free time activity (educational or non-education use)	0%	10%	25%	50%	75%	100%
10	Students using computers for word processing	0%	10%	25%	50%	75%	100%
11	Students using computers as a part of learning **science**	0%	10%	25%	50%	75%	100%
12	Students using computers to create multimedia projects	0%	10%	25%	50%	75%	100%
13	Students using the Internet for research	0%	10%	25%	50%	75%	100%
14	Students using e-mail for pen pal correspondence	0%	10%	25%	50%	75%	100%
15	Students manipulating digital photos for projects	0%	10%	25%	50%	75%	100%
16	Students constructing or interpreting data bases or spreadsheet data	0%	10%	25%	50%	75%	100%

Figure 22: Survey 9 – Administrative support.

Please circle the phrase on the right that most accurately rates each statement.

17	My school administration provides encouragement and personal support for me to use computer technology in my instruction.	Very Correct	Somewhat Correct	Somewhat Incorrect	Not at all Correct
18	My school administration provides technical support for the use of computer technology (e.g., a full-time technology coordinator).	Very Correct	Somewhat Correct	Somewhat Incorrect	Not at all Correct
19	My school administration provides funding for computer hardware, software, and upgrades.	Very Correct	Somewhat Correct	Somewhat Incorrect	Not at all Correct
20	My school administration allows me to purchase (with school funds) the computer hardware and software that best fit my instructional needs.	Very Correct	Somewhat Correct	Somewhat Incorrect	Not at all Correct
21	My school administration provides adequate professional development for me to use computer technology.	Very Correct	Somewhat Correct	Somewhat Incorrect	Not at all Correct
22	My school administration provides adequate preparation time for me to use computer technology effectively.	Very Correct	Somewhat Correct	Somewhat Incorrect	Not at all Correct

Figure 23: Survey 10 – Future participation.

Thank you so much for filling out the surveys during the past two weeks. You have been extremely helpful, cooperative, and enthusiastic.

As you know, I will be inviting a small subset of you to participate in the second phase of my research. If you indicate that you are interested, I will be contacting you in the next month or two with more details.

1. Please check one of the following:

❑ Yes, I am definitely interested in participating. Please give me more information.
❑ I am leaning towards wanting to participate, but would definitely like more information.
❑ I am leaning towards not wanting to participate, but please give me more information just in case.
❑ Unfortunately, I will not be able to participate during the next year.

2. This year, I think I will use Cal Alive! with students…
❑ 3+ times ❑ 2 times ❑ 1 time ❑ 0 times

Appendix 3

Repertory Grid Technique (RGT) Interview Process

I am using the interview from Munby's (1984) as an example of the RGT interview process. During the first stage of the process, Munby asked the teacher to generate a list of statements in response to a prompt like the following.

> What we are going to try to do is get you to talk about the teaching you do, and the sorts of things which cause you to teach in the way you do, and try to do that in a way that is hopefully your language and not my language. And the way in which this is done is to start by asking you to tell me what sorts of things I might see were I to visit your classroom, say next week, and if it was your best class in terms of the best sorts of teaching you like to do or maybe even the best kids if you wish. And tell me the sorts of things I would see in terms of brief statements like "The students are writing at their desks," "The teacher is writing on the board," "The teacher is lecturing," "The students are working in groups," those sorts of statements; and we'll aim to get around 12 or 15 of these…

After the teacher generated the statements, she put them into groupings as per the directions in a prompt like the following.

> Now please group the statements you wrote into as many groups as make sense to you. You can use each statement in as many groupings as you'd like. Discuss the reasons for your decisions to make groups in this way and the relationships (comparisons and contrasts) between groups of statements.

When the teacher finished making the groupings, Munby used the statements (he called "elements") and groupings (he called "constructs") to create a grid. The grid was made using the elements as the row headings and the constructs as the column headings. The following grid was made from his teacher's elements and constructs (only a portion of the grid is portrayed).

		Constructs				
		Using things at home	Originality	Learn how to paraphrase	Certain results teacher is after	A chance to use their imagination
Elements	Students write notes as teacher lectures					
	Students work in groups on labs					
	Students bring their projects to class and discuss them					
	Students explain answers to questions in class					
	Teacher calls on specific student to answer a question					
	Students read information and prepare questions as if they were the teacher					

During the second stage of the process, the teacher completed the grid according to the following prompt.

> For each pair of items (one from a row and one from a column), please rate the relationship that you feel exists. Use the following key to designate the relationship:
>
> 3 = the items are definitely associated
> 2 = the items are neutrally associated
> 1 = the items are definitely not associated

The teacher was not given directions about what kinds of relationships were appropriate. The teacher rated them based on the relationships she felt existed. The teacher's completed grid looked like this (again, only a portion of the grid is portrayed).

		Constructs				
		Using things at home	Originality	Learn how to paraphrase	Certain results teacher is after	A chance to use their imagination
Elements	Students write notes as teacher lectures	1	2	3	3	1
	Students work in groups on labs	1	1	1	3	1
	Students bring their projects to class and discuss them	3	3	1	3	3
	Students explain answers to questions in class	1	3	3	3	3
	Teacher calls on specific student to answer a question	1	1	3	3	2
	Students read information and prepare questions as if they were the teacher	1	1	3	2	3

Munby then conducted a factor analysis using principal components analysis with varimax rotation on the completed grid (Munby, 1984). The factor analysis was used to categorize the constructs into related groupings according to the ratings of the teacher. Using the example grid, the factor analysis resulted in two factors containing the following statements:

Factor 1	Factor 2
Using things at home	Learn how to paraphrase
Originality	A chance to use their imagination
	(-) Certain results the teacher is after

(The negative sign in factor 2 means that statement is inversely related to the other statements.)

