TEACHER AND STUDENT PERSPECTIVES ON MOTIVATION WITHIN THE HIGH SCHOOL SCIENCE CLASSROOM

Except where reference is made to the work of others, the work described in this dissertation is my own or was done in collaboration with my advisory committee. This dissertation does not include proprietary or classified information.

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TEACHER AND STUDENT PERSPECTIVES ON MOTIVATION WITHIN THE HIGH SCHOOL SCIENCE CLASSROOM

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TEACHER AND STUDENT PERSPECTIVES ON MOTIVATION WITHIN THE

HIGH SCHOOL SCIENCE CLASSROOM

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Melanie Turnure Pickens, daughter of Ronald Douglas and Ardell Reed Turnure, was born on September 23, 1964, in Huntsville, Alabama. She graduated from Lee High School in Huntsville, Alabama in 1982. She attended Samford University where she completed her Bachelor of Science degree in Secondary Science Education in 1986. Also in 1986, she married Timothy Leon Pickens, son of Herman and Patsy Pickens. Her daughter, Sarah Turnure Pickens, was born in 1992. While teaching science at Bob Jones High School in Madison, Alabama, she continued her education at Alabama A&M University graduating with a Master of Science Education degree in 1995. She then attended the University of Alabama and obtained an Educational Specialist degree in 1998. She became a National Board Certified Teacher in 2000. While continuing her teaching career, she entered into the Doctor of Philosophy Program in the College of Education at Auburn University.

DISSERTATION ABSTRACT

TEACHER AND STUDENT PERSPECTIVES ON MOTIVATION WITHIN THE HIGH SCHOOL SCIENCE CLASSROOM

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The purpose of this study was to investigate teacher and student perspectives on the motivation of high school science students and to explore specific motivational strategies used by teachers as they attempt to enhance student motivation. Four science teachers took part in an initial audio-taped interview, classroom observations with debriefing conversations, and a final audio-taped interview to discuss findings and allow member checking for data triangulation and interpretation. Participating teachers also took part in a final focus group interview. Student participants from each teacher's class were given a Likert style anonymous survey on their views about motivation and learning, motivation in science class, and specific motivational strategies that emerged in their current science class.

This study focused on effective teaching strategies for motivation commonly used by the four teachers and on specific teaching strategies used by two of these four teachers in different tracks of science classes. The intent was to determine not only what strategies worked well for all types of science classes, but also what specific motivational approaches were being used in high and low tracked science classes and the similarities and differences between them. This approach provided insight into the differences in motivating tracked students, with the hope that other educators in specific tracks might use such pedagogies to improve motivation in their own science classrooms.

Results from this study showed that science teachers effectively motivate their students in the following ways: Questioning students to engage them in the lesson, exhibiting enthusiasm in lesson presentations, promoting a non-threatening environment, incorporating hands-on activities to help learn the lesson concepts, using a variety of activities, believing that students can achieve, and building caring relationships in the classroom. Specific to the higher tracked classroom, effective motivational strategies included: Use of teacher enthusiasm, promoting a non-threatening class atmosphere, and connecting the adolescent world to science. In the lower tracked classroom, specific effective strategies were: Encouraging student-student dialogue, making lessons relevant using practical applications, building student self-confidence, and using hands-on inquiry activities. Teachers who incorporate such strategies into their classrooms regardless of the track will likely increase motivation and also enhance learning for all students.

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CHAPTER ONE

INTRODUCTION

Rationale for Study

The purpose of this study was to investigate teacher and student perspectives on the motivation of high school science students and to explore specific motivational strategies used by teachers as they attempt to enhance student motivation. Pedagogical philosophies and classroom practices affecting motivation in science students were examined from a qualitative perspective. The study examined the extent to which the selected teachers perceive that student achievement is impacted by these pedagogies.

Although much quantitative research exists in the area of motivation in science, very little qualitative data is available to educators. Quantitative studies have revealed that motivation has been positively correlated with class choice (Ferrar-Caja & Weiss, 2002; Sanfeliz & Stalzer, 2003), academic achievement (Alexander & Murphy, 1998; Legault, Green-Demers, & Pelletier, 2006; Schiefele & Krapp, 1996; Singh, Granville, & Dika, 2002), and student responsibility (Daniels & Arapostathis, 2005; Eccles et al., 1993; Stipek, Givvin, & Salmon, 1998). While most motivational studies focus on surveys which identify independent aspects of different motivational beliefs (Patrick, Hisley, & Kempler, 2000), there is a need for insight on student and teacher perspectives related to motivation in science (Lan & Skoog, 2003; Pintrich & Shunk, 2002). Motivational research has generally focused on different approaches for improving student motivation involving cause and effect (Bergin, 1999; Hidi & Harackiewicz, 2000) rather than on integrated techniques requiring qualitative analysis. Ames (1992) indicated that motivation is too often associated with quantitative changes in student behavior. Instead, to gain a greater understanding of student motivation, qualitative research is needed to assess the interaction of different environmental and social factors (Linnenbrink & Pintrich, 2002; Wigfield, Eccles, & Rodriquez, 1998) because such variables are not easy to measure or quantify. Investigations into student motivation in science education from the student's perspective have been rare and the issue has received little attention among researchers (Lan & Skoog, 2003). Daniels and Arapostathis (2005) assert that while much literature on student motivation exists, very few studies interview students or emphasize their voices. In fact, a comprehensive body of research that represents the needs and voices of disengaged students does not exist (Daniels & Arapostathis, 2005). To learn more about student motivational problems, researchers suggest that a qualitative approach is needed in order to examine in detail what students and teachers actually say in classrooms and what they do (Pintrich, Smith, Garcia, & McKeachie, 1993). Qualitative studies can address these issues more effectively than research with a quantitative base because qualitative studies allow the researcher to more fully explore issues in context as they emerge from the data. Hidi and Harackiewicz (2000) assert that the only way to help academically unmotivated students is to consider the multidimensional nature of motivation. Qualitative research offers the opportunity for discovering many dimensions of student motivation, and also the chance to embark on an in-depth investigation into teacher and student perspectives on these factors affecting motivation in science.

The problem of motivating students in science is not a new challenge for teachers. In fact, low levels of student motivation and lack of engagement in academic pursuits has been an issue of continuing concern to teachers for decades (Singh et al., 2002; Theobald, 2006). An abundance of research indicates that motivation and confidence in academic achievement declines gradually as students enter the middle school years (Eccles & Midgley, 1989; Eccles et al., 1993; Murdock & Miller, 2003; Renchler, 1992). This decline has been specifically documented in the area of science (Hidi & Harackiewicz, 2000; Singh et al., 2002; Wigfield, Eccles, & Rodriguez, 1998). In fact, research among middle school students who were surveyed and interviewed revealed that most children anticipated high school science to be exciting, hands-on, and fun (Speering & Rennie, 1996). However, in reality, these students were somewhat disillusioned due to the fact that science lessons in high school often involve lecture, note-taking, and working from the textbook; all of which can result in student disengagement. As a result, high school students often see science as boring, difficult, and basically irrelevant to happenings in their everyday lives (Lunetta, 1998; Yerrick, 2000). Contributing to the situation is an educational system that has traditionally emphasized factual memorization and rote learning in science (Lunetta, 1998; Patrick & Yoon, 2004). A longstanding perception of learning as being profoundly boring has only exacerbated the problem (Renchler, 1992). Because textbooks rarely encourage interest among students (Strong, Silver, & Robinson, 1995), teachers must find ways to make learning more meaningful (Sagor, 2002). Although the literature clearly indicates that motivating adolescents is not an easy task (Evans, 2004; Theobald, 2006), if teachers do not pay attention to what motivates their pupils to learn, more students will fail both academically and socially.

As educators, our job is not only to help our students learn, but to encourage them to want to learn. Although a myriad of instructional strategies are available to educators, ultimately teachers must utilize approaches that fit their individual teaching styles. The result will produce a motivational learning environment in the classroom that will lead to both positive attitudes and increased student achievement (Druger, 2000).

Theoretical Perspective

Perceiving that individuals learn best by actively constructing knowledge derived from personal experience (Bruner, 1973; Guba & Lincoln; 1982; Stake, 1995), the researcher approached this study from a constructivist perspective. As a result, the participants were actively involved with the researcher as she worked with them to understand the data and to construct interpretations (Lincoln & Guba, 1985; Schwandt, 2001; Staver, 1998). Beyond attempting to discover facts about the situation at this school, the researcher depended on input from the participants through interviews and solicited their aid in clarifying ideas through member checking as recommended by Merriam (1998). A small number of cases were studied in depth so that a greater understanding of this particular situation might be obtained (Patrick & Yoon, 2004).

As a classroom science teacher, the researcher had firsthand knowledge concerning the challenge of motivating students. Staver (1998) indicates that in the field of science particularly, observations, objects, data, and events do not exist independent of the researcher. In fact, the constructivist view would be that data interpretations are inextricably related to both the researcher and the participants as they interact in shared experiences (Clements & Battista, 1990). Performing this study at the researcher's own high school not only provided numerous opportunities for social interaction, but also allowed for a more personal and professional view of the findings. For example, as colleagues of the researcher, all four participants were enthusiastic about the study, willing to share their knowledge, and hoped to improve their own motivational strategies. The positive attitude of the teachers, and the understanding that everyone was on the same team, resulted in open communication between the researcher and the participants.

Participants

Participants in this study were high school science teachers who were considered to be successful at motivating their students, and students who were members of each participating teacher's class. Because the researcher's goal was to study effective motivational teaching strategies, purposive sampling was used to select teachers who appeared to successfully engage their students. According to Merriam (1998), this sampling strategy enables the researcher to establish criteria for the participants that reflects the purpose of the study.

Teacher participants were initially recruited through informed consent letters delivered to their school mailboxes by the researcher. Eleven teachers who returned the consent letters made up the pool of potential participants. The criteria for selection of the actual four teacher participants from an eleven initial volunteers was based on their years of teaching experience, perceived high ability to motivate students, reputation for excellence in the classroom, insightful views on student motivation, variation in the courses they taught, and class schedule. Participant selection was influenced by teacher responses on an initial semi-structured interview exploring how teachers see themselves and their role as motivators of students, factors they feel affect student motivation, problems they encounter in motivating students, and strategies they feel are effective in engaging students. For example, one teacher chosen for the study indicated that her students had very low expectations of their ability to succeed in science. She stated that she used motivational strategies primarily to raise these expectations among her students. Another teacher stated that he had no problem motivating his students because science in itself is so much more interesting than any other subject. All of the teachers chosen for this study emphasized the importance identifying the individual learning styles of their students and of using a variety of motivational activities. Student participants from the participating teachers' classes were selected contingent on their return of an informed consent letter sent home and signed by their parent(s).

Research Methods

The research design was a qualitative case study of four high school science teachers in their natural teaching environment. Merriam (1998) indicates that such research is appropriate in cases of studying teachers at a specific school. Yin (2003) recommends a case study approach when research involves direct observations and interviews in which behaviors are not manipulated. Additionally, because the researcher had an intrinsic interest in the unique situation as a fellow teacher, Stake (1995) indicates that the case study method is appropriate.

The main sources of data from the teacher participants addressed research question one which states, “How do science teachers view the role of motivation in their philosophical approach?” and research question two which states, “What strategies do they use in the classroom that support their views on motivation?" The data included semi-structured interviews, classroom observations of practice, field notes detailing observations, debriefing conversations, and a focus group discussion. Following a constructivist approach, the researcher collaborated with the teacher participants throughout the data collection process to ensure that all interpretations were mutually constructed. The main sources of data from the students included survey responses and classroom observations. Direct observation was used to address the third research question which states, "How do students respond to these motivational strategies?" These observations followed the suggestions of Chapman (2003) who indicated that the researcher must note the extent to which students appear to be exerting mental effort in accomplishing tasks, the level of student interest and positive attitude toward learning, and the extent to which students participate and actively respond to questions. Additionally noted in observations were specific student actions falling into the categories of active academic responses, including participation in activities and appropriate talk, task management responses such as paying attention and raising hands to ask questions; and competing responses which included behavioral issues such as inappropriate student talk, non-compliance, and aggression (Greenwood, Carta, Kamps, & Delquadri, 1997). These behaviors are valuable indicators of student motivation due to the fact that they involve very little observer inference. However, because observations focus only on overt student action, they may not fully capture the essence of motivation (Pintrich & Schunk, 2002). A more comprehensive picture of student motivation was gained by incorporating student surveys, which were utilized to address the fourth research question which was, "How do science students view these strategies as influencing their own motivation?” Student surveys were examined by the researcher in an effort to identify outliers. Five surveys were discarded due to students who had created designs out of the responses, answered with one response for the entire survey, or who left a significant number of items blank.

Together, the various data sources were used to address teacher and student perceptions of motivation. Interviews and conversations gave a teacher’s perspective on effective motivational strategies, while direct observations provided information on what teachers actually did in the classroom. These observations also allowed the researcher to note student responses to specific teaching strategies. Finally, student surveys provided a view of overall student perception of motivation in science and effectiveness of teaching strategies. The use of multiple data sources is recommended by Merriam (1998), who suggests that the credibility of a study may be enhanced through the use of triangulation of the data in which the findings are confirmed by multiple methods, and the incorporation of member checking, in which the participants agree upon the credibility of the results. To attain trustworthiness, Guba and Lincoln (1982) recommend such specific strategies as repeated observations, peer debriefing, prolonged engagement, and member checks, all of which were used in this study

Data Analysis and Results

The data in this study were analyzed using the constant comparative method (Glaser & Strauss, 1967; Merriam, 1998; Strauss & Corbin, 1998) by which the data evolve gradually as they are examined repeatedly. Interactions with the participants such as debriefing conversations and member checking interviews were used to validate the findings (Merriam, 1998) and thick descriptions were used to convey the views of the participants to the readers (Stake, 1995). Data from the student participants were obtained from classroom observations of student behavior and survey responses on motivation. Interview and observational data were placed on matrices (Appendix F). Following the data collection, the four cases were compared for emergent themes using a constant comparative method (Creswell, 1998; Merriam, 1998). While several themes were found to be consistent across all four cases, other themes emerged strongly among individual teachers showing different perspectives (Appendix G). Commonalities among the four teachers included the use of questioning to engage students, presenting lessons enthusiastically, promoting a non-threatening classroom environment, using inquiry to increase student understanding, using a variety of activities in the classroom, expressing a belief that all students can achieve, and building caring relationships with students. The researcher then compared the data for a general science class and an AP class in a search for the most effective strategies used in these different types of classes. Two teacher cases were chosen because they varied significantly in practice in the motivation of students from different tracked classes. The AP teacher's motivational strategies focused on generating enthusiasm in the classroom, promoting an environment in which students are not afraid to participate, and connecting the adolescent world to science through the use of stories. The general science teacher encouraged her students to discuss concepts with each other, used practical applications to make her lessons relevant, focused on building her students' self-confidence, and made use of hands-on inquiry activities to supplement learning.

Organization of this Dissertation

The research questions for this study were: (1) How do science teachers view the role of motivation in their philosophical approach to teaching science? (2) What strategies do they use in the classroom that support their views on motivation? (3) How do students respond to these motivational strategies? and (4) How do science students view these strategies as influencing their own motivation?

This dissertation is comprised of a comprehensive literature review which relates to the topic of the research, followed by two articles, and a final chapter representing the findings from the study. The first article gives an overall view of the motivational philosophies and strategies used by the teachers in this school. As the data were analyzed, similarities among all four cases were revealed by cross-case analysis. These common motivational strategies related to questioning, enthusiasm, support, variety, rapport, and classroom environment were comparable to those found in the literature.

The second article focuses on significant differences which emerged between two of the four cases as some motivational strategies in the more advanced class were different from those in the general science class. The data were analyzed to reveal specific areas in which each teacher was particularly successful in motivating his or her students. The general science teacher used strategies such as supporting student self-confidence, student/student dialogue, practical applications of the lessons, and hands-on inquiry activities to help her students learn concepts. The AP teacher motivated his students through the use of stories to add relevance to lessons, enthusiastic presentations, and a non-threatening classroom atmosphere which promoted student participation.