During the final stage in the process Munby interviewed the teacher, asking her to explain why these statements grouped together in this manner and what were the underlying reasons behind these groups? He also asked the teacher to think about past experiences that might have influenced the development of these aspects of her teaching.

Appendix 4

Figure 24: Lesson Plan Report and Reflection Sheet

Please fill out one of these forms for each lesson you report. Feel free to type directly on this form or answer the questions on a separate page (be sure to use the same numbering system). Use this form even if you are reporting on a time you only used Cal Alive! briefly during a larger lesson. If that is the case, please let me know about the larger lesson in which you used Cal Alive!. Thank you very much.

PART 1: Teacher Information

1. Your Name:
2. Today's date:
3. Grade level:
4. Approximate date(s) of lesson implementation:

PART 2: Background on lesson

5. Were there overall learning goal(s) and/or objective(s) for this lesson? _____ Yes _____ No
If yes, please state them:

6. Was this lesson part of a K-12 Alliance-type "conceptual flow" or "storyline?" (If possible, please send a copy of the flow or storyline)
_____ Yes _____ No

7. If not part of a conceptual flow or storyline, was this lesson part of a larger unit? (If possible, please send a copy of the unit)
_____ Yes _____ No

8. If you answered yes to either question 6 or 7, please describe briefly how this lesson fits into any conceptual flow, storyline, or unit.

9. Computer set-up (check all that apply):
_____ teacher projecting a computer screen for the whole class
_____ small groups of students at each computer <u>in the classroom</u>
_____ individual students at each computer <u>in the classroom</u>
_____ small groups of students at each computer <u>in a computer lab</u>
_____ individual students at each computer <u>in a computer lab</u>
_____ students rotating to different stations, with a computer at one or more stations
_____ other, please describe ____

10. Number of minutes using Cal Alive! during lesson:
Teacher: _____ 0-10 min _____ 10-25 min _____ 25-45 min _____ > 45 min
Students: _____ 0-10 min _____ 10-25 min _____ 25-45 min _____ > 45 min

11. Was lesson taken from Cal Alive! Classroom Guide? _____ Yes _____No
If yes, which lesson did you use? ____

12. Did you create a handout or modify an existing one for this lesson? (If possible, please send a copy of the handout)
_____ Yes _____No
If yes, please describe:

13. Did the students create any products/do any projects associated with this lesson? (If possible, please send an example of a student artifact)
_____ Yes _____No
If yes, please describe:

14. Did you assign any homework as part of this lesson? _____ Yes _____No
If yes, please describe:

15. Please complete this sentence: I would describe this lesson as more…
_____ teacher-driven
_____ student-driven
_____ a mixture of teacher- and student-driven
Please elaborate:

PART 3: Lesson Plan Details

We realize that you probably use different formats when designing lessons. Therefore, if you used the 5E format for this lesson (the format that was emphasized during the K-12 Alliance Summer Institute), please answer question #16. If you used any other format, please answer question #17.

16. Please describe your lesson using the 5E format. Include as much of the Engage, Explore, Explain, Extend, and Evaluation components in your description as possible. Please indicate clearly the part of the lesson that included Cal Alive!, but describe the whole lesson. Please use as much space as necessary to give an adequate idea of the lesson.

17. Please describe your lesson. Use as much space as necessary to give an adequate idea of the lesson. Include any introduction, procedures, extensions, or assessments used. Please indicate clearly the part of the lesson that included Cal Alive!, but describe the whole lesson.

18. We are aware that lessons often turn out differently than planned; sometimes better, sometimes worse, or sometimes just different. Were you surprised by anything that happened during this lesson? Did it go exactly as you had planned? Please describe how the lesson went compared with how you had planned it to go. Include any unexpected situations/outcomes. What might you do differently if you did this lesson again?

19. We are also aware that external issues (e.g., limited access to a computer lab, only one computer in the classroom, lack of support for teaching science) can influence how you do a lesson. Were there any issues that caused you to modify your lesson from what your ideal lesson would have been? Please explain.

20. Do you feel that you met your goals for this lesson? Please explain.

Appendix 5

Figure 25: Daily Teaching Activity Checklist

Name: Date: Grade:

1. Please briefly describe your lesson for today (e.g., *students learned about chemical elements. They did research on their assigned element*).

2. Was today's lesson part of a 5E lesson plan? ❑ Yes ❑ No
If yes, which part was it? ❑ Engage ❑ Explore ❑ Explain ❑ Extend ❑ Evaluate

3. Did you have any learning goal(s) for today's lesson? ❑ Yes ❑ No
If yes, please write it/them here (e.g., *Students will be able to use the internet to find information on one chemical element. Students will know the difference between electrons, protons and neutrons*).

4. Please read the activities below and check off any and all that describe what you did during one science class period. Then indicate approximately how much time you spent doing each activity. [The time may add up to more than one class period. For example, if you had students work for 20 minutes in small groups on computers, both "Having students work in small groups" and "Having students use computers" would have been done for 20 minutes.]

✓	Today, during this class period, I spent time…	I spent approx. this much time
	Managing the classroom (e.g., quieting students, dealing with behavior problems)	
	Conducting administrative duties (e.g., taking roll, checking agendas, collecting homework)	
	Instructing the whole class (e.g., giving directions, explaining concepts, preparing students for an activity)	
	Leading a whole class discussion	
	Leading a question and answer period with the whole class	
	Having students work in small groups	
	Having students work individually	
	Having students conduct an experiment or activity	

✓	Today, during this class period, I spent time…	I spent approx. this much time
	Having students reading from a textbook or other material	
	Having students write (e.g., essay, paragraph, journal)	
	Having students fill out a worksheet or teacher-made handout	
	Having students give group or individual presentations	
	Having students watch a video	
	Projecting a computer screen for whole class instruction	
	Having students use computers	
	Having students use any other type of technology besides computers (e.g., lab equipment, calculator, digital camera, video camera)	
	Having students do free-choice activities	
	Having students prepare for taking standardized tests	
	Having students take standardized tests	
	Having students prepare for or take a quiz or other non-standardized test (e.g., teacher-made)	

5. If technology was used today (by teacher or students), please briefly describe how it was used (e.g., *students visited teacher-specified internet sites to look up information about chemical elements to fill out a worksheet*):

6. Did you assign homework for today? ❑ Yes ❑ No
If yes, please briefly describe the homework (e.g., *students will complete their chemical element worksheet at home*):

7. Please attach any handouts or worksheets that were used today (please date each page). If possible, attach a student artifact (or copy) from today's lesson.

Appendix 6

Julia's Munby RGT Interview Results

Teaching with Computers

Table 26: Grid ratings elicited from Julia's Munby RGT interview on *teaching with computers*. Julia's elements are the row headings and her constructs are the column headings. Julia rated the relationship between each element and construct with a 3 if she felt they were definitely associated, a 2 if they were neutrally associated, and a 1 if they were definitely not associated.

3 = definitely associated 2 = neutral 1 = definitely not associated	Student activity during class period.	Computers used to motivate kids in science.	Computers used independently by students.	Students guide their own learning.	Computers used as an instructional aid by teacher.	Computers used as a station in class.	Technology used to extend a lesson.	Technology used for non-teaching purposes.	Parent communication.	Communication.	Challenge activity for gifted students.	Computers used as a teacher tool for lesson planning.	Students engaged in technology with the teacher as support only.	Computers used as part of teacher evaluation process.
I am showing my students a space shuttle launch through MSNBC.com, projected on the TV screen.	3	3	2	1	3	1	3	1	1	3	2	1	2	2
Students are individually sharing their "Space News" article obtained from the Internet.	3	3	2	2	1	1	2	1	1	3	2	1	3	3
I am projecting the computer onto the classroom screen to demonstrate how to get into a particular site.	2	2	1	2	3	1	2	1	1	3	2	1	1	2
Students are at 8 stations for an air pressure lesson. 2 of those are comp. stations exploring Cal Alive Air Pressure/climate.	3	3	1	3	1	3	2	1	1	3	1	1	3	3
Students are in groups of 4, huddled around a computer exploring an internet site as an "extend" part of their lesson.	3	3	1	3	1	3	3	1	1	3	1	1	3	2

3 = definitely associated 2 = neutral 1 = definitely not associated	Student activity during class period.	Computers used to motivate kids in science.	Computers used independently by students.	Students guide their own learning.	Computers used as an instructional aid by teacher.	Computers used as a station in class.	Technology used to extend a lesson.	Technology used for non-teaching purposes.	Parent communication.	Communication.	Challenge activity for gifted students.	Computers used as a teacher tool for lesson planning.	Students engaged in technology with the teacher as support only.	Computers used as part of teacher evaluation process.
I am using the computer to send in the lunch count and attendance.	1	1	1	1	1	1	1	3	1	3	1	1	1	3
I am reading email from a parent telling me her child will be missing school.	1	1	1	1	1	1	1	3	3	3	1	1	1	1
Some of my students are taking notes on their personal computers while reading the text.	3	1	3	3	1	1	2	2	1	3	2	1	2	1
I am communicating through email to my principal.	1	1	1	1	1	1	1	3	2	3	1	1	1	3
I am showing a virtual tour of a science fair through the projector from the internet.	3	3	1	2	3	1	2	1	1	3	2	1	2	1
Students are getting ideas for their science fair from several internet sites. They are in groups of 4.	3	3	1	3	1	2	2	1	1	3	2	1	3	1
A student is done with the assignment, so he is on the computer looking at Earthpulse Center, a virtual site of scientific data finding.	3	3	3	3	1	1	3	1	1	3	3	1	3	1
I am creating a Power Point presentation on the steps involved in Science Fair project selection.	1	2	1	1	3	1	1	1	2	3	1	3	1	1

3 = definitely associated 2 = neutral 1 = definitely not associated	Student activity during class period.	Computers used to motivate kids in science.	Computers used independently by students.	Students guide their own learning.	Computers used as an instructional aid by teacher.	Computers used as a station in class.	Technology used to extend a lesson.	Technology used for non-teaching purposes.	Parent communication.	Communication.	Challenge activity for gifted students.	Computers used as a teacher tool for lesson planning.	Students engaged in technology with the teacher as support only.	Computers used as part of teacher evaluation process.
Students are watching my Power Point presentation on the projector.	3	2	1	2	3	1	2	1	1	3	1	1	1	1
Students learn how to link to the Internet from a Power Point lesson.	3	2	1	2	3	1	1	1	1	3	1	1	1	1
I am giving my students directions on their computers on how to save their work.	3	1	3	2	1	1	2	1	1	3	2	1	1	1
I am taking pictures of students on a digital camera and saving them to my hard drive for a future presentation.	1	3	1	1	2	1	2	1	2	3	1	2	1	3

Table 27: Factors from Julia's *teaching with computers* Munby RGT interview. Constructs and label for each factor are presented. A (-) symbol in front of a construct means it was inversely related to the other constructs in that factor.