CHAPTER TWO

MOTIVATION IN THE HIGH SCHOOL SCIENCE CLASSROOM

Lack of student motivation in the classroom has been an ongoing issue of concern to teachers for many years. In fact, former Secretary of Education, Terrell Bell, once remarked, “There are three things to remember about education. The first is motivation. The second is motivation. The third is motivation.” (Raffini, 1996, p. 9). Motivation has been defined as an internal process that arouses action, directs behavior, and results in a sustained effort over time (Howland, Laffey, & Espinosa, 1997; Wiseman & Hunt, 2001; Woolfork, 2001). Derived from the Latin word *movere,* which means “to move,” the concept of motivation inherently involves action. Motivation can be considered to be an innate part of the human personality which is exhibited through behavior (Skollingsberg, 2003). In the field of education, motivation also involves persistence, initiation, show of effort, confrontation of challenges, and questioning of issues outside the classroom on the part of students (Patrick, Hisley, & Kempler, 2000). In fact, the significance of motivation can be seen in virtually all areas of teaching and learning (Pintrich & Shunk, 2002). Motivation is of real interest to science educators because of its perceived relationship to conceptual change and cognitive engagement (Daniels & Arapostathis, 2005; Maehr & Meyer, 1997; Pintrich, Marx, & Broyle, 1993). In fact, Theobald (2006) indicates that the intricate task of stimulating a student’s desire to learn is one of the most significant challenges for educators in the 21^{st} century.

As policy makers push the educational community to produce standardized, measurable results of student achievement, teachers are feeling increased pressure to motivate their students to perform. In fact, increasing numbers of teachers have become frustrated with students who expect to excel academically yet who are not willing to work for that success (Daniels & Arapostathis, 2005; Mendler, 2000). Every day educators must deal with students who do not want to work or who do not seem to care. Ruggiero (1998) asserts that the indisposition to learn appears to be considerably more widespread in our communities than it was even a generation ago. Complicating the situation is a society that promotes exposure to commercial media which has conditioned students to gravitate solely to action-packed environments. It is no wonder that today's teenagers have difficulty in concentrating on individual learning tasks. After all, the television media has exposed them to more than 800 attention shifts in a typical hour of programming (Ruggiero, 1998). Such conditioning has presented a new challenge for educators as they strive to motivate students who are accustomed to fast-moving, constantly changing images and settings. As the phenomenon of student disengagement becomes even more prevalent, increasing numbers of researchers are studying the problem of motivating reluctant learners (Brophy, 2004; Daniels & Arapostathis, 2005).

Motivation in Science

Student motivation in science is of particular interest to researchers because of its relationship to student attitude, cognitive engagement, and academic achievement (Evans, 2004; Pintrich, Marx, & Broyle, 1993; Singh, Granville, & Dika, 2002). Early research on student learning separated motivational and cognitive factors. Motivation certainly drives the development and emergence of metacognitive skills, which subsequently activates thinking and learning ability (Wiseman & Hunt, 2001). However, since the 1980's, the research has shifted its focus to the relationship between cognitive and motivational factors and how together they impact student learning and achievement (Linnenbrink & Pintrich, 2002). Much literature exists supporting the relationship between student motivation and academic achievement (Eccles et al., 1993; Martin, 2002; Murdock & Miller, 2003). Researchers also presume that motivation is a function of student expectation for success in addition to the inherent value that students assign to learning (Wigfield & Eccles, 1992). Specifically, student motivation is a tool used by researchers to clarify the degree to which pupils show effort and interest in their pursuits, regardless of whether these tasks are desired by the teacher (Brophy, 2004).

Because research indicates that academic motivation declines gradually as students enter the middle school years (Hidi & Harackiewicz, 2000; Singh et al., 2002), secondary educators in particular must discover pedagogies to address the situation. Upon entering the middle and high school years, the emphasis on learning in science shifts from a focus on participation to a focus on performance. Such a transition is difficult for many students. When adolescents perceive that they do not possess the skills needed to meet such challenges, they are less likely to even attempt tasks (Csikszentmihalyi, 1990). Furthermore, as students enter high school, they typically view science as dull and tedious (Lunetta, 1998). So it becomes the duty of high school educators to meet the challenge of engaging these students. Teachers are not powerless to impact motivation among their students. According to Raffini (1996), "Although we cannot force horses to drink, we can increase the probability of their taking a drink if we feed them a pail of salt before leading them to the drinking trough." (p. 9).

Although science influences many areas of everyday life, the subject is especially relevant to such adolescent interests as personal health, recreational activities, and career choice. Research has shown that when teachers consider the interests of students, motivation in the classroom increases and students become more scientifically literate (Linnenbrink & Pintrich, 2002; Sanfeliz & Stalzer, 2003; Vavilis & Vavilis, 2004). Both students and teachers can offer valuable insights into suggestions for changes in the classroom that will increase motivation among students and sustain their interest. Given a choice, students generally want to enjoy their science classes, and many students have a desire to learn. However, today's teachers must compete with numerous influences in the technological and social realms that never existed in previous generations. Therefore, new ideas and strategies for motivation must be identified and implemented.

In relation to student learning, motivation is not only correlated with academic performance (Alexander & Murphy, 1998; Legault et al., 2006; Schiefele & Krapp, 1996; Skaalvik & Rankin, 1995), but it has also been linked to mastery understanding, high achievement, and personal responsibility (Ames, 1992; Daniels & Arapostathis, 2005; Stipek, Givvin, & Salmon, 1998). In fact, research has shown a possible reciprocal effect between motivation and academic engagement as each quality enhances the other and learning is furthered (Singh et al., 2002). Although all students are not alike, they have in common a degree of motivation to learn. However, this characteristic is exhibited at varying times, in different degrees, and in various contexts (Renchler, 1992; Theobald, 2006). The importance of student motivation, Renchler (1992) suggests, means that all educators are obligated to support students in the acquisition of self-motivation because it leads to a perpetual desire for knowledge.

The expectation of a positive experience in secondary science has been shown to determine the attitude and motivation toward the act of learning (Singh et al., 2002). Despite the fact that frustrated educators may want to give up because teachers cannot make students want to learn, Rinne (1998) reports that it is not the student's responsibility to be motivated. Rather, teachers must alter practices and make changes in the science classroom to meet the special challenge presented by unmotivated students. Ideally, the learning and teaching environment of such a classroom is characterized by fulfillment, enjoyment, engagement, and ownership in learning, along with an atmosphere of mutual respect between students and teachers (Clark, 2003; Goodrum, Hackling, & Rennie, 2001). Such a positive atmosphere obligates teachers to engage students in learning science. The process of engagement has the potential to excite pupils and fill them with the wonder and amazement of scientific investigation (Evans, 2004). The science laboratory itself is a unique educational setting which can be used as a tool to enhance manipulative skills in the pursuit of increased student motivation (Debacker & Nelson, 2000; Hofstein & Walberg, 1995).

The importance of motivating students in science can also be seen on the global level. Research indicates that there is a disturbing decline in the number of U.S. students who are majoring in a scientific area while the number of jobs requiring science is continuing to grow (Musella, 2004). Evidently, our high schools and colleges are not graduating sufficient numbers of students who desire to enter scientific fields (Field, 2004). Research shows that this situation is especially true among minority students

(Manning, 1998; National Science Foundation, 1994; Weld, 1999). Additionally, the demand for engineers and scientists is growing at a rate five times faster than the need for other types of labor (Field, 2004). To address this problem, educators must search for ways to increase student participation in the sciences, particularly at the senior high school level. Motivation is believed to be a vital part of developing a lifelong interest in scientific learning and for supporting students of all ethnic backgrounds who decide to pursue science beyond high school (National Research Council, 2000). In order to compete scientifically on a global level, more students must be encouraged to pursue careers in science. In fact, the importance of producing scientists cannot be overemphasized in our country. Since the inception of the Homeland Security Department in the wake of September 11th, the training of United States citizens to become scientists has gained a new significance as scientific research plays an increasingly integral role in the protection of our citizens. The shortage of Americans entering areas of scientific research poses a critical problem that must be addressed (Hart-Rudman Report, 2002). Resolving this situation can start in the high school science classroom, where teachers work to motivate future scientists.

The significance of student motivation cannot be overemphasized. Researchers believe that motivation is absolutely essential to the educational process (Skollingsberg, 2003) because it gives teachers the ability to maximize learning. When learning is increased, not only is misbehavior among students minimized (Wiseman & Hunt, 2001), but the overall learning environment in the classroom is greatly improved. Furthermore, research shows that increased motivation leads to improvement in cognitive and behavioral engagement while ultimately resulting in conceptual understanding (Patrick &

Yoon, 2004). In the area of science, motivation is recognized as a necessity for the support of a lifelong interest in learning (National Research Council, 2000).

Types of Motivation

Intrinsic Motivation

The acquisition of knowledge can sometimes be initiated from inside the student. When students consider a learning task to be inherently worthwhile and enjoyable, they become motivated from within. Such initiative is referred to as *intrinsic motivation*. Researchers define intrinsic motivation as the desire to be involved in an activity purely for its own sake (Deci & Ryan, 1991; Wiseman & Hunt, 2001). At the core of intrinsic motivation lies the desire to seek and conquer academic challenges (Raffini, 1996). Many psychologists feel that human beings are motivated from within to master challenges. For example, small children master the art of escaping from their cribs, they learn how to open doors, and they succeed in learning how to tie their shoes. One never hears parents complain that their preschooler is "unmotivated" to learn (Raffini, 1996). Unfortunately, that abundance of intrinsic motivation seems to greatly decrease or at the least become hidden as many students reach adolescence. Because it is contextual by nature, intrinsic motivation changes often with the modification of views over time and changing circumstances (Linnenbrink & Pintrich, 2002); yet it is also considered to be durable and self-enhancing (Kohn, 1993; Strong, Silver, & Robinson, 1995). The literature shows that students who are intrinsically motivated persist when facing failure, take on challenging tasks, exhibit creativity, and remain engaged in cognitive tasks for a greater period of time than students who are motivated by extrinsic rewards (Ormond, 1995). Experts agree that rewards which are intrinsic in nature are generally successful reinforcers of learning because they have the innate ability to teach on their own (Chance, 1992). Intrinsic learning is especially appealing because it has the potential of translating into such desirable behaviors as exerting effort, choosing challenging tasks, and exhibiting persistence (Ferrer-Caja & Weiss, 2000). Research also shows that students are intrinsically motivated to observe and learn when what they are experiencing assists them in solving life's problems (Swanson, 1995).

Extrinsic Motivation

Another type of motivation exhibited by students in the classroom is referred to as *extrinsic motivation*. Researchers define extrinsic motivation as the desire to be involved in an activity only to finish the assignment (Pintrich & Shunk, 2002; Wiseman & Hunt, 2001) which is external to the student or to the task (Strong et al., 1995). Some researchers go so far as to refer to extrinsic motivation as coercion or bribery with no permanent results (Kohn, 1993). However, research indicates that for certain students, extrinsic tools are necessary to initiate engagement with the hope that the strategy will eventually result in motivation that is more intrinsic in nature (Theobald, 2006). Literature also suggests, that although extrinsic motivation can be effective in some situations, reliance solely on external factors to produce lasting commitment to a task has proven to be counterproductive (Daniels & Arapostathis, 2005; Kohn, 1993). In fact, extrinsic motivation has traditionally been perceived as the "bad boy" of motivational theories (Strong et al., 1995). Motivation with extrinsic rewards has been shown to actually undermine the intrinsic motivation of students (Kohn, 1993). Certainly the use of rewards can control some student behaviors, but indiscriminate use of extrinsic motivators can seriously undermine intrinsic motivation for the very behaviors and activities being controlled (Raffini, 1996). Still, because many teachers become frustrated by their inability to control student behavior, they resort to bribery and rely on it as a primary motivational strategy (Raffini, 1996).

Although students can learn for reasons that are intrinsic or extrinsic by nature, research indicates that learning intrinsically is not only more enjoyable, but is also positively correlated to achievement, learning, and perceptions of self-competence. Additionally, intrinsic motivation is negatively correlated to student anxiety (Pintrich & Shunk, 2002). Research performed by Pintrich and Shunk (2002) also provides evidence that intrinsic motivation can promote achievement and learning more effectively than motivation of an extrinsic nature. Ultimately, researchers believe that student motivation results not from extrinsic or intrinsic factors exclusively, but instead from a combination of the two types (Sansone & Harackiewicz, 2000; Skollingsburg, 2003).

Factors Affecting Motivation in Science

Studies have identified several factors affecting motivation in the science classroom. Such factors include home life, parental influence, and peer pressure (Martin, 2002; Singh et al., 2002). None of these situations can be easily changed by the teacher. However, other factors are under the teacher's control. For example, classroom atmosphere, school environment, teaching style, and relevance of the subject matter are all areas in which educators can actively influence student motivation (Ames, 1992; Evans, 2004; Swanson, 1995) Research by Paris and Turner (1994) suggests that teachers utilize project-based inquiry exercises, current technology, and authentic assessment in the improvement of motivation in the classroom. When teachers incorporate life experiences, hobbies, and other student interests into the lesson, motivation is improved significantly (Parsons, 2000).

The importance of effective instruction is evidenced by the fact that teachers prevent many problems from occurring in their classrooms through the effective use of motivational and managerial techniques that are regularly incorporated into their instruction (Wiseman & Hunt, 2001). Research has shown that people do not learn science by absorbing facts that are poured into their brains (Bremer, 1973; Schwandt, 2001). Rather, students construct meaning out of varied experiences provided by the teacher (Raloff, 1996). This constructivist view supports the fact that in recent years, educational reform has produced a variety of motivational strategies – both old and new – that teachers are encouraged to implement in their classrooms. Such strategies include the use of scientific inquiry, by which students gain the ability to design, conduct, and ultimately understand scientific investigations (National Research Council, 2000). Classroom discussion is an effective motivational tool because it requires students to actively participate (Theobald, 2006). Raffini (1996) indicates that making lessons personal and relevant is an effective motivational strategy because students are highly receptive when they can relate the subject directly to their own experiences. Additional approaches include an enthusiastic presentation that communicates excitement to the students (Murdock & Miller, 2003; Theobald, 2006), building rapport with students to demonstrate teacher caring (Coleman, 2001), and creating a positive learning environment to support student learning (Theobald, 2006). These areas overlap and encompass a vast array of educational constructs.

Variety of Strategies in Science

Wiseman and Hunt (2001) define instructional variety in the classroom as the teacher's "diversity of information-sending techniques or strategies used during the presentation of lessons" (p. 96). Teachers do not want their students to enter the classroom with a feeling of boredom, knowing exactly how the class will proceed every day. Instead, variety of presentation by the teacher results in student excitement and expectancy as the day begins and throughout the lesson (Druger, 2000; Sagor, 2002). Additionally, research indicates that students learn in different ways and it is a primary job of the teacher to address these differences during classroom instruction (Theobald, 2006). Teachers who strive to match instructional strategies to varying student learning styles have more interested students and an increase in student learning overall (Wiseman & Hunt, 2001). Although not all students arrive in the science classroom with the same level of motivation or with the same readiness to meet academic challenges, research suggests that these students can benefit from strategies that will aid them in becoming more engaged in the learning process (Daniels & Arapostathis, 2005). It is imperative that teachers recognize the fact that their students represent a vast array of individual interests and abilities. Coleman (2001) asserts that exemplary educators are driven by a need to see all of their students succeed. Clearly it is not easy in practice to respond to every student's individual motivational needs. However, much progress can be made if teachers use an assortment of different instructional strategies instead of limiting their practices to one or two (Hofstein & Walberg, 1995; Theobald, 2006). Not only does varying the presentation methods reduce boredom and invigorate the classroom atmosphere, but multiple strategies also meet the various levels of cognition and learning styles present in students (Linnenbrink & Pintrich, 2002; Theobald, 2006).

Literature supports the fact that higher levels of student engagement and fewer instances of classroom management problems are evident when educators utilize several different effective teaching strategies (Wiseman & Hunt, 2001). Research shows that strategies used by educators are vital components of the motivational learning environment (Druger, 2000). Wiseman and Hunt (2001) assert that teachers who are skilled at incorporating a number of different types of strategies into their lessons are more effective than those teachers who are limited to only a few instructional approaches. The skillful use of varying instructional strategies requires flexibility on the part of educators. In fact, teachers who know and appreciate the impact of motivation on learning will spend much time and energy to create a positive environment in the classroom to promote the development of attitudes, perceptions, and feelings all in the support of student motivation (McCombs & Whisler, 1997). Although teachers cannot force reluctant students to become motivated to learn, they can pay close attention to what their students like and dislike and work to utilize strategies that address those needs. The teacher who uses varying instructional approaches creates increased student interest, piques student curiosity to learn, and creates unique stimuli in the classroom, all of which increase the cognitive ability of students (Theobald, 2006; Wiseman & Hunt, 2001).