Factor	Constructs	Julia's Label
1	• Student activity during class period. • Computers used to motivate kids in science. • Students guide their own learning. • Computers used as a station in class. • Technology used to extend a lesson. • Students engaged in technology with the teacher as support only. • (-) Technology used for non-teaching purposes. • (-) Parent communication.	• Computers used to engage and motivate
2	• Computers used independently by students. • Technology used to extend a lesson. • Challenge activity for gifted students. • (-) Computers used as a station in class.	• Without the teacher
3	• Computers used as a station in class. • Technology used for non-teaching purposes. • Students engaged in technology with the teacher as support only. • Computers used as part of teacher evaluation process. • (-) Computers used as an instructional aid by teacher.	• Outcomes of lesson planning
4	• Student activity during class period. • Students guide their own learning. • Computers used as a station in class. • Students engaged in technology with the teacher as support only. • (-) Parent communication. • (-) Computers used as a teacher tool for lesson planning.	• Implementation of the lesson plan

Science Teaching

Table 28: Grid ratings elicited from Julia's Munby RGT interview on *science teaching*. Julia's elements are the row headings and her constructs are the column headings. Julia rated the relationship between each element and construct with a 3 if she felt they were definitely associated, a 2 if they were neutrally associated, and a 1 if they were definitely not associated.

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher led activity	Student lead activity (students guide instruction)	Teacher uses activity as an engage for lesson	Students are exploring	Students are explaining	Teacher leads students in discovery	Evaluation
I am doing a demo as an engage for my students.	3	1	3	1	1	2	1
I am explaining directions for the lab students will be doing.	3	1	1	1	1	1	1
Students are in groups of four working at their station.	2	3	1	3	1	3	1
I am walking around the lab, questioning students as they do their labs.	2	2	1	3	3	3	3
Students are drawing their rendition of what they think is happening in the lab.	2	3	1	1	3	1	3
I am asking questions of each group as they draw to clarify drawings.	3	2	2	1	3	2	3
I am projecting Cal Alive or an Internet hands on lesson to show students how to access the site for group learning.	3	1	3	1	1	1	1
I am walking around the room as students work on computers in groups of 4, making sure students are on task.	1	3	1	3	1	1	2
I am helping a student with his computer.	2	2	1	2	1	1	1
I am leading a discussion with my class, leading their thinking through Socratic questioning.	3	2	2	2	3	2	3
Students are quietly at their desks working on a student worksheet after a lab.	2	2	1	1	1	1	3

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher led activity	Student lead activity (students guide instruction)	Teacher uses activity as an engage for lesson	Students are exploring	Students are explaining	Teacher leads students in discovery	Evaluation
Students are in groups of 4, thinking up a skit to demonstrate their understanding of the concept taught.	2	3	1	1	2	1	3
Students are actively listening while a group of students perform a skit.	2	3	1	1	3	1	2
Students are asking questions of a group who are sharing a white board during the lesson.	2	3	1	1	3	1	2
I am leading a group of students in a skit to demonstrate a science concept.	3	2	3	1	3	3	1

Table 29: Factors from Julia's *science teaching* Munby RGT interview. Constructs and labels for each factor are presented.

Factor	Constructs	Julia's Label
1	• Teacher-led activity • Teacher uses activity as an engage for lesson	• Teacher in front • Attention on teacher
2	• Student-lead activity (students guide instruction) • Students are explaining • Evaluation	• Students on the stage
3	• Students are exploring • Teacher leads students in discovery	• Discovery learning

General Teaching

Table 30: Grid ratings elicited from Julia's Munby RGT interview on *general teaching*. Julia's elements are the row headings and her constructs are the column headings. Julia rated the relationship between each element and construct with a 3 if she felt they were definitely associated, a 2 if they were neutrally associated, and a 1 if they were definitely not associated.

3 = definitely associated 2 = neutral 1 = definitely not associated	Stop everything for teachable moment	Discipline comes before teaching	Mutual Respect	Learning can be fun	Expository reading – important skill to learn	Group work benefits all	Planning, organizing teaching time	ALL students should be challenged	Balanced teaching with all modalities	Teach thinking strategies – thinking as a tool	Mistakes teach us the most
Students are listening to directions about what they are to do during the period.	1	2	3	1	1	2	1	3	3	1	1
A student is repeating the directions given out loud.	1	2	1	1	1	2	1	1	3	1	1
Students are working individually on paperwork or reading their text and taking notes.	1	1	1	2	3	1	1	2	2	1	1
Students are in small groups exploring an experiment.	1	1	2	3	1	3	1	3	3	3	2
Mrs. Wilson is circulating asking questions during a lab.	1	1	1	2	1	3	1	3	1	3	2
Mrs. Wilson is doing a demo in the front of the room.	1	1	1	2	1	1	1	2	3	2	2
Students come into class in the morning and get daily space news off internet to share headlines with class.	2	1	1	3	3	1	1	3	3	2	1
Students are in groups of 2-3, researching glaciers on the internet.	1	1	2	3	3	3	1	3	3	2	1
Students are working on Power Point presentations for Glacier projects.	1	1	2	3	3	2	1	3	3	1	2

3 = definitely associated 2 = neutral 1 = definitely not associated	Stop everything for teachable moment	Discipline comes before teaching	Mutual Respect	Learning can be fun	Expository reading – important skill to learn	Group work benefits all	Planning, organizing teaching time	ALL students should be challenged	Balanced teaching with all modalities	Teach thinking strategies – thinking as a tool	Mistakes teach us the most
Students are presenting Power Point and oral reports on Glaciers.	1	1	3	3	2	1	1	3	3	1	1
Mrs. Wilson is using Socratic questioning strategies in a discussion with class.	2	1	1	3	1	1	1	3	2	3	1
Mrs. Wilson is showing a demo to the class so they can write up what is happening for a performance assessment.	1	1	1	3	1	1	1	3	2	1	2
Mrs. Wilson is talking with a student about how to improve his grades.	1	2	3	1	1	1	1	3	1	3	3
Students are cleaning up a lab.	1	1	3	1	1	1	1	1	1	1	1
Mrs. Wilson is setting up a lab for students.	1	1	3	1	1	1	3	1	1	1	1
Teacher stops talking, so disruptive student will stop talking.	2	3	3	1	1	1	1	2	1	1	1
Students go outside for a brief demonstration on condensation with breath in cold winter air.	3	1	2	3	1	1	1	3	2	3	1
The class is reviewing for a test by playing Jeopardy with facts from the unit.	1	1	2	3	1	1	1	2	3	1	2
A student is given an extra assignment to challenge him at home on the Internet.	1	1	2	3	2	1	1	3	2	2	1
Mrs. Wilson works with an RSP student on lab for an experiment.	1	1	2	1	2	1	1	3	2	2	1
Mrs. Wilson talks about the mistake she just made- why a lab won't work with rest of class.	2	1	3	1	1	1	1	2	1	3	3

Table 31: Factors from Julia's *general teaching* Munby RGT interview. Constructs and label for each factor are presented. A (-) symbol in front of a construct means it was inversely related to the other constructs in that factor.

Factor	Constructs	Julia's Label
1	• Learning can be fun • Expository reading; important skill to learn • ALL students should be challenged • Balanced teaching with all modalities • (-) Planning, organizing teaching time	• Reaching all children: Good strategies for meaningful learning
2	• Teach thinking strategies; thinking as a tool • Mistakes teach us the most • (-) Expository reading; important skill to learn • (-) Balanced teaching with all modalities	• Critical thinking underlies all learning
3	• Group work benefits all • Balanced teaching with all modalities • (-) Stop everything for a teachable moment	• System for teaching all modalities
4	• Discipline comes before teaching • (-) Learning can be fun • (-) Planning, organizing teaching time	• Good classroom management needs to come before teaching
5	• Mutual respect • Planning, organizing teaching time • (-) Learning can be fun • (-) Balanced teaching with all modalities	• Respect

Appendix 7

Kiran's Munby RGT Interview Results

Teaching with Computers

Table 32: Grid ratings elicited from Kiran's Munby RGT interview on *teaching with computers.* Kiran's elements are the row headings and her constructs are the column headings. Kiran rated the relationship between each element and construct with a 3 if she felt they were definitely associated, a 2 if they were neutrally associated, and a 1 if they were definitely not associated.

3=definitely associated 2=neutral 1=definitely not associated	Students use computers to take notes and draw.	I use computers to teach students.	Students use the Internet to do research.	Students use instructional materials on computers.	Students drive computer use
Students use computers to take notes.	3	3	3	2	1
I project computer screen with LCD projector for students to see.	1	3	2	2	1
I project information from the computer screen.	1	3	3	2	1
Students use computers to draw maps.	3	1	1	3	3
Students use computers to do research for their science fair projects.	3	1	3	3	3
Students use computers to type their reports.	3	1	1	3	3
Students use computers to create reports, power point presentations.	3	1	2	3	3
Students use computers to work on Cal Alive and other materials.	1	2	1	3	2
Students use computers to research science articles.	1	1	3	3	3
I use computers to show different websites, science web videos to students on the television.	2	3	2	1	1

Table 33: Factors from Kiran's *teaching with computers* Munby RGT interview. Constructs and label for each factor are presented. A (-) symbol in front of a construct means it was inversely related to the other constructs in that factor.

Factor	Constructs	Kiran's Label
1	• Students use computers to take notes and draw • Students use instructional materials on computers • Students drive computer use • (-) Teacher uses computers to teach students	• Technology in class • Technology in education
2	• Students use the Internet to do research	• Keeping current with technology

Science Teaching

Table 34: Grid ratings elicited from Kiran's Munby RGT interview on *science teaching*. Kiran's elements are the row headings and her constructs are the column headings. Kiran rated the relationship between each element and construct with a 3 if she felt they were definitely associated, a 2 if they were neutrally associated, and a 1 if they were definitely not associated.