Scientific Inquiry

Early science education consisted mainly of daily recitations from lectures and books. Use of the laboratory for educating students was unheard of before the mid 1800's. However, in the late 1800's, this sentiment changed, primarily due to the fact that observation and manipulation were thought to be beneficial for "disciplining" the mind (Lawson, 1995). In the early 1900's, John Dewey (1916) addressed the National Education Association with the argument that "science is primarily the method of intelligence at work in observation, in inquiry, and in experimental testing" (p. 75). Still, although the old methods of rote memorization were criticized, it was more than forty years before this practice was lessened in large-scale curriculum movements. In the early 1960's, the National Science Foundation developed inquiry-based curriculum projects such as the Biological Sciences Curriculum Study, the Chemical Education Material Study, the Science Curriculum Improvement Study, and the Physical Science Study Committee (Lawson, 1995). In the 1990's, the National Research Council (1996) developed a vision for making scientific literacy a reality for all students in the next century. A new definition of inquiry was established.

> Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (p. 23).

Although these projects produced excellent inquiry-based activities, they did not generate a systematic method of instruction. Because changes in science education have been slow to evolve, traditional teaching—lecture, notes, worksheets, and testing—has been the prevalent mode of instruction in our classrooms for the past few decades.

Unfortunately, the vast majority of students often view science as something that is stagnant—a myriad of boring facts that scientists know and students are required to learn (Heflich, Dixon, & Davis, 2001). In reality, science is dynamic in nature, but students do not often experience it in such a way. Educational research consistently supports the value of scientific inquiry as a motivational tool. For example, science courses that incorporate student-centered inquiry techniques have proven to be extremely effective in efforts to improve not only content learning, but also science processes, creativity, logic, and attitudes toward learning science (Caton, Brewer, & Brown, 2000; Singh et al., 2002). Additionally, research has shown that increased use of open-ended inquiry activities results in improved student behavior which translates into a more positive learning environment (Caton et al., 2000).

Teachers seeking to implement scientific inquiry must develop and use clear and purposeful motivational strategies for deciding which questions to ask, when to ask them, and in what order (Penick, Crow, & Bonnstetter, 1996). Such questioning stimulates the mind to "think outside of the box." One researcher, upon observing his own kids in school, was disappointed to note the obvious boredom of students who were merely memorizing the parts of a cell. He would much prefer to see teachers encourage his kids to investigate structures developed by cells to carry out specific functions (Raloff, 1996).

Science itself is always in a state of change. Likewise, science education is an ever-changing experiment. Research shows that in allowing students to control the directions of their investigations, they not only discover important scientific concepts but also have fun (Raloff, 1996). When teachers create a learning environment in which instruction is dictated by the needs of the students rather than curriculum learning objectives, the students ultimately benefit (Coleman, 2001). Such implementation of inquiry activities that relate to life outside the classroom is a definite motivator.

The unpredictability of science is part of its attraction. As students work to confirm their hypotheses, the direction of the inquiry lesson is rarely predictable (Cherif, 1993). This innate uncertainty is attractive to students because they have a natural curiosity. When we fail to convey to students what science truly is, we dampen their natural curiosity and stifle their motivation (Genoni, 1995). According to Budiansky (1997), the endless wonder of science is that the more we know, the more we know there is to know. Scientific inquiry always involves a response to wondering and exploring as it piques student interest. If teachers can tap into the natural curiosity of students by way of scientific inquiry, research indicates that students will not only be more motivated to learn, but they will also gain the skills needed to harness knowledge for solving personal and societal problems (American Association for the Advancement of Science, 1993). The cornerstone of virtually every recommended science reform program in education encompasses inquiry-rich investigations for students spanning elementary grades all the way through graduate school. After all, inquiry-based experiences, peer interaction, and participation in group discussion is the only way to reach beyond the scientific facts and into the real world of science (Genoni, 1995).

Classroom Discussion

Dialogue is also an important component of the successful science classroom. In fact, the National Board for Professional Teaching Standards in 2000 considered classroom discussion important enough to be included as one of six standards required for mastery in certification. Teachers routinely use class discussions to gauge students' emerging knowledge (Beghetto, 2004). When teachers encourage students to engage in meaningful discussion, the possibilities for increasing motivation to learn are greatly enhanced as students have the opportunity to appreciate, justify, and perhaps even defend the concepts they are learning (Vavilis & Vavilis, 2004). The value of the democratic process of learning is experienced in classes where students are encouraged to exchange ideas in open discussion (Vavilis & Vavilis, 2004). When teachers show that they value the opinions of their students and that these views will not be judged, students will be more likely to participate in classroom discussions (Theobald, 2006). Furthermore, when educators are successful in community-building in the classroom, student motivation is greatly enhanced as meaningful learning emerges. Because students can spend an inordinate amount of time interacting with their peers, teachers often take advantage of the motivational impact of these relationships by allowing student discourse in the classroom. Vygotsky (1978) emphasized the fundamental role of social interaction in the development of cognition as he focused on the connections between students and their shared experiences. In fact, social cognitive theory emphasizes the impact of these interactions on student motivation (Pintrich & Shunk, 2002). Teachers who put an emphasis on the social and personal development of their students are vital in fostering engagement and motivation to learn (McCombs & Whisler, 1997).

Teacher Enthusiasm

A significant body of research shows that one of the most important influences on student motivation in high school science is teacher enthusiasm exhibited for the subject matter during instruction (Clark, 2003; Coleman, 2001; Goodenow, 1993; Meyer & Turner, 2002). In fact, students' intrinsic motivation to learn has been shown to be positively correlated with the teacher presenting lessons in an energetic, dynamic, and enthusiastic manner (Patrick et al., 2000). To some degree, teacher enthusiasm makes learning more enjoyable while also giving students the impression that mastering concepts is achievable (Coleman, 2001). Perhaps this factor, above all others, is under the greatest control of the classroom teacher. Enthusiasm exhibited by teachers can have a direct impact upon student motivation not only in science, but in all subject areas.

Students are continually observing their teachers. Student comments concerning teachers' looks, dress, and mannerisms can be overheard in the halls of any high school. Thus, a teacher who exhibits enthusiasm about the subject matter provides students with a motivational model (Patrick et al., 2000). Literature reveals that enthusiasm is conveyed to the students when teachers project excitement about the learning process (Theobald, 2006). Wiseman and Hunt (2001) describe teacher enthusiasm as an "estimation of the amount of vigor and power shown by the teacher" (p. 203). This excitement is associated with energy, involvement, and interest in the subject matter. In the face of such enthusiasm, students are more likely to become excited and thus, motivated to learn as they see that their teachers are enjoying their work and are excited about teaching in the classroom (Wiseman & Hunt, 2001). In fact, research indicates that enthusiasm may serve as a catalyst to spark the fire of curiosity and interest in students (Patrick et al., 2000). When teachers exhibit this kind of enthusiasm, they communicate confidence in their own abilities and in the abilities of their students to learn (Wiseman & Hunt, 2001).

Building Student Rapport

Developing relationships with students is an important aspect of effective teaching. Research indicates that there are numerous motivational benefits in the promotion of a positive teacher-student relationship (Patrick, et al., 2000). A caring attitude on the part of a teacher goes a long way in developing this association and in supporting the self-confidence of students. In an effort to build relationships with students, teachers should support, encourage, and show interest in their students as people (McCombs & Whisler, 1997; Theobald, 2006). Brophy (2004) suggests that teachers should not only get to know students, but to enjoy them. Research indicates that the more effectively educators can connect with their students, the greater will be their impact on motivation and learning (Coleman, 2001). Additionally, research supports the student-teacher relationship as a significant influence on the level of student motivation and the amount of effort students are willing to put forth (Daniels & Arapostathis, 2005). Teachers have a unique role in communicating high expectations to their students. When such a practice is in place, students receive numerous motivational clues that say, "You can do this!" In fact, the support and encouragement of teachers makes the journey to success more bearable for students. When students feel that the teacher is on their team rather than an opponent, they also believe that the teacher's ultimate goal for them is success (Daniels & Arapostathis, 2005). Effective educators have a distinct advantage in their ability to motivate because most students have no wish to disappoint teachers they feel genuinely care about them (Coleman, 2001; Debacker & Nelson, 2000).

Student rapport can be enhanced when teachers take a genuine interest in the lives of their students. Recognizing students individually can translate into a greater understanding of their interests and background (Theobald, 2006). A seemingly minor act such as greeting students by name at the classroom door communicates interest. Teacher attendance at sporting competitions, awards ceremonies, local community events, and other extracurricular activities communicates the importance of students' interests outside of the classroom. Taking time to build relationships with students initiates dialogue, which sends a message of caring. Noddings (1995) indicates that much can be gained by incorporating themes of caring into the school curriculum. Literature supports the importance of building school communities in which students trust in authority figures (Daniels & Arapostathis, 2005). When teachers spend time building relationships of trust, they are in a unique position to become special people in the lives of their students (Noddings, 1995).

Making Lessons Relevant

Interaction with students outside the classroom provides teachers with the opportunity to discover current trends among adolescent culture. Although many lessons hold great educational value for the future of our kids, the challenge is to relate topics to their present lives. Motivational teachers create curiosity in the science classroom by relating the lesson to students' personal lives (Daniels & Arapostathis, 2005; Sagor, 2002; Strong, Silver, & Robinson, 1995). Research shows that even reluctant learners will become engaged in activities if they see a value in the lesson (Daniels & Arapostathis, 2005; Smith & Wilhelm, 2002). Students are turned off by being told that the information will be useful to them "someday" (Theobald, 2006). Within the classroom, when teachers make their lessons relevant to the present "real world" of adolescents, they will see more engaged students (McCombs & Whisler, 1997). Teachers must ask themselves, "With what issues are adolescents wrestling? How can we connect them to our curriculum?" (Smith & Wilhelm, 2002; Strong et al., 1995). Research indicates that when students can connect instructional material to something they understand or have experienced, they will be more likely to show interest in the lesson (McPhail, Pierson, Freeman, Goodman, & Ayappa, 2000; Theobald, 2006).

The advent of the Science/Technology/Society (STS) movement has provided a focus on teaching and learning science in the context of both technology and human experiences (Yager & Lutz, 1995). The STS program utilizes current issues in society and in the lives of students as a basic foundation of learning. Over forty years ago, technology was eliminated from the science curricula in most schools. The STS initiative seeks to incorporate current technology back into the science classroom, thus making instruction more relevant to the everyday lives of students. Extensive research supports the benefits of STS instruction as it emphasizes thinking, problem-solving, and decision-making based on evidence and reasoning as tools used in the pursuit of scientific literacy (National Science Teachers Association, 1990; National Research Council, 1999; Yager, 2000). Additionally, students who learn through the STS program have increased motivation to learn, better attitudes toward science, and a more positive view of careers in science (Weld, 1999).

The Learning Environment

According to literature, student motivation can vary depending on classroom contextual factors that may change daily such as the demeanor of the teacher, the subject matter, particular teaching strategies, and the physical environment of the classroom (Linnenbrink & Pintrich, 2002). For teachers, the fact that student motivation can be influenced by factors external to the students provides valuable opportunities to create a highly motivational learning climate. Such a learning environment can communicate a sense of interest to students. In 1993, the coach of the Dallas Cowboys was asked how he had turned a losing team into Super Bowl champions. He replied, “Treat them as winners, and they will win.” The same concept applies to the classroom. A positive learning environment conveys to students the message that they can succeed. This can be achieved by making supportive comments, having a positive attitude, and even devoting attention to the physical surroundings of the classroom. For example, bulletin boards displaying newspaper articles of student accomplishments tell everyone that the teacher has made an extra effort to emphasize student achievements. Posting announcements about school and community events which showcase student skills and talents communicates a sense of interest by the teacher (Theobald, 2006). Motivational posters send constant messages of support to students who see them every day. In other words, teachers should create an inviting physical atmosphere in their classrooms (Brophy, 2004). Such a non-threatening learning climate in which students believe they can succeed and are not afraid to take academic risks supports increased motivation (Coleman, 2001; Debacker & Nelson, 2000).

Educators can have a powerful impact on the motivation of their students simply by arranging conditions in their classrooms in ways that support students' needs for enjoyment of learning. The desire for "fun" is a basic need of all human beings (Raffini, 1996). When teachers create lively classroom atmospheres with student dialogue and a sense of community, there is an unspoken realization that students have a duty to support each other in achieving academic success (Coleman, 2001; Sagor, 2002). Brophy (2004) suggests that teachers should deliberately make their classrooms "learning communities" by which students learn via collaboration with the teacher and with their classmates. Ruggiero (1998) explains that teachers should strive to create classrooms in which student discussion is emphasized in questioning, problem-solving, issue analysis, data evaluation, and finding conclusions. Such an environment is conducive to student motivation and presumably greater academic success.

Assessing Student Motivation

In recent years there has been a gradual shift in research from traditional achievement-related motivation theories to social models of cognitive-related motivation (Pintrich & Schunk, 2002). A major premise of social cognitive theory is that motivation is multifaceted and dynamic. This assumption is in contrast to the traditional quantitative view of previous models of achievement motivation (Linnenbrink & Pintrich, 2002). Many quantitative assessment devices are available for use by researchers. These instruments include the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1993) and the Learning and Study Strategies Inventory (LASSI) (Weinstein, Palmer, & Schulte, 1987). However, such measurements may not be completely accurate. Traditional quantitative assessment often inhibits students' motivation for learning because testing situations that are evaluative, comparative, and not genuine can elicit inaccurate and counterproductive motivation and learning from students (Paris & Turner, 1994). According to current theory, student motivation cannot be easily quantified as "motivated" or "not motivated" because students can be motivated in multiple ways. In fact, Linnenbrink & Pintrich (2002) assert that assessment instruments producing a single "motivation" score for students are quite possibly misleading due to the fact that such evaluations do not take into account the multifaceted nature of student motivation. This view of student engagement supports qualitative measures of assessment including classroom observations, interviews, and self-measures.

Due to the fact that motivation is difficult to measure in a quantitative manner, researchers may use indices that infer the presence of motivation among students. Pintrich and Schrunk (2002) cite four indicators of motivation: choice of tasks, effort, persistence, and achievement. For example, students who freely choose to undertake a task can be considered motivated to perform that task. Effort exerted to perform a difficult assignment is also indicative of student engagement. Additionally, when students work for an extended period of time, even when facing obstacles, motivation is present. Finally, the combined indices of task choice, effort, and persistence can give the researcher insight into student motivation; however, studied individually, they are not necessarily accurate depictions.

Assessing motivation may be accomplished in several ways. Pintrich and Schunk (2002) suggest three major methods for assessing student motivation including direct observations, ratings by others, and self-reports. However, the most accurate depiction of student motivation is obtained by utilizing several different methods, and then using the process of triangulation to validate the results because, as with all assessment, a single method is generally insufficient (Beghetto, 2004).

All educators routinely make observations of student behavior in their own classrooms. Generally, teachers are looking for behavioral clues that indicate the level of student engagement. When performed judiciously, classroom observations of student persistence, effort, and avoidance behavior can provide valuable insight to the teacher (Beghetto, 2004). In fact, Chapman (2003) indicates that direct observations are a valuable tool for noting student engagement in learning. Direct student observations of motivation refer to situations in which tasks are chosen, effort is expended, and persistence is exhibited (Pintrich & Schunk, 2002). Specific examples of motivational behaviors include students asking for assistance, taking risks by asking questions, demonstrating creativity, exhibiting a positive attitude, and expressing an interest in learning (Beghetto, 2004). Ideally, direct observation of student motivation should include criteria in the cognitive, behavioral, and affective realms (Chapman, 2003; Pintrich & Schrauben, 1992). To accomplish this task, the researcher must note the extent to which students appear to be exerting mental effort in accomplishing tasks, the level of student interest and positive attitude toward learning, and the extent to which students willingly participate and actively respond to questions (Chapman, 2003). Other researchers approach student observation by dividing observational data into active academic responses including participation in activities and appropriate talk, task management responses such as paying attention and raising hands to ask questions, and competing responses which include behavioral issues such as inappropriate student talk, non-compliance, and aggression (Greenwood, Carta, Kamps, & Delquadri, 1997). These behaviors are valuable indicators of student motivation due to the fact that they involve very little observer inference. However, because observations focus only on overt student action, they may not fully capture the essence of motivation (Pintrich & Schunk, 2002). Still, having an awareness of specific motivational behaviors and focusing on these, teachers can integrate the assessment of student motivation into observational practices currently used in their classrooms (Beghetto, 2004).

Another method of assessing student engagement is the use of summative rating scales to gauge levels of student motivation. One example of a rating instrument for student motivation is a scale found in a study conducted by Skinner, Wellborn, & Connell (1990) which focuses on students' perceptions of engagement and control of academic tasks. The instrument asks teachers to rate their students on willingness to participate in activities and their emotional responses to these assignments. Included in the scale are items rating effort, attention, persistence, interest, and anxiety. Assessments such as this are advantageous in that teachers may be more objective about students than students are about themselves as expressed in self-reports (Pintrich & Schunk, 2002). Additionally, such ratings attempt to identify motivational processes that influence behaviors, providing data not easily obtained through direct observations. However, ratings by teachers may be limited by the selective and constructive aspects of memory, which can result in invalid indicators of student motivational characteristics.

Self-report measures are commonly utilized by researchers to measure the cognitive, behavioral, and affective aspects of student motivation (Chapman, 2003). Self-reporting as an assessment of student motivation has the ability to capture people's statements and judgments about themselves (Pintrich & Schunk, 2002). One advantage to self-report measures is that they have the ability to indicate not only to what degree students are engaged in learning, but also why this is the situation.

There are many types of self-report measures including dialogues, interviews, and questionnaires. Dialogues are simply conversations that are held between two or more people. Generally, the dialogue is recorded and the researcher analyzes the transcript for motivational statements. An advantage of dialogues is that they involve actual interactions between the researcher and the subject; however the data interpretation can be quite time consuming and not always accurate. An interview is actually a type of questionnaire in which the researcher presents questions and the participant responds orally. The interview technique involves dialogue between the researcher and the participant. Questionnaires present participants with open ended questions or Likert type items that ask people about their beliefs and actions. Examples of commonly used questionnaires that measure student motivation include the Skinner et al. (1990) instrument associated with perceived control, and the MSLQ utilized by Pintrich et al. (1993) which measures students' motivational beliefs and their view of learning strategies (Pintrich & Schunk, 2002).

Although the methods for assessing student motivation are varied, there is no one best type of measurement that fits all classroom situations. Pintrich and Schunk (2002) recommend the use of interviews when researchers are interested in exploring beliefs and feelings in depth. For covering a large amount of material efficiently in a short time frame, questionnaires are the instrument of choice. Dialogue offers opportunities to investigate unique interaction patterns between subjects. Ultimately, the choice of assessment technique must necessarily depend on the researcher's aims, the purpose of the study, and the research design.

Student Motivation and Tracking

Public education in the United States exists to serve all students. Efforts have been made over the years to provide equal academic and motivational opportunities for every student; however, some students invariably slip through the cracks and are missed.

Certainly the practice of tracking in our schools supports this view. Tracking refers to the division of students into various kinds of classes or sequences of courses based on their proficiency or achievement as measured by previous course grades or standardized test scores (Haury & Milbourne, 1999; Oakes, 2005). Historically, tracking began when high school students were placed in general, academic, or vocational tracks, preparing them for college or trade work based on demonstrated skills and academic motivation (Hallinan, 2004). However, in recent years, such obvious labeling of students into specific tracks has largely been replaced by the more subtle practice of placing students into tracks of classes within individual subject areas (Lucas & Good, 2001; Oakes, 2005; Yonezawa & Jones, 2006). In response to concern that the United States was in danger of losing its competitive academic edge, a more rigorous curriculum was made available to all students as states began mandating tougher minimum graduation requirements in core subject areas. Now, students are tracked primarily by ability within core subjects and placed into basic, regular, or advanced courses dependant upon their performance in previous classes, scores on standardized tests, or teacher recommendations. Although tracking is sometimes an intentional practice, such as when students are assigned to classrooms composed of individuals assumed to have similar abilities and interests, it also occurs naturally as academically motivated high-achieving students gravitate to Advanced Placement classes for which the lower achieving students may not be academically prepared.

Many educators support the modern version of ability-based tracking because of the ease with which teachers can tailor instruction to the ability level of the entire class (Hallinan, 2004; Oakes, 2005; Welner & Burris, 2006).). Historically, teachers have indicated a preference for teaching in the higher ability track (Ball, 1981; Finley, 1984) most likely because students in general classes tend to exhibit negative behavior, poor attitudes, and less motivation to learn which makes them more challenging to teach in the classroom (Finley, 1984; Taylor, 1993). Additionally, teachers in heterogeneous classes often feel that they must teach to the “middle” students, a practice that may require the omission of some parts of the curriculum as teachers strive to instruct different levels of students within a class period (Hallinan, 2004).

Parents of the higher performing students support tracking not only because they feel that it benefits their high achieving children, but they also fear that less motivated students will disrupt the learning environment and expose their children to the negative influence of low-achieving peers who may be involved with alcohol or drugs (Heubert & Hauser, 1999; Welner & Burris, 2006). Additionally, parents fear that heterogeneous grouping of students will result in lowered learning standards and a watered-down curriculum (Burris & Welner, 2005). Thus, detracking may be viewed as taking away from some children while giving to others (Welner & Burris, 2006).

Research shows that students assigned to general classes fare poorer academically than those same students who are placed in mixed or advanced level classes (Hallinan, 2004; Oakes, 2005). Critics of tracking cite that although it results in greater learning opportunities for the higher performing students, the practice is detrimental to the learning of the lower tracked students because theses classes lack a challenging curriculum and are generally taught by the least knowledgeable teachers (Yonezawa & Jones, 2006). Additionally, the negative perception of these classes falls disproportionately on minority students, who are overrepresented in lower tracked classes

(Burris & Welner, 2005). These students are subsequently characterized by teachers, administrators, and their peers as "dumb," "average," or "slow," and are often treated differently from the higher tracked students (Oakes, 2005). Often in general class instruction, topics are omitted and students who respond to questions incorrectly are ignored (Hallam & Ireson, 2005; Yonezawa & Jones, 2006). In fact, Oakes (2005) indicates that there is a type of hidden agenda in schools which encourages the lower tracked students to conform, work quietly, and get along with their peers as teachers proceed more slowly and cover less of the curriculum (Hallam, Ireson, & Hurley, 2005).

Tracking in Science

Compared to other industrialized nations, most American students continue to perform poorly in science (Gonzales et al., 2004; Pratt, 2006). This situation is ironic given the importance that our society places on competence in science and technology. Contributing to the problem is an educational system that separates students of different measured abilities and fails to recognize the academic potential of every student, particularly in science (Lynch, 2000). Research shows that by the time students enter eighth grade, they are already separated into differentiated math classes and attitudes toward school are already formed (Mullis, 1991; Singh et al., 2002). Although much research exists on the negative effects of tracking on students of particular ethnicities and socioecomonic status (Ladson-Billings, 1995; Oakes, 2005), there is little literature pertaining to how the practice impacts student motivation in science and how teachers effectively motivate lower tracked students to achieve academically. Furthermore, it is difficult to locate and study veteran teachers who are excellent motivators of general science students because the most experienced teachers generally have "worked their way up" to the advanced classes in a typical high school, leaving the lower tracked students with less experienced teachers.

Because science courses are generally sequential in nature, performance in the introductory classes is imperative for academic success in advanced classes and in science courses beyond high school (Singh et al., 2002). The necessity of building on prior science skills results in the placement of only higher-achieving students into the advanced classes, leading to a type of unintentional tracking practiced by schools who want students to be adequately prepared for their science classes.

Tracking and Expectations

Expectations of student success have been shown to vary with the ability level of classes (Hallam & Ireson, 2003). Teacher expectations have a proven effect on student motivation and achievement. In 1968, researchers conducted what has come to be known as the Pygmalion study (Rosenthal & Jacobsen, 1968). This study concluded that teacher expectations act as self-fulfilling prophesies—student achievement ultimately reflects these expectations. Unfortunately, studies have shown that educator expectations for student learning differ dramatically based on student tracking, which appears to justify those expectations (Wheelock, 1992). Research shows that, for too many adolescents in general classes high school has become an impersonal environment where low expectations are the norm (Gehring, 2003). Such students are taught by less qualified educators, receive less challenging instruction, and are subsequently less motivated to learn science (Oakes, 1990). Once placed in the lower track, Yerrick (2000) states that students become concerned that they will never find success in the higher track of science. Often, such students become disillusioned, viewing science as a collection of abstract facts requiring the practice of rote skills in a watered-down curriculum. Perhaps worse for students in general classes is the fact that they are rarely promoted to more advanced classes due to the reputation of belonging to the lower group (Yerrick, 2000). At the other extreme are students in the academic track, who receive instruction emphasizing scientific reasoning and inquiry-based activities (Haury & Milbourne, 1999). Research indicates that higher tracked students themselves recognize the inequitable nature of tracking and express discomfort with the situation (Yonezawa & Jones, 2006).

Society often mistakenly labels students as average, gifted, or slow, which becomes a certification of ability and identification of status in the educational system (Oakes, 2005; Welner & Burris, 2006). Such sorting of students predictably results in decreased self-confidence and below average expectations for low track students which few educators can change (Oakes & Lipton, 2001; Oakes, 2005). The challenge for educators is to put aside preconceived expectations and strive to meet the motivational needs of all students (Yonezawa & Jones, 2006). In fact, this practice was a clear goal of the National Science Education Standards as they adopted a principle of excellence and equity for all students (National Research Council, 1996). Research indicates that when every student has access to the finest learning opportunities, the achievement levels of all students can improve (Burris & Welner, 2005).

Theoretical Framework of this Study

Critical theorists believe that education is “a social institution designed for social and cultural reproduction and transformation.” (Merriam, 1998, p. 4). In this study, the researcher recognized the validity of this framework particularly in the support that critical theory provides for the issues of alienation and social struggles that tracked students may experience (Creswell, 1998). In today's schools, students in more advanced classes generally receive a more high quality education than their peers obtain in basic classes. The researcher understands the inequality of this situation and believes that all students deserve a quality education. Furthermore, the practice of pre-sorting children into defined tracks greatly limits their future educational and career opportunities.

Methodologically, the researcher approached this research from a constructivist perspective. According to Bruner (1973) individuals learn actively by constructing knowledge derived from their own experiences. In fact, most qualitative researchers recognize the significance of constructed knowledge by learners (Guba & Lincoln, 1982; Stake, 1995). In the field of science, constructivist teaching is especially relevant as students gain experience in the modern methods of science by way of inquiry learning, practice of skills through hands-on activities, and investigation of real problems facing society through classroom dialogue and research (Lynch, 2000). Consistent with the goals of Project 2061, constructivism promotes teaching that links instruction to the real world of science and students' lives as teachers encourage all of their students to make observations in the laboratory and connect them to life outside the classroom (American Association for the Advancement of Science, 1993). Science teachers are also learners in their professional field. From a constructivist perspective, teachers use their past classroom experiences to restructure their teaching strategies in an effort to more effectively motivate their students. One assumption of this study was that veteran teachers had more classroom experiences from which to derive their knowledge. Building on years of teaching experience, the participants had amassed a wide variety of motivational teaching strategies. However, each teacher participant also realized that instructional strategies are continually modified to meet the motivational needs of individual learners. Thus, this study had at its basis the view that knowledge is not fixed, but instead exists in a constant state of change as learning is constructed by learners in response to real world experiences.

Constructivist theory was also the basis of data analysis in this study as the researcher worked with the participants to understand their perceptions and to interpret the data (Haney & McArthur, 2002; Staver, 1998). As a teacher at the school in this study, the researcher was subjectively involved in the research, and this situation provided a unique insider's view (Clark, 1997). The working relationship between the researcher and her colleagues was advantageous in allowing the researcher and the participants to strengthen co-constructed meanings throughout the study. Specifically, the use of member checking promoted mutual conversations between the researcher and the teacher participants as the data were interpreted. Follow-up conversations also provided opportunities for the researcher to clarify meanings.

The case study approach affords the researcher an opportunity to become immersed in a particular situation in a search for meaning and understanding as it is viewed by the participants. Inherent to case studies is a limitation on the ability to generalize to other cases (Yin, 2003). However, Stake (1995) indicates that the constructivist view does not eliminate generalizations altogether. Instead, a constructivist approach in case studies provides the readers with rich, thick descriptions (Geertz, 1973) allowing them to make their own generalizations in similar situations. According to Yin

(2003), case studies use direct observation and interviews to provide a more comprehensive view of the particular situation and these sources of data may be used to support reliability in the study through triangulation (Stake, 1995). No generalizablity is expected in such an approach except that which fits similar contexts with the reader. However, Lincoln and Guba (1985) recommend a focus on the consistency of the findings obtained from the data rather than an emphasis on a replication of the results in other studies. Ensuring that the study's results make sense based on the data should be the main focus for the qualitative researcher (Merriam, 1998).

The researcher approached this study from an educator's perspective. As a veteran high school science teacher with over twenty years of experience in the classroom, the researcher recognized the ongoing challenge of motivating students not only in her own classroom, but also in the classes of her peers. Having interacted with science teachers at other schools, it became evident to the researcher that student motivation is a common problem for science teachers. It appeared that the degree of student motivation was a complex issue influenced by teacher personality, teaching strategies, class composition, and other unknown factors. Personal experience and peer observations over the years showed the researcher that some teachers seemed to be highly motivational in any class they taught and that these teachers had the ability to engage even the least motivated student. The approach taken in this study was to investigate how these teachers effectively motivated their students, thus allowing other teachers at this school to use the findings in their own classrooms.

As a classroom teacher, the researcher realized that although much research on student motivation exists, that information is not readily available to the typical high school teacher. Literature indicates that because they operate in vastly different worlds, the only real connection between K-12 schools and university research is usually through teacher preparation programs in schools of education (Kirst & Venezia, 2003). Thus, there is a growing need for the integration of educational research and practice in the classroom (Buysse, Sparkman, & Wesley, 2003).

As a practicing high school science teacher, the researcher brought unique insight into the study of student motivation by providing the perspective of one who was in the classroom, immersed in the situation, and personally experiencing the challenge of motivating students. This insider perspective, and the resulting rapport between the researcher and the participants, made this study stronger by creating opportunities for discourse involving sharing, explanation, interpretation, and evaluation (Clements & Battista, 1990). The fact that the researcher was a teacher in the research setting provided a unique opportunity for collaboration and reflection that would not have been possible for an outside researcher (Daniels & Arapostathis, 2005). As a subjective researcher, the data and interpretations are possibly stronger due to a mutually understood and constructed perspective of a commonly shared experience. Literature indicates that researcher bias is an inherent part of qualitative research (Miles & Huberman, 1994; Marshall & Rossman, 1995). Because the researcher is considered to be the instrument of data collection (Creswell, 1994), it is generally impossible to completely separate the researcher's view from that of the participants. Lincoln and Guba (1985) indicate that a constructivist approach to research necessitates interactions between the researcher and the participants. Efforts to understand and interpret data are influenced by the researcher's ideas and background as well as those of the participants.

The Need for Qualitative Research on Motivation

Despite the fact that much quantitative research exists in the area of student motivation, the problem of engaging students remains a top concern for educators today (Theobald, 2006). Relatively little qualitative research exists allowing educators to delve into the minds of teachers and students regarding their thoughts on student motivation. This study addresses student motivation from a qualitative view. The research questions for this study are: (1) How do science teachers view the role of motivation in their philosophical approach to teaching science? (2) What strategies do they use in the classroom that support their views on motivation? (3) How do students respond to these motivational strategies? and (4) How do science students view these strategies as influencing their own motivation?