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher is greeting and acknowledging students	Students getting straight to work	Students read the agenda	Students' prior knowledge	Teacher is explaining	Students are learning about directions for today's lesson	Students are working together by following directions	Teacher is helping students work together	Students are researching and working on the activity	Students summarize their findings	Students put findings in drawing or writing form to create a visual	Students are explaining their findings	Evaluation
I am greeting students at the door as they come in.	3	3	3	1	2	3	3	1	2	2	2	2	2
Students are copying agenda in the their planners.	3	3	3	2	2	2	3	2	2	2	2	2	3
I am explaining the standard and agenda to the students. I am also showing it on the LCD projector.	2	2	3	2	3	3	3	3	3	3	3	3	2
Students pass out work to the team leaders' desks.	3	1	1	2	2	1	1	1	1	1	1	1	3
Students are working on the opener which is a short engage activity.	3	3	3	3	3	3	3	2	2	2	2	2	3

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher is greeting and acknowledging students	Students getting straight to work	Students read the agenda	Students' prior knowledge	Teacher is explaining	Students are learning about directions for today's lesson	Students are working together by following directions	Teacher is helping students work together	Students are researching and working on the activity	Students summarize their findings	Students put findings in drawing or writing form to create a visual	Students are explaining their findings	Evaluation
I am reviewing yesterday's lesson to connect and explain that we are at the explore step of 5 E model.	2	2	2	3	3	3	3	2	3	2	2	2	2
I am showing digital pictures on the LCD projector of them (students) working on their project.	2	2	2	3	3	3	3	3	3	2	2	2	2
Students are reading and discussing directions with each other.	3	2	2	2	3	3	3	3	3	3	3	3	3
We go over the directions together and I demonstrate step-by-step directions by showing them on the LCD projector.	3	2	3	3	3	3	3	3	3	2	2	3	2
Students follow directions and work on the activity.	3	3	3	3	3	3	3	3	3	3	3	3	3
I walk around and help them with the activity.	3	3	3	3	2	2	3	3	3	3	3	3	1
Students are using laptops (Cal Alive, internet, word processor, power point etc.) to complete the activity.	3	3	3	3	3	3	3	3	3	2	2	3	3
Students debrief their explanations with each other within their group.	3	2	3	3	3	3	3	3	3	3	3	3	3
Students summarize their findings on the chart/butcher paper.	3	2	3	3	3	3	3	3	3	3	3	3	3
Next day students explore more after our beginning of class activities which are mentioned in number 1-5.	3	3	3	3	3	3	3	3	3	3	3	3	3

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher is greeting and acknowledging students	Students getting straight to work	Students read the agenda	Students' prior knowledge	Teacher is explaining	Students are learning about directions for today's lesson	Students are working together by following directions	Teacher is helping students work together	Students are researching and working on the activity	Students summarize their findings	Students put findings in drawing or writing form to create a visual	Students are explaining their findings	Evaluation
I walk around and help them with the activity.	1	2	3	2	2	2	3	3	3	3	3	3	3
Students add more information to their butcher paper and explain it to the whole class.	2	2	2	3	3	3	3	3	3	3	3	3	3
Students and I ask questions from students who are presenting.	2	2	2	2	3	3	2	2	2	2	2	3	3
Next day, after the beginning of the class procedure, I debrief yesterday's lesson by sharing the agenda and pictures of students working.	2	3	3	2	3	3	3	3	3	3	3	3	3
I point to their drawings and writing on the butcher paper.	2	2	2	1	3	3	3	3	3	3	3	3	3
Students work on the extend activity. This activity is either a lab or a real life connection thinking and exploration activity about what they have explored.	2	2	2	3	3	3	3	3	3	2	2	2	3
After the extend activity, students show what they learned either by answering questions, completing a lab sheet, a worksheet or by adding more information to their butcher paper.	2	2	2	3	2	3	3	2	3	3	3	3	3
Students read their textbook.	2	2	2	2	2	3	2	2	2	2	2	2	3

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher is greeting and acknowledging students	Students getting straight to work	Students read the agenda	Students' prior knowledge	Teacher is explaining	Students are learning about directions for today's lesson	Students are working together by following directions	Teacher is helping students work together	Students are researching and working on the activity	Students summarize their findings	Students put findings in drawing or writing form to create a visual	Students are explaining their findings	Evaluation
Students discuss this information with each other with in their group and then they explain it to the whole class.	2	2	2	3	2	3	3	3	2	2	2	3	3
At the end of the period, I wrap up or conclude this concept through questions and discussion and tell them that tomorrow we will work on this concept.	2	2	2	2	3	3	2	2	2	2	2	2	3
During this three-day lesson, I evaluate students through visual observation, all the activities and worksheets.	2	3	3	2	2	3	3	3	3	3	3	3	3

Table 35: Factors from Kiran's *science teaching* Munby RGT interview. Constructs and label for each factor are presented. A (-) symbol in front of a construct means it was inversely related to the other constructs in that factor.