The continuing challenge of engaging students has far-reaching societal implications, particularly in the area of science. Research indicates that there is a disturbing decline in the number of U.S. students who are majoring in a scientific area while the number of jobs requiring science is continuing to grow (Musella, 2004). The shortage of Americans entering areas of scientific research poses a critical problem that must be addressed (Hart-Rudman Report, 2002). Resolving this situation can start in the high school science classroom, where teachers work to motivate future scientists in all tracks of classes. As science educators, it is our duty not only to meet the challenge of student motivation, but also to recognize the underlying contributing factors and to make every effort to improve the situation. Continuing research is a first step in that direction.

CHAPTER THREE

MOTIVATIONAL STRATEGIES USED BY FOUR HIGH SCHOOL SCIENCE TEACHERS

Introduction

Motivating students has been an ongoing challenge to educators for many years. Although history has seen societal and educational changes over the past several decades, the problem of student motivation continues to frustrate teachers as they deal with students who expect to excel academically, yet who are not willing to work for that success (Mendler, 2000). The situation is especially prevalent in secondary education, due to the fact that student motivation has been shown to steadily decline as students enter the middle school years (Hidi & Harackiewicz, 2000; Singh, Granville, & Dika, 2002).

Research indicates that in the field of science, lack of student engagement is of particular interest due to its relationship to conceptual change and cognitive engagement (Maehr & Meyer, 1997; Pintrich, Marx, & Broyle, 1993). Wiseman & Hunt (2001) assert that students have a natural motivation to learn when they experience situations which are new to them. They have an innate need to incorporate this knowledge into their life experiences and subsequently modify their understanding of the world around them. This conceptual change is initiated by motivation. However, Ruggiero (1998) indicates that the indisposition to learn appears to be considerably more widespread in our society than it was even a generation ago. Compounding the problem is a society increasingly steeped in technology with a decline in the number of U.S. students who are majoring in a scientific area (Musella, 2004). While high schools and colleges are not graduating sufficient numbers of students who desire to enter scientific fields, the demand for engineers and scientists is growing at a rate five times faster than the need for other types of labor (Field, 2004). To address this situation, teachers must look for ways to increase student engagement in science, particularly at the secondary level. Furthermore, research shows that increased motivation leads to improvement in cognitive and behavioral engagement while ultimately resulting in conceptual understanding (Patrick & Yoon, 2004). In the area of science, motivation is recognized as a necessity for initiating and supporting a lifelong interest in learning (National Research Council, 2000).

Addressing the motivational needs of students first requires exploration of effective instructional strategies in the science classroom. However, the overall effectiveness of these pedagogies should also be examined from the perspective of the teachers who are out in the classroom daily and from the view of the students who know what "works" to motivate them. Despite the fact that much quantitative research exists in the area of student motivation, the problem of engaging students remains a top concern for educators today (Theobald, 2006). Unfortunately, there is a paucity of qualitative research into teacher and student perspectives on motivation (Daniels & Arapostathis, 2005; Pintrich & Shrunk, 2002). Qualitative research in science classes offers the opportunity for learning in depth about the many dimensions of student motivation, and also the chance to investigate effective strategies utilized by highly motivational educators.

The purpose of this paper is to highlight teaching strategies used by these four science teachers to promote student motivation in their classes. The issue was approached from the perspectives of the researcher as a teacher, the teachers of the students, and the students themselves. Viewing the situation from a constructivist perspective, data and data interpretations were expressed in the actual words of the participants so that their perspectives reflected reality. The data were interpreted and findings were co-constructed by the researcher and the participants so that the findings would be stronger. Results may be used by educators in other subject areas to improve student motivation in their own classrooms. The research questions for this study are: (1) How do science teachers view the role of motivation in their philosophical approach to teaching science? (2) What strategies do they use in the classroom that support their views on motivation? (3) How do students respond to these motivational strategies? and (4) How do science students view these strategies as influencing their own motivation?

Factors Affecting Student Motivation

Motivation has been defined as an internal process that arouses action, directs behavior, and results in a sustained effort over time (Howland, Laffey, & Espinosa, 1997; Wiseman & Hunt, 2001; Woolfork, 2001). Derived from the Latin word *movere,* which means "to move," the concept of motivation inherently involves action. In the field of education, motivation also involves persistence, initiation, show of effort, confrontation of challenges, and questioning of issues outside the classroom on the part of students (Patrick, Hisley, & Kempler, 2000). In fact, the significance of motivation can be seen in virtually all areas of teaching and learning (Pintrich & Shunk, 2002).

Research has identified several factors influencing student motivation in the science classroom. Some of these factors are related to student background, peer pressure, and societal issues (Martin, 2002). Such influences are not easily changed by teachers. However, other factors are under the teacher's control. For example, classroom atmosphere, school environment, teaching style, and relevance of the subject matter are all areas in which educators can actively influence student motivation (Ames, 1992; Evans, 2004; Swanson, 1995). When teachers incorporate life experiences, hobbies, and other student interests into the lesson, motivation is improved significantly (Parsons, 2000; Theobald, 2006).

Wiseman and Hunt (2001) define instructional variety in the classroom as the consistent "use of a number of different instructional techniques" by the teacher rather than reliance on only a very few strategies (p. 93). Variety of presentation by the teacher results in student excitement and expectancy as the day begins and throughout the lesson (Druger, 2000). In the science classroom, not all students arrive with the same level of motivation or with the same readiness to meet academic challenges. Still, research suggests that these students can benefit from strategies that will aid them in becoming more engaged in the learning process (Daniels & Arapostathis, 2005). Varying presentation methods reduces boredom and invigorates the classroom atmosphere (Theobald, 2006). Additionally, the field of science inherently lends itself to hands-on learning and laboratory explorations that are commonly used as instructional tools.

Because science itself is in a constant state of innovation, science education must also adapt to meet these changes. The teacher who uses varying instructional approaches creates increased student interest, piques student curiosity to learn, and creates unique stimuli in the classroom, all of which increase the cognitive ability of students (Wiseman & Hunt, 2001). When science teachers create a constantly changing learning environment in which instruction is dictated by the needs of students rather than the limits of curriculum learning objectives, the students ultimately benefit (Coleman, 2001).

Scientific Inquiry

Early science education consisted mainly of daily recitations from lectures and books. Only recently has this practice been lessened in large-scale curriculum movements. In the 1990's, the National Research Council developed a vision for making scientific literacy a reality for all students in the next century. A new definition of inquiry was established.

> Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (National Research Council, 1996).

Unfortunately, the vast majority of students often view science as something that is stagnant—a myriad of boring facts that scientists know and students are required to learn (Heflich, Dixon, & Davis, 2001). In reality, science is dynamic in nature, but students do not often experience it in such a way. Educational research consistently supports the value of scientific inquiry as a motivational tool. For example, science courses that incorporate student-centered inquiry techniques have proven to be extremely effective in efforts to improve not only content learning, but also science processes, creativity, logic, and attitudes toward learning science (Caton, Brewer, & Brown, 2000).

The unpredictability of science is part of its attraction. This innate uncertainty is attractive to students because they have a natural curiosity. When we fail to communicate to our students what science truly is, we stifle their natural curiosity (Genoni, 1995). If teachers can tap into the natural curiosity of students by way of scientific inquiry, research indicates that students will not only be more motivated to learn, but they will also gain the skills needed to harness knowledge for solving personal and societal problems (American Association for the Advancement of Science, 1993).

Classroom Discussion

Dialogue is also an important component of the successful science classroom. In fact, the National Board for Professional Teaching Standards recognizes the importance of classroom discussion and requires the practice as a standard for certification. Teachers routinely use class discussions to gauge students' emerging knowledge (Beghetto, 2004). Meaningful discussion enhances learning as students have the opportunity to appreciate, justify, and perhaps even defend the concepts they are addressing while also providing them an opportunity to exchange ideas in open discussion (Vavilis & Vavilis, 2004). When teachers show that they value the opinions of their students and that these views will not be judged, students will be more likely to participate in class dialogue (Theobald, 2006). Because students spend significant time interacting with their peers, teachers often take advantage of the motivational impact of these relationships by allowing student discourse in the classroom. In fact, social cognitive theory emphasizes the impact of these interactions on student motivation (Pintrich & Shunk, 2002). Teachers who put an emphasis on the social and personal development of their students play a vital role in fostering engagement and motivation to learn (McCombs & Whisler, 1997).

Teacher Enthusiasm

One of the most important influences on student motivation in high school science is teacher enthusiasm exhibited for the subject matter during instruction (Coleman, 2001; Meyer & Turner, 2002; Theobald, 2006). In fact, students' intrinsic motivation to learn has been shown to be positively correlated with the teacher presenting lessons in an energetic, dynamic, and enthusiastic manner (Patrick et al., 2000). To some degree, teacher enthusiasm makes learning more enjoyable while also giving students the impression that mastering concepts is achievable (Coleman, 2001).

Literature reveals that enthusiasm is conveyed to students when their teachers project excitement about the learning process (Theobald, 2006). Wiseman and Hunt (2001) describe teacher enthusiasm as the "energy and vigor shown by the teacher; believed to communicate to students the degree to which the teacher enjoys teaching and the degree to which the teacher believes that the students will be successful in their learning." (p. 203). This excitement is associated with energy, involvement, and interest in the subject matter. In the face of such enthusiasm, students are more likely to become excited and thus, motivated to learn as they observe their teachers enjoying their work (Wiseman & Hunt, 2001). When teachers exhibit this kind of enthusiasm, they communicate confidence in their own abilities and in the abilities of their students to learn (Wiseman & Hunt, 2001).

Building Student Rapport

Developing relationships with students is an important aspect of effective teaching which has numerous motivational benefits (Patrick et al., 2000). The science lab provides a unique environment for building relationships as teachers have the opportunity to interact with students on a more personal level by answering questions, making observations, and providing feedback. Coleman (2001) suggests that the more effectively educators can connect with their students, the greater will be their impact on motivation and learning. Additionally, literature supports the student-teacher relationship as a significant influence on the level of student motivation and the amount of effort students are willing to put forth (Daniels & Arapostathis, 2005).

Student rapport can be enhanced when teachers take an interest in the lives of their students by recognizing them individually (Theobald, 2006). Such a minor act as greeting students by name at the classroom door communicates interest. Taking time to build relationships with students initiates dialogue, which sends a message of caring. Noddings (1995) indicates that much can be gained by incorporating themes of caring into the school curriculum. Literature supports the building school of communities in which students trust in authority figures (Daniels & Arapostathis, 2005). When teachers spend time building relationships of trust, they are in a unique position to become special people in the lives of their students (Noddings, 1995).

Making Lessons Relevant

Interaction with students outside the science classroom provides teachers with the opportunity to discover current trends among adolescent culture which can be used to enhance motivation (Druger, 1998; Strong, Silver, & Robinson, 1995). Although many lessons hold great educational value for the future of our kids, the challenge is to relate topics in science to their lives outside the classroom. Research shows that even reluctant learners will become engaged in activities if they see a value in the lesson (Daniels & Arapostathis, 2005). When teachers make their lessons relevant to the present real world of adolescents, they will see more engaged students (McCombs & Whisler, 1997). Research indicates that when students can connect instructional material to something they understand or have experienced, they will be more likely to show interest in the lesson (Theobald, 2006).

Connecting science classrooms to the real world has been a primary objective of the Science/Technology/Society (STS) movement. Focusing on teaching and learning science in the context of technology and human experiences (Yager & Lutz, 1995), the STS program utilizes current issues in society and in the lives of students as a basic foundation of learning. Research supports the benefits of STS instruction as it emphasizes thinking, problem-solving, and decision-making based on evidence and reasoning as tools used in the pursuit of scientific literacy (National Research Council, 1999; Yager, 2000). Additionally, students who learn through the STS program have increased motivation to learn, better attitudes toward science, and a more positive view of careers in science (Weld, 1999).

The Learning Environment

Student motivation varies depending on classroom contextual factors such as the subject matter, classroom design, and teacher personality (Linnenbrink & Pintrich, 2002). In 1993, the coach of the Dallas Cowboys was asked how he had turned a losing team into Super Bowl champions. He replied, “Treat them as winners, and they will win.” The same concept applies to the classroom. A positive learning environment conveys to students the message that they can succeed. In other words, teachers should create an inviting physical atmosphere in their classrooms (Brophy, 2004) and strive to create classrooms in which student discussion is emphasized in questioning, problem-solving, issue analysis, data evaluation, and finding conclusions (Ruggiero, 1998). Such an environment is conducive to student motivation and academic success.

Context of the Study

The setting for this study was a large suburban high school in the Southeastern United States. The school, which consisted of students in grades ten through twelve, had a diverse student and teacher population. Although the school was located in an affluent community, it also served neighboring areas of lower socioeconomic status. Twelve percent of the student body was eligible for the free/reduced lunch program. Out of the 1,850 students attending this school, 78% were Caucasian, 18% were African American, and 2% were of another ethnicity. There were 110 teachers at the school, 89% of whom were Caucasian and 11% were African American. The school operated on a traditional 4x4 block schedule with each class period lasting 96 minutes. The school system was relatively small, with only one high school, but was growing rapidly in the past several years with the influx of government contract workers and their families. The community was highly educated, and had high academic expectations of the school system.

The science department at this school consisted of fifteen teachers, thirteen of whom held at least a masters certification in science. The school offered a wide variety of classes in order to meet the four required science courses for graduation in the state of Alabama. Each science teacher taught three 96 minute classes each day with a 96 minute planning period. Teacher morale appeared to be high, and the number of teachers in the department has grown consistently for the past sixteen years.

The researcher was a colleague of the teacher participants and was also the science department chair at the high school. Having had twenty years of experience as a science teacher, the researcher has noted that student motivation has been an issue of concern among her peers. Additionally, a principal's survey of the teachers at this school indicated that student motivation was a top concern by the faculty as a whole. This research addressed the issue of student motivation through the lens of a teacher who was immersed in the situation throughout the period of the study. Approaching the research from a constructivist perspective, the researcher collaborated with the participants in the data collection and analysis process to co-construct interpretations.

Methods of the Study

Participants and Design

Prior to the research study, fourteen science teachers at the high school were given an informed consent letter explaining the purpose of the study and soliciting their participation. Eleven teachers who returned the informed consent became potential participants in the study. These teachers agreed to take part in an initial audio-taped, semi-structured interview asking about their teaching experience, professional backgrounds, and thoughts on student motivation and their teaching practices supporting it (Appendix A). Additionally, this interview explored how the teacher participants see themselves and their role as motivators of students, factors they feel affect student motivation, problems they encounter in motivating students, and strategies they feel are effective in engaging students including the use of inquiry and lab activities.

Because the researcher's goal was to study effective motivational teaching strategies, purposive sampling was used to select teachers who successfully engaged their students. According to Merriam (1998), this sampling strategy enables the researcher to establish criteria for the participants that reflects the purpose of the study. The criteria for selection of the actual four teacher participants from the eleven was based on their years of teaching experience, perceived high ability to motivate students, insightful views on student motivation, and class schedule. The researcher assumed that due to their experience in the classroom, veteran teachers with several years of service had more insight into student motivation than newer teachers who had little classroom teaching experience. Therefore, only teachers with at least five years of teaching experience were considered as potential participants. Secondly, each teacher's perception of his or her own ability to motivate students was a significant factor in participant selection. Initial interview responses were helpful in revealing which teachers were confident in their motivational skills. These responses also revealed teachers' general perceptions on student motivation in science. Class schedule was another determining factor as to which teachers could participate in the study. Therefore, convenience sampling was also utilized to select participants. Because the researcher conducted many classroom observations during her planning period, the researcher's planning period could not coincide with those of the participating teachers. The researcher had to include only teachers whose classes were available to be observed during the first, second, and fourth blocks of the day. Additionally, teachers from the final candidate pool were selected based on variation in the subject courses and difficulty level of classes. General science classes were defined as those that had no grade or course prerequisites and met the basic graduation requirement. Advanced level or AP classes were defined as college preparatory elective courses that had a prerequisite grade requirement of having passed Biology with at least a B average. Advanced classes referred to elective Advanced Placement courses in which students could obtain college credit by passing an AP exam at the end of the semester. Prerequisites for this course included having passed Biology with an A average. Varying types of courses and tracks of difficulty were selected for this study so that the data would reflect an overall picture of motivation among all types of high school science students and not be limited to the higher or lower tracked students or particular science discipline. Considering both purposive and convenience criteria, four teachers were ultimately selected to participate in the study.