Factor	Constructs	Kiran's Label
1	• Students are working together by following directions • Teacher is helping students work together • Students are researching and working on the activity • Students summarize their findings • Students put findings in drawing or writing form to create a visual • Students are explaining their findings • Students read the agenda • Students are learning about directions for today's lesson • (-) Teacher is greeting and acknowledging students	• Steps to follow • Directions to follow to do activity
2	• Teacher is greeting and acknowledging students • Students getting straight to work • Students read the agenda • Students are learning about directions for today's lesson	• Beginning class procedures
3	• Teacher is explaining • Students are learning about directions for today's lesson • Student's prior knowledge	• Direct teaching
4	• Evaluation • Students are learning about directions for today's lesson • (-) Students' prior knowledge	• Evaluation • Authentic assessment and interventions

General Teaching

Table 36: Grid ratings elicited from Kiran's Munby RGT interview on *general teaching*. Kiran's elements are the row headings and her constructs are the column headings. Kiran rated the relationship between each element and construct with a 3 if she felt they were definitely associated, a 2 if they were neutrally associated, and a 1 if they were definitely not associated.

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher greets students	Students start work right away	Students listen carefully to the directions	What I am doing when the students work	Students research,, do a lab or investigate	Students discuss their findings	students create visuals	Students present to the whole class	Peers give feedback	Teacher gives feedback
Students line up quietly outside the classroom.	3	3	3	3	2	1	1	1	1	1
Students come in quietly after I greet them.	3	3	3	3	3	2	1	1	1	1
Students copy the agenda in their planners. I praise them for doing a good job.	3	3	3	3	2	2	1	1	1	1
I explain the directions to students and answer their questions.	1	3	3	3	3	3	3	2	1	1
Students listen to the directions.	1	3	3	1	3	3	3	3	3	1
I check for understanding by asking students to explain directions back to me.	1	1	3	3	3	3	3	3	2	1
Students start working on the activity. I go around and help them.	1	3	3	1	3	3	3	3	2	1
I go around and help students.	1	1	1	3	3	3	3	3	3	3
Depending on the activity, students work with computers, work on a lab or go through different stations.	1	1	3	1	3	3	3	3	1	2
I give them constant feedback on their behavior and performance.	1	1	1	3	3	3	3	3	1	3
Periodically, I bring the whole class together and answer questions if many students ask the same question.	1	1	1	3	3	3	3	1	1	3
I check on how much they have accomplished by going to different groups.	1	1	1	3	3	3	3	1	1	3
Sometimes students also work individually during the follow up activity.	1	1	3	1	3	2	3	1	1	3

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher greets students	Students start work right away	Students listen carefully to the directions	What I am doing when the students work	Students research,, do a lab or investigate	Students discuss their findings	students create visuals	Students present to the whole class	Peers give feedback	Teacher gives feedback
Students discuss with their findings and observations with each other with in their groups.	1	1	3	1	3	3	3	1	3	3
Students create visuals such as power point presentations, posters, charts or whiteboard their findings.	1	1	3	3	3	2	3	1	1	3
Students explain their findings to the whole class.	1	1	3	3	3	3	3	3	3	3
Students ask questions from the presenters and give them feedback.	1	1	1	3	3	3	3	3	3	2
Presenters reflect on their work and make any necessary changes.	1	1	3	2	3	3	3	3	3	2
Teacher gives feedback to presenters at the end.	1	1	1	3	3	3	3	3	3	3

Table 37: Factors from Kiran's *general teaching* Munby RGT interview. Constructs and label for each factor are presented. A (-) symbol in front of a construct means it was inversely related to the other constructs in that factor.

Factor	Constructs	Kiran's Label
1	• Students research, do a lab or investigate • Students discuss their findings • Students create visuals • Students present to the whole class • Peers give feedback • (-) Teacher greets students	• Student progress • Overall authentic assessment
2	• Students research, do a lab or investigate • Students discuss their findings • Students create visuals • Teacher gives feedback • (-) Teacher greets students • (-) Students start work right away • (-) Students listen carefully to the directions	• Classroom management • Tool for evaluation/check for understanding
3	• Students listen carefully to the directions • (-) What I do when the students work	• Following directions to understand or learn • Attention

Appendix 8

Barry's Munby RGT Interview Results

Teaching with Computers

Table 38: Grid ratings elicited from Barry's Munby RGT interview on *teaching with computers*. Barry's elements are the row headings and her constructs are the column headings. Barry rated the relationship between each element and construct with a 3 if she felt they were definitely associated, a 2 if they were neutrally associated, and a 1 if they were definitely not associated.

3 = definitely associated 2 = neutral 1 = definitely not associated	I use an LCD projector for instruction.	Students are directly involved with the use of the computer.	Use of the Internet.	Utilizing Cal Alive.	Students are using the computers for word processing.
Students are rotating through 6 laptops to do Internet research on science fair topic ideas.	3	3	3	1	3
I am projecting an interactive website about hurricanes.	3	1	3	1	1
Students are working in groups to explore microscopic slides using the Intel Play micro-scopes that are run with the laptops.	2	3	1	1	1
I am projecting Cal Alive tutorials (before we had our laptops).	3	2	1	3	1
The students are using the Cal Alive tutorial disk on weather.	2	3	1	3	1
Students use the laptops to keep a daily warm up assessment.	2	3	1	1	3
Students use the laptops to obtain real time data about weather conditions to record in a weekly weather data log sheet.	3	1	3	1	1
I am projecting weather satellite imagery and forecasts maps.	3	1	3	1	1
Students are word processing science fair reports.	2	3	1	1	3
I am projecting a quiz that I wrote and the students are recording their answers on their own paper.	3	1	1	1	1
I am projecting the S'COOL (student cloud observation on-line) data entry form. We gathering cloud coverage data outside and now we enter our info. on-line.	3	1	3	1	1
I am showing a power point presentation about how to develop a science fair project.	3	2	2	1	1

Table 39: Factors from Barry's *teaching with computers* Munby RGT interview. Constructs and label for each factor are presented. A (-) symbol in front of a construct means it was inversely related to the other constructs in that factor.

Factor	Constructs	Barry's Label
1	• Students are directly involved with the use of the computer • Students are using the computers for word processing • (-) I use an LCD projector for instruction • Use of the Internet.	• Student-centered vs. teacher-led
2	• Use of the Internet • Students are using the computers for word processing • (-) Utilizing Cal Alive.	• Research and writing

Science Teaching

Table 40: Grid ratings elicited from Barry's Munby RGT interview on *science teaching*. Barry's elements are the row headings and her constructs are the column headings. Barry rated the relationship between each element and construct with a 3 if she felt they were definitely associated, a 2 if they were neutrally associated, and a 1 if they were definitely not associated.

3 = definitely associated 2 = neutral 1 = definitely not associated	Lab investigation or "hands-on" activities	Teacher-lead or direct instruction	Utilizing technology such as computers and LCD projectors	Student centered activities	Students doing scientific writing	Students researching a scientific topic
Students are watching a video on a science topic	1	2	1	2	2	2
Students are completing a daily warm up to assess learning on prior topic(s) or to pre-assess on topic(s) to be taught	1	1	2	3	3	2
Students are recording observations on a teacher-lead lab demonstration	3	3	1	1	3	1
Students are working in groups of 4 and rotating through a sequence of lab stations	3	1	2	3	3	2
Students are working individually on a written assessment (quiz, test, etc.)	1	1	1	1	1	1
Students are working in groups to research or explore a science topic on the Internet	2	1	3	3	2	3

3 = definitely associated 2 = neutral 1 = definitely not associated	Lab investigation or "hands-on" activities	Teacher-lead or direct instruction	Utilizing technology such as computers and LCD projectors	Student centered activities	Students doing scientific writing	Students researching a scientific topic
Students are researching in the library for a science fair and/ or science report topic	1	1	2	3	3	3
Students are reading a section of the science textbook and answering comprehension questions	1	2	1	3	2	1
Students are working in groups to explore slides using the computer microscopes	3	2	3	3	1	1
Students are experiencing a lesson on astronomy in the Starlab inflatable planetarium	1	3	1	1	1	2
Students are working in groups to launch water rockets with our TOPS scientist	2	2	1	2	1	2
Students are designing and constructing science booklets on a given science topic	2	1	2	3	3	3
Students are using whiteboards to present group learning in an lab investigation	3	1	1	3	3	1
Students are doing individual presentations about a science article summary	1	1	2	3	2	2
I am showing a power point presentation about how to design and construct a science fair project	1	3	3	1	1	1
I am showing a power point presentation about a particular science topic	1	3	3	1	1	2
I am giving directions for a lab investigation	1	3	1	1	1	1

Table 41: Factors from Barry's *science teaching* Munby RGT interview. Constructs and label for each factor are presented. A (-) symbol in front of a construct means it was inversely related to the other constructs in that factor.

Factor	Constructs	Barry's Label
1	• Student centered activities • Students doing scientific writing • Students researching a scientific topic • (-) Teacher-lead or direct instruction	• Student-centered learning by researching and writing a scientific topic
2	• Utilizing technology such as computers and LCD projectors • Students researching a scientific topic	• Using technology to research and present found knowledge
3	• Lab investigation or "hands-on" activities • (-) Students researching a scientific topic	• Hands-on learning

General Teaching

Table 42: Grid ratings elicited from Barry's Munby RGT interview on *general teaching*. Barry's elements are the row headings and her constructs are the column headings. Barry rated the relationship between each element and construct with a 3 if she felt they were definitely associated, a 2 if they were neutrally associated, and a 1 if they were definitely not associated.

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher-lead or direct instruction	Students are doing group work	Students are writing	Students are being assessed	Student centered learning activities
I am explaining a lab investigation that will be done in class.	3	1	2	1	1
I am explaining a writing assignment or project.	3	1	2	1	1
Students are working in groups on a lab investigation	1	3	3	3	3
Students are using the computers to type a writing assignment	1	2	2	3	3
Students are using computers to research a scientific topic	1	2	2	2	3
Students are taking notes	2	1	3	1	2
Students are reading	1	2	1	2	3
Students are presenting group work using a computer power point presentation	1	3	1	3	3
Students are working in groups on a project	1	3	3	3	3

3 = definitely associated 2 = neutral 1 = definitely not associated	Teacher-lead or direct instruction	Students are doing group work	Students are writing	Students are being assessed	Student centered learning activities
Students are viewing a video and taking notes or answering questions	1	1	3	3	3
Students are taking a quiz, or test	1	1	3	3	3
I am presenting a scientific topic to the class (direct instruction)	3	1	2	2	1

Table 43: Factors from Barry's *general teaching* Munby RGT interview. Constructs and label for each factor are presented. A (-) symbol in front of a construct means it was inversely related to the other constructs in that factor.

Factor	Constructs	Barry's Label
1	• Students are doing group work • Students are being assessed • Student-centered learning activities • (-) Teacher-led or direct instruction	• Student-centered • Group activities
2	• Students are writing • (-) Students are doing group work	• Integration and articulation in the disciplines