The first teacher, Mrs. Oliver (pseudonym), was an African American female with eighteen years of teaching experience. She had experience teaching in every area of science, and had recently become certified in school administration. She demonstrated professionalism in all situations, but she also had a great sense of humor which she shared often with her peers. During the semester of this study, she taught three Earth/Space Science classes which meet the graduation requirements for science primarily for 11^{th} and 12^{th} grade students. These students often avoid more challenging science classes. The second teacher, Mrs. Hatch (pseudonym), was a white female with twelve years of teaching experience, primarily in physical science. She had been teaching at this school for three years, having moved from another state where she earned her Masters Degree certification. A former professional softball player, Mrs. Hatch not only coached at this school, but she also approached her classes with a team mentality. During the semester of this study, she taught three classes of Physical Science, a class designed to meet the basic graduation requirement for a physical science primarily for 10th grade students. Students taking Physical Science generally have made a C or below in Algebra I and are not ready to take Chemistry. The third teacher, Mr. Benson (pseudonym), was a white male with ten years of teaching experience, primarily in biological science. He was a proponent of the theory of evolution, global warming, and respect for the environment. A National Board Certified Teacher, he had completed his inservice teaching at the school in this study, and then taught for several years at a feeder middle school before returning to the high school. The students had a genuine affection for Mr. Benson as evidenced by the fact that over 120 students signed up for his AP Biology class the first year it was offered. During the semester of this study, he taught three classes of Advanced Placement Biology, an elective science class attracting high-achieving students from all grade levels. The fourth teacher, Mrs. Ray (pseudonym), was a white female with seventeen years of teaching experience, all in biological science. She earned both her Masters Degree and National Board Certification, and over the years she had gained a true reputation of caring about her students. During this study, she taught three Anatomy and Physiology classes which are upper tracked elective courses consisting mainly of 11th and 12th graders. Students in these classes are generally planning to attend college and often hope to major in a medical field.

Table 1

Characteristics of teacher participants and classes

Teacher	Course Name	Grades	Track
Mrs. Oliver	Earth/Space Science	11-12	Low
Mrs. Hatch	Physical Science	10	Low
Mrs. Ray	Anatomy &Physiology	11-12	High
Mr. Benson	AP Biology	10-12	Advanced

In addition to the four teachers, students enrolled in the participating teachers' classes were included in this study. Towards the end of the course, student participants from each teacher's class were given a Likert style anonymous survey on motivation consisting of five response choices—Strongly Agree (5), Agree (4), Undecided (3), Disagree (2), and Strongly Disagree (1). The survey covered student views about motivation and learning in general, motivation and learning in their current science class, and specific motivational strategies that emerged in their current science class (Appendix B). The survey was developed by the researcher following a review of the literature on student motivation in science. The researcher wanted to know whether or not students enjoyed science overall, their degree of motivation to learn science, and the perceived effectiveness of various motivational strategies used by their science teachers. Survey items also covered student perceptions of classroom atmosphere, teacher enthusiasm, and instructional variety. It was the goal of the researcher to explore a range of areas influencing student motivation, as found in the literature. The researcher wrote the survey specifically to give students a voice in this study and to see if students' perceptions corroborated the views of the teacher participants. The surveys were administered and collected by each classroom teacher, and then returned to the researcher. Only the teacher's class was identified.

Taking place over the 2005-2006 academic year, the design of this research followed a case study approach. According to Merriam (1998), case study research is appropriate for studying such intrinsically bounded units as groups of teachers at a specific school. Yin (2003) adds that case studies involve direct observations and interviews in which relevant behaviors are not manipulated. Stake (1995) indicates that case study research is appropriate when the focus is on a unique case and the researcher has an intrinsic interest in the particular situation. Case studies are particularly appropriate in this study because they allow the researcher the opportunity to address questions of student motivation in an inductive manner, by recording characteristics and details about students as they interact with other students, the teachers, and objects in the classroom (Beghetto, 2004).

Data Collection

Following the initial interviews, each teacher invited the researcher into his/her classroom during one semester to conduct a series of observations of lessons (7-9 total for each) which the teacher felt were highly motivational or had elements that were highly motivational to students. The purpose of these observations was to explore specific teaching strategies stated by the teacher in initial interviews, and to observe the actual actions of the teachers and their impact on students' achievement oriented behavior. Such behavior was illustrated by students being on task, responding to teacher questions, asking questions of their own, and actively participating in classroom activities. During these observations, the researcher recorded field notes concerning classroom environment, teacher demeanor, teaching strategies, context of the lesson, teacher comments, nonverbal student responses, and specific student comments. Field notes made during classroom observations were organized in a chart form listing *Descriptive* and *Reflective* notations as the two main headings (Creswell, 1998). Descriptive notes detailed the classroom atmosphere, lesson context, and what the teachers and students said and did in the classroom as it happened. The reflective portion of the chart consisted of the thoughts, reactions, and interpretations of the researcher that occurred immediately after the observation. Particularly noted were observations of literature-based indicators of student motivation such as the degree to which students appeared to be engaged in the lesson, their willingness to answer questions, their general attentiveness, and their time on task. The researcher recorded specific incidents of students requesting assistance, asking questions about the lesson, demonstrating creativity through comments, displaying a positive attitude, and verbally expressing an interest in learning (Beghetto, 2004).

Each classroom observation was followed by a debriefing conversation with the teacher which consisted primarily of discussions related to the effectiveness of the motivational teaching strategies observed. Data from these conversations were recorded in the field notes under the reflective section. Examination of data from previous observations and conversations raised emergent areas of focus for each teacher's new observations. These new foci allowed unique and rich data to be gathered on each teacher's motivational strategies (Miles & Huberman, 1994).

After all classroom observations and debriefing conversations were complete, teachers took part in individual member checking, giving each participant an opportunity to view the researcher's interpretations of the data and to co-construct meaning from it (Lincoln & Guba, 1985). Finally, the teacher participants were brought together to take part in a confidential audio-taped focus group interview where the researcher reiterated questions on reiterating questions on student motivation again and solicited teachers' perceptions of effective motivational strategies to see if these views had changed during the course of the study. The focus group discussion was intended to further discern teacher perceptions on motivation as the participants interacted with each other and to clarify data previously collected and meanings were co-constructed by the larger group.

Marshall and Rossman (1999) indicate that focus group interviews are appropriate in cases where the participants share characteristics that pertain to the research questions of a particular study. Taylor and Bogdan (1998) suggest that a major advantage to group interviews is the researcher's opportunity to use group dynamics to gain new insights as the participants interact. Key to the success of a focus group interview is a risk-free environment (Marshall & Rossman, 1999). To support such a non-threatening atmosphere, the focus group interview was held in a teacher workroom where the science faculty members regularly meet to converse, eat lunch, and complete paperwork.

Data Analysis

Data were analyzed using the constant comparative method (Glaser & Strauss, 1967; Merriam, 1998; Strauss & Corbin, 1998) in which the data evolve gradually as they are examined repeatedly. Proceeding simultaneously with the data collection, data analysis began with the transcription of the initial interviews and focus group interview. Teacher interviews, the focus group interview, field notes of observations, and follow-up conversations were initially coded using a descriptive method as suggested by Strauss and Corbin (1998) on the research questions. The analysis of transcripts was based on an inductive approach by which patterns in the data were identified by means of thematic codes which emerged from the data. Following the initial data analysis, preliminary categories for each case were set up in matrices to help organize the coded data for each research question (Miles & Huberman, 1994). For example, Mrs. Ray discussed her sense of humor in the initial interview and also displayed it in the classroom. Her joking was described under a category labeled, "Teacher Personality." This category was common to research question one—dealing with how teachers view their role in student motivation—

and to question two—covering what teachers actually do in the classroom to support their views. The names of the categories were constantly refined as the data were examined in more detail. For example, the "Teacher Personality" category ultimately became "Teacher Enthusiasm" as it was refined to encompass specific teacher comments by Mrs. Ray such as "It's just amazing!" and "Isn't that cool?" Also related to teacher enthusiasm was research question three—which dealt with how students reacted to the motivational strategies used by their teachers. While the "Teacher Enthusiasm" category described teacher actions, field notes from the classroom observations described specific student responses to these teaching strategies. For example, when Mrs. Ray made a joke about a certain part of the anatomy during a naming activity, her students laughed and participated enthusiastically in the lesson. Student actions in direct response to the teacher's enthusiasm were also listed under the "Teacher Enthusiasm" category.

Next, the researcher read through the data and cited recurring ideas as key words by making notes in the margins. For example, when reading through the classroom observations of Mrs. Hatch, key words included, "movement," "voice," "talking," "social," "positive feedback," and "questioning." In examining the interview transcripts of Mr. Benson, such concepts as "love of subject," "body language," "enthusiasm," and "relaxed atmosphere" emerged. The researcher repeatedly analyzed the data inductively from all four cases in this fashion in order to seek ideas emergent in one case across the other cases (Taylor & Bogdan, 1998).

As the data sources were examined further, additional categories were identified, labeled, and refined for each case. Throughout the process of data analysis, each code was repeatedly compared to all other codes in an effort to identify patterns, similarities, and differences. Ultimately, final matrices were set up to facilitate visualization of relationships among the pieces of data. Matrices listed the categories as headings which included *Dialogue in the Classroom, Teacher Enthusiasm, Classroom Environment, Inquiry Learning, Lesson Presentation, Building Rapport,* and *Relevant Lessons.* Each category was also defined to clarify its meaning. Using seven relatively broad common categories facilitated the emergence of similarities across the cases. Under each heading, the researcher placed quotes and field notes of descriptively coded data that related to each category. Related data were identified by their data source such as, "initial interview," "classroom observation," or "focus group discussion," and were placed on the matrix under category headings.

After examining the matrix data for emergent themes in each category, several themes emerged. As new themes emerged within categories in each case, all previous analyses were reexamined for similar themes (Guba, 1978; Marshall & Rossman, 1999). In this iterative process, each teacher was considered to be a separate case which was subject to single case analysis. Yin (1994) recommends that the investigator attempt to construct general explanations that fit each of the individual situations, although the details of the single cases will vary.

Subsequent to the single case analysis, data from all cases were compared in a search for common themes across cases. According to Stake (1995), in searching for meaning, the researcher must find patterns that reappear across cases because direct interpretation depends primarily on this search for patterns. A new matrix was set up so that the cases could be visualized side by side. Teachers' names were listed along the top of the matrix, and all categories with supporting themes from every case were listed down the side of the chart. The researcher then examined the data again to determine which themes were present in each case. This information was recorded by checking boxes under each teacher's name if the theme emerged significantly in that case. Organizing the data in this fashion allowed the researcher to easily identify seven themes that emerged strongly across all four cases.

Student Survey Data

Student survey responses were obtained to address the fourth research question which explored students' views on the effectiveness of teaching strategies in influencing their own motivation in science. The survey responses were examined separately from the other data. Although there were five possible responses to each item on the survey, the researcher decided to combine the responses into three responses—agree, undecided, and disagree. This decision was made primarily because the individual classes were very small with fewer than twenty student participants in each group. Also, survey data from all four cases were combined in order to obtain a larger view of overall student perceptions on motivation. The responses were coded as percentages of the total group. For example, 71 students responded to the survey item on desiring to pursue a career in science. Out of this group, 27 students selected "Agree" or "Strongly Agree" as a response. These 27 students represented 38% of the respondents, and this value was reported in the results as the number of students who responded that they agreed with this item. The student responses to particular items were then compared to individual themes emergent from the other data sources.

Results

Upon examination of the data, seven significant common themes across all four cases emerged from this study. These themes included *Questioning Engages Students in the Lesson, Teacher Enthusiasm Excites Students, Promoting a Non-Threatening Environment, Using Inquiry to Help Students Understand Concepts, Using a Variety of Activities, Belief that Students Can Achieve, and Building Caring Relationships.* These common themes were strongly represented by the teacher participants. In each case, the theme was substantiated by at least two data sources including both interview and observational data. Triangulation of these data with student survey responses further validated many of the findings. Student survey data corroborated the motivational themes of teacher enthusiasm, variety of lesson presentation, positive learning environment, and building rapport. Survey results did not reflect each emergent theme because each theme was not represented in the survey items.

Student survey data provided a general description of how students view themselves academically. Overall, survey responses described the student participants as enjoying cooperative activities (86%) and having high academic expectations for themselves (80%). Additionally, 89% classified themselves as good students and 80% expected to do well in their current science class. However, only 38% agreed that they would like to pursue a career in science, 54% indicated that they enjoy science, and 45% agree that they enjoy scientific challenges. Although survey responses indicated that the respondents expect to succeed and see themselves as good students, they did not have a positive view of science and they prefer rote memorization to higher level thinking skills.

Theme 1: Questioning Engages Students in the Lesson

Teachers utilized questioning as a motivational tool in several ways. For example, in the focus group discussion, Mrs. Oliver indicated that she used questioning to keep students on their toes and awake in class. She stated that,

> Questioning calls for fast action on the part of the students. They never know who's going to be called on next. Questioning takes students into a realm of having to think critically and analyze what their answer is going to be.

Other teachers expressed the same sentiment that questioning can be used to bring students back on task. However, such a strategy is most likely akin to nudging students out of a perceived "classroom coma."

Questioning was also used most frequently by the teachers to obtain feedback and to promote student participation. During the focus group discussion, Mrs. Ray explained that she gauges student understanding by questioning her students, stating, "I always expect students to have some answer to my questions." This practice was exhibited in her classroom during a discussion about steroids when she asked, "Is it bad to have lipids in your diet? Why not?" and during a body part identification activity when she pointed to a leg muscle and asked, "What does it do?" In both cases, Mrs. Ray received verbal responses to her questioning. Similarly, Mr. Benson used questioning to expand classroom discussion in his AP Biology class. For example, when discussing chordates, he asked, "Why do amphibians have to be near water?" This question initiated a class discussion about tadpoles, frogs, and post-anal tails. Students also freely asked questions in Mr. Benson's class. During a discussion on DNA replication, a student asked, "How exactly does the strand cut off the end?" Questions were also asked as a check for understanding. For example, as Mr. Benson was showing the class a video clip on DNA polymerase, he asked, “Do you understand what’s happening here?” Student responses allowed the teacher to gauge the level of student understanding of scientific concepts.

Mrs. Hatch, offered encouragement as she questioned her physical science students and urged them to participate. Stating in the final interview that her students often lack self-confidence, she explained that she gives them plenty of time to respond to her questions and encourages them to ask their own questions. Mrs. Hatch was quite adept at boosting student self-confidence through questioning, and thus, most of her students joined in the lessons. For example, following a discussion and lab activity on pressure differences involving collapsing heated soda cans in cold water, a special education student in her class felt comfortable enough to question her, “So if you cool it down, then put it in hot water, will it go back out?” Mrs. Hatch also used questioning to check for student understanding. During a discussion of differences between heat and temperature, she asked, “What happens when you put hot glass in cold water?” Every question was asked with the expectation that students would have an answer.

Theme 2: Teacher Enthusiasm Excites Students

A second theme prevalent among all four cases was that of teacher enthusiasm. In the initial interviews, teachers expressed the importance of enthusiasm in their classrooms. For example, Mr. Benson described enthusiasm as the “main thing for me.” In the focus group discussion, he emphasized the motivational power in teacher enthusiasm by stating, “Being excited about your subject is contagious!” Mrs. Ray agreed that students pick up on teacher enthusiasm. Additionally, in the focus group discussion, she stated,

> An energetic presentation and a love of the subject are the keys to generating enthusiasm in my classroom. Enthusiasm is very important! I believe I could teach my students how to blow their nose with enthusiasm and they would be motivated to learn this concept!

Not only did the teachers emphatically express the positive power of enthusiasm to motivate students, but each of them also displayed this belief in the classroom. Mrs. Oliver was observed expressing excitement about the lesson as she encouraged her students to imagine different climates of the world. She exclaimed, “Let’s visit some warm places!” Mrs. Ray’s enthusiastic comments illustrated her sense of humor. As students were learning about body systems, she loudly commented, “I think you’re familiar with the genital region!” Such comments were routine in her classroom, and students were observed smiling and laughing in response. Mrs. Ray was also quite adept at spicing up a lecture with such comments as, “It’s just amazing!” “Isn’t that cool?” and “Boy, that’s a neat thing!” Similarly, Mr. Benson conveyed his excitement about learning to his students. In fact, his energetic enthusiasm was exhibited as he often ran across the room, swung a meter stick, and used gestures to illustrate points. He made such comments as, “That’s cool!” “Amazing!” and “This is a beautiful, beautiful thing!” His students picked up on his enthusiasm as evidenced by their actions and comments noted in class observations. Although many of Mr. Benson’s students raised their hands to ask questions, others seemed too excited to wait and proceeded to ask questions without the teacher calling on them. One student expressed her enthusiasm by exclaiming, “I’m so excited!” after she answered a question correctly.

Mrs. Hatch was more low key in expressing her enthusiasm because she felt that her students were more likely to be disruptive. She preferred to generate excitement using a "team" approach. In the focus group discussion, Mrs. Hatch stated that,

> I use comments to push students along and get them excited about the lesson like, "This is what we're going to do today, guys!" and "Come on guys, we can all get this done!" It's the nature of my class; it's my convincing them that they can do this.

Her students seemed to respond to this strategy during a lesson on thermal expansion as they had their heads up, their eyes on the teacher, and they raised their hands to ask questions.

Student survey data also emphasized the importance of teacher enthusiasm in motivating students in science. Out of all students surveyed, 79% agreed or strongly agreed that teacher enthusiasm had a great influence on their motivation to learn. Only 8% of students surveyed expressed disagreement with this view.

Theme 3: Promoting a Non-Threatening Environment

In the four cases of this study, the teachers focused on the positive nature of class atmosphere to include a non-threatening or risk-free environment. Each teacher felt that if students were comfortable in the classroom and in the science lab, they would be more likely to participate in activities. This view was supported by Mrs. Hatch, who indicated in an interview that,

> A negative environment can extinguish student interest. Students are more willing to participate when the chance of failure is lessened. Failure can be defined by grades and/or feelings. If a student feels like a contributor, they will feel success.

Mr. Benson stressed that his relaxed personality set a non-threatening tone for his classroom. In the final interview he stated,

> I try to keep things light and jovial, partly because that's pretty much my personality. The class pretty much determines how relaxed I am—which is usually pretty relaxed with my AP classes. I'm probably a lot more flexible than most other teachers.

The laid back atmosphere in his class was demonstrated by students who were allowed to have a "pet" fish for good luck on the lab table during activities. One student even wore an orange paper "thinking hat" to "help" him in class. The "fun" factor was obvious in this class and students obviously enjoyed what they were learning. Mrs. Ray's class was also relaxed. In fact, on her birthday the kids sang to her in class. In post observation interviews and in the focus group discussion, she expressed the need for students to feel comfortable about making comments and asking questions. Classroom observations corroborated her view. In the third observation, a student gave an incorrect answer on how the body uses cholesterol, and he was not ridiculed by the other students. During cooperative activities such as building clay models of muscles, students moved around freely and smiled often. Behavior such as this indicated that students were comfortable in the classroom. In fact, this perception was confirmed through student survey responses in which 85% of the students agreed or strongly agreed that classroom atmosphere had a great influence on their motivation to learn in the science classroom. Only 7% of the students surveyed expressed disagreement with this statement.

Theme 4: Using Inquiry to Help Students Understand Concepts

Science is inherently a hands-on subject. Ideally, scientific inquiry should comprise at least some part of a hands-on curriculum. Student-directed inquiry was observed only minimally by the researcher in this study. However, each of the four teachers utilized teacher-directed inquiry-based activities to promote increased student understanding. For example, Mrs. Oliver assigned her students a web quest exploring different climates around the world. This activity required students to collect data, answer questions, and present information to the class in a format resembling a local weather report. Mrs. Hatch also encouraged her physical science students to take an active role in their own learning. For example, she incorporated her view of scientific inquiry, that "kids are in charge of the design," during a lab activity in which the students were given marbles, a stopwatch, and materials with different viscosities. Students then designed a demonstration to illustrate the viscosities of the materials, made observations, collected data, constructed data tables, and shared results with classmates. As students interacted with each other in this activity, they asked each other, "How can you tell when the marble hits the bottom (of the fluid)?" and "What if it doesn't move?" Mrs. Hatch indicated that labs are her "number one student motivator" because they give kids "a chance to see and experience a topic."

Mr. Benson indicated that he was very limited in the implementation of student-directed inquiry activities because of the strict laboratory requirements of the Advanced Placement program. He felt that with time constraints, the twelve required AP Biology labs were all he could include in the curriculum. When asked about his perception of scientific inquiry, Mr. Benson stated that to him, inquiry was:

> Getting away from cookbook labs and letting the student struggle. Give them a problem and materials needed to solve it and let them go through the process themselves. But there is discomfort with teachers and students. Students designing their own investigations makes them (students and teachers) feel uncomfortable.

In his view, it is ironic that students in the most advanced classes are required to follow lab procedures in which the answers are pre-determined to a large degree. Still, Mr. Benson required his AP students to make observations, record data, and answer questions during laboratory activities. In fact, student observations in the lab generated questions used for classroom discussion. For example, in a lab on isopod behavior, students were required to alter the physical environment, by adding water, decreasing temperature, or changing the pH, and then to observe the effect it had on the isopods. During this activity, students asked Mr. Benson if rolly pollies die rolled up and if there are boy and girl rolly pollies. It was evident that the students enjoyed the inquiry activities and that these labs expanded the lessons.

In reference to inquiry learning, student survey responses indicated a level of discomfort with student-directed inquiry. For example, when presented with a scientific investigation not having a preset procedure, only 29% of the students agreed or strongly agreed that they would enjoy such an investigation. The same number of students, 29%, disagreed or strongly disagreed indicating that they would not like such an investigation. However, the majority of respondents, 41%, were undecided on whether they would enjoy this type of activity. Such responses bring into question student understanding and familiarity with student-directed inquiry learning. A second survey item questioned students on their preference for lab experiments having a step-by-step procedure with "correct" answers. A full 72% of the students agreed or strongly agreed that they preferred such a procedure. Again, the majority response to this question indicated that students were more comfortable with traditional "cookbook" type lab activities in science than with student-led inquiry.

Theme 5: Using a Variety of Activities

All four teachers were very specific in their views that variety of lesson presentation was key to engaging students. During the 96 minute class blocks, each teacher used a minimum of four different teaching strategies. Every teacher expressed strong views about the value of variety in the classroom, and these opinions were discussed in the focus group. For example, Mrs. Oliver recognized that,

> It takes a lot of strategies and various types of motivational techniques to keep them focused because students will fall asleep if you lecture too long. I use a variety of strategies in the classroom to reach all students because all students learn differently.

Mr. Benson agreed that students like multiple approaches. Additionally, he stated that he "doesn't want to get stale" in his teaching by using only a few instructional strategies. Mrs. Hatch and Mrs. Ray expressed the view that, because all students are different, they do not all respond to the same strategy. Mrs. Hatch stated, "By varying strategies, you can teach most students in terms of learning styles."

In each of the four cases, the teachers used variety as a tool to reach students with different learning styles and various motivational needs. For example, in a single class period, Mrs. Hatch started with a bellringer activity on metric conversions to focus the students, then a short lecture and discussion on standards of measurement, followed by a worksheet of practice problems completed independently in class. Next she took the class to the lab, where they performed an activity to practice measuring, followed by a final class discussion in which students shared their results. Lab activities unique to science were noted by the teachers as playing a significant role in creating variety of instruction.

Student survey responses also supported the teacher perceptions on this theme. Concerning lesson presentation, 70% of the students agreed or strongly agreed that they preferred their science teachers use a wide variety of instructional strategies during a class period rather than just one or two. Although 26% of the respondents were undecided on the effectiveness of variety in presentation, only 4% of the students expressed disagreement on this issue.

Theme 6: Belief that All Students Can Achieve

Under the category of *Building Rapport*, two themes emerged across all four cases in the study. One theme, involved supporting students academically. An obvious goal of education is to provide students with the tools they need to succeed academically. Due to the diverse nature of the classes in this study, the four teachers handled academic support differently with the same goal in mind.

Mrs. Oliver's classroom practices reflected the belief she expressed in the initial interview that students need multiple opportunities for success due to their individual learning styles. She stated in her initial interview,

> I try and use a variety of strategies in the classroom to reach all students. For example, we know that all students learn differently. I try to identify the different needs of my students and just try to find out what works for them. You have so many different learning styles and abilities in the classroom.

She was especially concerned with ensuring that students understood the material and she communicated this concern to her students. For example, while reviewing for a test on world climates, she told her class, “I want to clarify this so you aren’t confused.” She also provided her students with rubrics so that they would understand her expectations. Mrs. Oliver talked slowly, spelled out difficult words, and provided pneumonic devices all as an effort to help her students achieve success in the classroom.

Mrs. Hatch’s students in Physical Science were similar in ability to those in Mrs. Oliver’s Earth/Space Science class. However, Mrs. Hatch encountered students whose academic self-esteem was very low. This situation was illustrated during a class activity on density. Given blocks of different materials, students were measuring volumes and masses, and then calculating densities. A frustrated student revealed his lack of self-confidence stating, “I’m just not good at this stuff!” In response, Mrs. Hatch walked over to his lab group and offered encouragement. Mrs. Hatch indicated that she spends much of her time trying to convince students that they can succeed in the classroom. In the focus group interview she expressed that,

> When they come into my classroom I’m telling them, “You can do this and I’m going to show you how!” The best way to motivate students is to convince them that they can. Once you convince them they can do it, you’ve got them.

Students in the advanced classes of Mrs. Ray and Mr. Benson were highly motivated to succeed academically, and both teachers emphasized that grades were a significant motivator with their students. Because of this desire to succeed, both teachers supported learning primarily by providing positive verbal feedback when their students performed well. While discussing exocytosis, Mrs. Ray encouraged her kids verbally when they responded correctly, stating, “Right! I knew that would come back to you!” During a discussion on amniocentesis in Mr. Benson’s AP Biology class, a student asked, “Couldn’t you fix the chromosome if you found something wrong with it?” Mr. Benson responded, “That’s a good question!” All four teachers perceived that believing in their students had a significant impact on motivation.

Theme 7: Building Caring Relationships

A second theme that fell under the category of *Building Rapport* dealt with student-teacher relationships. All four teachers recognized the importance of communicating a caring attitude to their students. Mrs. Oliver indicated that, “A caring teacher is the most important factor in motivating students.” She expressed her concern for students by learning their names, greeting them at the door, and referring to them by name. Mrs. Oliver often referred to her students as “ladies and gentlemen” and thanked them for demonstrating appropriate classroom behavior.

While Mrs. Oliver demonstrated caring inside the classroom, Mrs. Hatch’s approach to building relationships with her students extended to areas outside the classroom. For example, during a lab activity on pressure differences in which students heated up empty soda cans, then collapsed them in a cold water bath, a student asked Mrs. Hatch about her horses—a topic of mutual interest. Although the topic was unrelated to the lesson, Mrs. Hatch conversed with the student about how her horses were being treated for a hoof problem. Having built a caring relationship with her students, Mrs. Hatch stated that,

> Students show up with a lot of baggage. If we can get them to put that aside to make their head clearer to focus on classroom matters, we can definitely motivate

them. Building rapport is the first step in that direction. Maybe they're willing to try a little more because maybe they think you care.

Taking that thought a step further, Mrs. Ray was a firm believer in communicating her feelings verbally to the students. Her caring attitude was evident as she greeted her students at the classroom door with such comments as, "It's good to see you today!" She also exclaimed to her students each day as they left her class, "Have a nice day!" In the focus group discussion, she expressed the importance of verbalizing to students that she cares about them. She stated that she tells her students, "I care about you-I love you." She was close to tears in the focus group when she stated, "I have genuine concern for students. Everything I do, teach, or say to them is done in love." She also recognized that students enter the classroom with all kinds of personal issues that influence their actions. "You have to look beyond the trash students bring in to see the person inside."

The importance of teacher caring was also reflected by student survey responses. For example, 79% of the respondents agreed that having a teacher who really cared about them made them want to do better in their science class. An even greater number of students, 84%, agreed that it was easier for them to learn from a teacher who made an effort to get to know them. The survey data corroborated the findings of teacher interviews and classroom observations relating to the theme of teacher caring.

Discussion

Motivating students is a significant challenge encountered by virtually every high school science teacher. This study was designed to explore both teacher and student perceptions of motivation and motivational strategies in the science classroom through also studying cases of actual classroom practice and student behavior. Data from interviews and observations in this study supported the findings of previous research which identified specific factors affecting student motivation. These factors include a positive learning environment (Brophy, 2004; Evans, 2004; Theobald, 2006), teacher enthusiasm (Meyer & Turner, 2002; Theobald, 2006; Wiseman & Hunt, 2001), use of scientific inquiry (National Research Council, 2000; Patrick & Yoon, 2004), and variety of lesson presentation (Druger, 2000; Patrick et al., 2000; Wiseman & Hunt, 2001), all of which are controlled by the classroom teacher.

Interviews indicated that teachers recognized the specific impact of the environment of the classroom on student motivation by expressing the importance of creating a climate in which students feel free to participate without fear of ridicule. For example, the focus in Mrs. Ray's classroom was for students to feel comfortable about asking questions and making comments. Not only did the students sing to Mrs. Ray on her birthday, but they also smiled often and participated enthusiastically in class activities. Although Mrs. Ray was quite serious about making sure her students understood such concepts as the function of muscles in the body, she also solicited student input during discussions and activities. Mrs. Ray understood the importance of a positive learning environment on the motivation of her students. This perception reflects the work of Wiseman and Hunt (2001), who indicate that physically and emotionally safe environments where students feel that they belong significantly impact their level of motivation to learn.

Another way that these teachers created a non-threatening learning environment was by presenting the material with a sense of excitement. Interviews revealed that the teachers placed great value on enthusiasm in the classroom and recognized its contagious nature. Enthusiasm was particularly noted in Mr. Benson's AP Biology class, in which one might expect students to have a higher level of motivation to learn. During class observations he demonstrated this enthusiasm for learning by making excited comments and presenting material in an energetic fashion. In the initial interview, Mr. Benson indicated that it would be impossible to communicate enthusiasm to his students if he wasn't personally excited by the material. It was interesting to observe that in response to enthusiasm exhibited during the lesson by both Mr. Benson and Mrs. Ray, students smiled, laughed, and made enthusiastic comments themselves. Research supports this view of enthusiasm as a key component of effective teaching and as a valuable motivational tool (Patrick et al., 2000).

A key finding of this study was the way in which teachers used inquiry in their classrooms. Each teacher focused primarily on teacher-directed inquiry and hands-on activities that were not necessarily inquiry rather than on student-directed inquiry investigations. Initial interview data revealed that three of the participants believed that they routinely used inquiry in their classrooms, and although the teachers shared a deeper understanding of inquiry as somewhat student-directed and open-ended, these same teachers did not implement this form of inquiry. One teacher, Mr. Benson, identified time constraints as a major factor in his limited use of any inquiry. All four teachers acknowledged the value of inquiry in the science classroom and recognized the fact that even implementation of teacher-directed inquiry necessitates time, willingness, and training. Class observations showed that all four teachers were using primarily teacher-guided inquiry lessons to aid in student understanding and to practice basic laboratory procedures rather than student-directed inquiry (National Research Council, 2000). For example, Mr. Benson's students performed several hands-on activities found in the AP Biology laboratory manual. These labs consisted primarily of step-by-step procedures where students were required to follow a particular protocol from the AP lab manual which involved gathering data, such as how fruit flies react to three different stimuli. Observations were made and recorded by the students, and questions in the lab manual were answered based upon the observations made during the activity. Mrs. Oliver's students performed a web quest activity in which they had to investigate world climates and report their findings to the class. They followed a procedure set forth by the teacher and the students worked through this protocol to take a virtual tour of each location, making observations and answering questions along the way. Mrs. Hatch implemented more student-directed inquiry activities in her class than did the other teachers. Her students were given a problem, such as comparing the viscosities of different materials, and then asked to design a demonstration illustrating the differences between these materials. Supplied with a list of materials, her students made observations, collected data, constructed data tables, and shared results with their peers.

An interesting finding from the student surveys was also revealed in the area of inquiry learning. With a significant percentage of the respondents (41%) undecided on whether they would enjoy a lab investigation that did not have a preset procedure, the rest of the students were evenly split between agreeing and disagreeing on this issue. In fact, with almost three-fourths of the students expressing a preference for labs with a step-by-step procedure, it seems that they are either unfamiliar or uncomfortable with student-directed scientific inquiry. Out of curiosity, the researcher separated the student survey responses concerning inquiry for the four cases so that the individual classes could be compared.

Table 2

Student Survey Responses on Inquiry

Teacher	Course Name/Type	Percent With Positive View
Oliver	Earth/Space Science-General Science	30%
Ray	Anatomy & Physiology-Advanced	31%
Hatch	Physical Science-General Science	33%
Benson	AP Biology-Advanced	19%

Surprisingly, the AP Biology students had a more negative view of student-directed inquiry learning than students in the general science classes. Possibly these students were accustomed to following rules and procedures, and were not comfortable with deviating from that pattern. Also, such students may prefer the familiarity of sequential steps and procedures which are easy to follow and generally result in high grades earned simply by following a series of directions. Teacher observations indicated a similar discomfort with student-directed inquiry as the practice was seen only minimally in the classroom.

The concept of variety in lesson presentation was another motivational tool used by these teachers. Changing teaching strategies allowed the teachers not only to lessen student boredom, but also to create an air of expectation in the classroom. In the initial interview, Mrs. Hatch stressed that variety plays a fundamental role in motivating students because it decreases boredom and creates an atmosphere of expectancy. During each class period, Mrs. Hatch kept her students busy and engaged in multiple activities such as bell ringers, class discussions, hands-on activities, guided practice, and demonstrations. Similarly, Mrs. Oliver used multiple strategies to enhance student learning. While some students responded to worksheets and independent work, others enjoyed cooperative activities such as web quests and class presentations. Recognizing the different learning styles of students in her classroom, Mrs. Oliver used variety in her lessons each class period as a strategy to meet their individual motivational and learning needs.

More specific motivational approaches emerging from this study were not found significantly in the literature. These strategies included the use of teacher questioning to engage students in the lesson, building rapport with students, and believing in the academic potential of students who do not believe in themselves. In each case, the teachers in this study not only communicated these specific philosophies during interviews, but also practiced them in their classrooms.

Questioning was used by these teachers to obtain feedback from the students, to check for student understanding, to promote student participation, and to maintain student interest. Although questioning was used in different ways by these teachers, its main purpose was to motivate students and to engage them in the lessons. Interviews and observations reflected the practice of questioning to encourage participation among reluctant learners, as illustrated by Mrs. Oliver who consistently questioned her students to keep them alert. She indicated that she often questions her students just to keep them from falling asleep. Recognizing that her students were often distracted and not engaged in the lesson, Mrs. Oliver used questioning primarily to encourage student interest and participation. Similarly, Mrs. Ray questioned her students to promote engagement by calling on her students by name, while Mr. Benson generally tossed out questions to the entire class to obtain feedback from the group as a whole.

Effective teachers believe every student has the capacity to learn, and that building relationships with students is a critical in recognizing the motivational needs of each student (Theobald, 2006). The concept of caring relationships was expressed by teachers in the interviews and observed in the classroom. Due to differences in the classes, and in teacher personalities, caring was shown in different ways. While Mrs. Oliver's focus was on showing respect to her students by demonstrating politeness, Mrs. Ray verbalized her feelings to the students directly. Mrs. Hatch conversed with students about common interests outside the classroom and Mr. Benson bantered with students in the classroom to build rapport. Each of these teachers communicated caring to the students in their classes and worked to build rapport. Noddings (1995) recognizes the importance of building relationships with students because this sends a message of caring. When students understand this concern, not only will they have a desire to please the teacher, but they will also want to be in the classroom and will be more likely to learn the material (Theobald, 2006). Teachers are in a unique position to earn the right to be heard by showing that they care about students.

Interview data from Mrs. Hatch indicated that she had high academic expectations for her students, and observations revealed that she verbally communicated these expectations to students in the classroom by using such comments as, "You can do this and I'm going to show you how." Mrs. Hatch's students also appeared to demonstrate a lack of self-confidence in their academic abilities which needed to be overcome before they could hope to succeed in her class. A key finding of this study was that such students responded positively when the teacher had high expectations of them and communicated those expectations to them verbally. Responding to Mrs. Hatch's encouragement, her students invariably joined in during class discussions, responded to her questions, and participated in lab activities. Mrs. Oliver promoted student learning through the use of rubrics so that her high expectations were clearly communicated to the students. Additionally, she recognized the different learning styles of her students, and in response she provided multiple opportunities for all of her students to succeed academically.

Further Research

The results of this study indicate that despite the motivational value of inquiry activities, teachers in this school were not using the process to its fullest potential. Teachers seemed comfortable with hands-on activities comprised of sequential steps that offered students practice in basic laboratory procedures; some of which could be characterized as teacher-directed inquiry (National Research Council, 2000). However, these teachers used very little student-directed scientific inquiry. Furthermore, science students at this school were not comfortable with activities that veered away from traditional step-by-step instructions and pre-determined answers. When examined as separate cases, student groups reported surprisingly different perceptions on the use of inquiry in the classroom. Key to further research should be the question of why the most advanced students at this school had the most negative view of inquiry. If such a trend is present at other schools, further research into the underlying causes would be beneficial to teachers who are attempting to implement inquiry into their science classrooms.

A second area of further research is in the study of relating instruction to the scientific world outside the classroom. With very few students indicating that they enjoy scientific challenges and even fewer stating that they would like to pursue a career in science, there is obviously a disconnect between the high school science classroom and the scientific community. Key to further research should be determining if students recognize the myriad of career opportunities available to them in scientific fields, if they have misconceptions about the work done by scientists on a day-to-day basis, or if they even comprehend what a real scientist does. Often school science is not authentic in its mirroring of real science. Literature supports relevancy as a key motivator for students in science (Evans, 2004; Swanson, 1995). Although the Science-Technology-Society movement aims to relate science instruction to the real world (Yager, 2000), such a connection was not evident in the science classes at this school. Although the students in this study expected to perform well in their science classes, they did not see the value in pursuing science after high school. Such a situation does not offer a promising outlook for relieving the current shortage of scientists in the United States (Musella, 2004). Further research is needed to study what differences exist in attitudes toward science and careers in science between student populations who engage in inquiry within the paradigm of school science and those who do so within more authentic, project-based science.

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Appendix A

Initial interview questions for teachers

1. How many years have you been teaching?

2. What subjects have you taught?

3. Tell me about your professional accomplishments (advanced degrees, certifications, etc.)

4. How do you see the teacher's role in motivating his/her students?

5. What strategies do you use that motivate students? Which ones are the most effective?

6. How do you know when a student is motivated? Give a few examples.

7. Comment on the importance of motivation among your science students.

8. How are you an effective motivator? What do you do? Give examples.

9. What factors influence student motivation in your classroom?

10. What should be the teacher's role in engaging his/her students?

11. What are some problems associated with motivating your students?

12. What strategies have worked for you? Why?

13. What strategies have not worked for you? Why not?

15. What is your definition of scientific inquiry?

14. Have you ever used scientific inquiry in your lessons? How often have you used this strategy?

15. Was the use of inquiry effective in motivating your students to learn science? How could you tell?

16. If you have not used inquiry in your science class, is there a particular reason? (discomfort with the strategy, classroom dynamics, lack of training, etc).

17. How do you use laboratory activities to motivate your students? Is this effective for you?

18. Do you feel that it is easier to motivate students in science than in other subjects? Why/not?

Appendix B

Student Survey

Please darken the circle to select the response that best represents your reaction to each statement.
5 = strongly agree
4 = agree
3 = undecided
2 = disagree
1 = strongly disagree

1. I enjoy science.
5 4 3 2 1

2. I am normally motivated in science class.
1 2 3 4 5

3. I am motivated in this class
5 4 3 2 1

4. I enjoy scientific challenges
1 2 3 4 5

5. You have to be motivated to learn.
5 4 3 2 1

6. It is my teacher's responsibility to motivate me.
1 2 3 4 5

7. It is my responsibility to become motivated.
5 4 3 2 1

8. I can learn better by working in groups with other students.
1 2 3 4 5

9. Classrooms discussions are a good way to motivate students.
5 4 3 2 1

10. I believe that achievement is related to motivation.
1 2 3 4 5

11. I enjoy learning more now that I'm in high school than I did in earlier grades.
5 4 3 2 1

12. I would like to pursue a career in science.
1 2 3 4 5

13. I feel that I am a good student.
5 4 3 2 1

14. It’s hard to pay attention in this science class.
1 2 3 4 5

15. I am a better student now than I was in elementary school.
5 4 3 2 1

16. Science is interesting to me.
1 2 3 4 5

17. My science teachers have used scientific inquiry in the classroom.
5 4 3 2 1

18. When we do labs, I would prefer a step-by-step procedure.
1 2 3 4 5

19. I expect to do well in this class.
5 4 3 2 1

20. I think my teacher should reward me for doing my work.
1 2 3 4 5

21. I enjoy project-based assignments.
5 4 3 2 1

22. Teacher enthusiasm has a great influence on my motivation to learn.
1 2 3 4 5

23. Classroom atmosphere has a great influence on my motivation to learn.
5 4 3 2 1

24. Making the lesson relate to student interests is a very important motivator.
1 2 3 4 5

25. I would prefer that my science teacher use a wide variety of instructional strategies rather than just one or two.
5 4 3 2 1

26. It’s easier for me to learn from a teacher who makes an effort to get to know me.
1 2 3 4 5

27. Memorization is an effective learning tool for me.
5 4 3 2 1

28. I would rather do a worksheet in class than a scientific investigation.
1 2 3 4 5

29. I learn effectively by taking notes.
5 4 3 2 1

30. I enjoy taking notes.
1 2 3 4 5

31. I often wonder how things work.
5 4 3 2 1

32. I enjoy scientific investigations that don't have a preset procedure.
1 2 3 4 5

33. My science teacher allows us to have classroom discussions.
5 4 3 2 1

34. Interacting with my friends makes learning more enjoyable.
1 2 3 4 5

35. Having a teacher who really cares about me makes me want to do better in class.
5 4 3 2 1

36. It's important to me that my teachers attend extracurricular events at our school.
1 2 3 4 5

37. Defining vocabulary terms from the back of the textbook is an effective way of learning for me.
5 4 3 2 1

38. My science textbook is interesting.
1 2 3 4 5

Appendix C

Final Semi-Structured Interview Questions

1. Having read over the observational notes I made from your classes, do you feel that they accurately portray what happened in your classroom? Please comment.

2. Do you feel that my interpretations of the events in your classroom are accurate? Explain.

3. How do you feel about what I observed during the study period in light of my original research questions?

Appendix D

Teacher Focus Group Questions

1. Has your view on student motivation changed since the study began? How?

2. Have your motivational strategies changed during this study? How?

3. What do you think is the very best way to motivate students in science? Why?

4. List several factors that have a direct impact on student motivation in your classroom.

5. Do you think about motivation in your classroom more often now than before this study started?

6. Do you now attempt to use more different motivational strategies in the quest for engaging your students? Do you use more of the ones that work for you now? What about others?

Appendix E

Field Note Format

Teacher: **Date:**	**Class:** **Period:**
Descriptive	**Reflective**

CHAPTER FOUR

MOTIVATIONAL STRATEGIES USED BY TWO TEACHERS IN DIFFERENT TRACKED SCIENCE COURSES

Tracking in Science

Compared to other industrialized nations, most American students continue to perform poorly in science (Gonzales et al., 2004; Pratt, 2006). This situation is ironic given the importance that our society places on competence in science and technology. Contributing to the problem is an educational system that tracks students of different measured abilities and fails to recognize the academic potential of every student. Tracking refers to the practice of dividing students into various courses or class sequences based primarily on their proficiency or achievement determined by previous course grades or by standardized test scores (Haury & Milbourne, 1999). Often, tracking is an intentional practice by educators. However, tracking also occurs by student and parent choice as high-achieving students enter Advanced Placement classes. Certain factors influence a student's decision on what type of science class to take in high school, including peer pressure, parental expectations, student interest, and judgments about ability (National Science Foundation, 1994). Research shows that by the time students enter eighth grade, they are already separated into differentiated math classes (Mullis, 1991). Although much research exists on the negative effects of tracking on students of particular ethnicities and socioecomonic status (Ladson-Billings, 1995; Oakes, 2005), there is little literature pertaining to how the practice impacts student motivation and how teachers effectively motivate lower tracked students to achieve academically. Furthermore, it is difficult to locate and study veteran teachers who are excellent motivators of general science students because the most experienced teachers generally have "worked their way up" to the advanced classes in a typical high school, leaving the lower tracked students with less experienced teachers. Historically, teachers have indicated a preference for teaching in the higher ability track (Ball, 1981; Finley, 1984) most likely because students in general science classes tend to exhibit negative behavior and poor attitudes which makes them more challenging to teach in the classroom (Finley, 1984; Taylor, 1993). Often in lower track instruction, topics are omitted and students who respond to questions incorrectly are ignored (Hallam & Ireson, 2003). In fact, Oakes (2005) indicates that there is a type of hidden agenda in schools which encourages the general class students to conform, work quietly, and get along with their peers as teachers proceed more slowly and cover less of the curriculum (Hallam, Ireson, & Hurley, 2005).

All teachers face motivational challenges with their students despite the type of class, and the significance of this challenge cannot be overemphasized. Researchers believe that motivation is absolutely essential to the educational process (Skollingsberg, 2003) because teachers who have the ability to maximize learning by students also obtain the reward of minimizing misbehavior in their classrooms (Wiseman & Hunt, 2001). Research shows that increased motivation leads to improvement in cognitive and behavioral engagement while ultimately resulting in conceptual understanding (Patrick & Yoon, 2004). In the area of science, motivation is recognized as a necessity for initiating and supporting a lifelong interest in learning (National Research Council, 2000).

This study investigated teacher and student perspectives on student motivation and examined specific motivational strategies used by two science teachers as they attempted to enhance student motivation in general and advanced high school science classes. The research questions for this study are: (1) What motivational strategies are espoused and used by these two highly motivational science teachers in general and advanced science courses? and (2) How do tracked science students view these strategies as influencing their own motivation?

The purpose of this paper is to highlight teaching strategies used by these two science teachers, who teach different types of classes, to promote student motivation in science. The issue was approached from the perspectives of the teacher as a researcher, the teachers of the students, and the students themselves. Viewing the situation from a constructivist perspective, data and data interpretations were expressed in the actual words of the participants so that their perspectives reflected reality. The data were interpreted and findings were co-constructed by the researcher and the participants so that the findings would be stronger. Recognizing the differences in potentially motivating students in different tracked science classes, the researcher hoped to learn effective solutions for motivation and student achievement for all science students at this high school.

Teacher Expectations and Instruction

A fundamental belief about effective teaching is that all students have the ability to succeed (Ladson-Billings, 1995). However, expectations of student success have been shown to vary with the ability level of classes (Hallam & Ireson, 2005). Research indicates that teachers of general science classes exhibit lower levels of expectations for their students to achieve than do teachers of AP classes (Lynch, 2000; Oakes, 1990). Teacher expectations have a proven impact on student motivation and achievement. In 1968, researchers conducted what has come to be known as the Pygmalion study (Rosenthal & Jacobsen, 1968). This study concluded that teacher expectations act as self-fulfilling prophesies—student achievement ultimately reflects these expectations. Unfortunately, studies have shown major differences in educator expectations for student learning (Boaler, 1997; Hallam & Ireson, 2005). These expectations, based on student placement in different classes, appear to be justified (Wheelock, 1992). In AP classes, teachers often convey high expectations through fast-paced instruction (Hallam, Ireson, & Hurley, 2005). In contrast, research shows that for many adolescents in the general science classes, high school has become an impersonal environment where low expectations are the norm (Gehring, 2003). These perceptions are communicated to the students who then develop lower expectations for themselves (Boaler, 1997; Hallam & Ireson, 2005). Furthermore, such students are taught by less qualified educators, receive less challenging instruction, and are subsequently less motivated to learn science (Oakes, 2005). On the other hand, students in the more advanced classes receive instruction emphasizing scientific reasoning and inquiry-based activities (Haury & Milbourne, 1999). The challenge for educators is to put aside preconceived expectations and strive to meet the motivational needs of all students. In fact, this practice is a clear goal of both the National Science Education Standards (National Research Council,1996) and the American Association for the Advancement of Science (1990) having adopted a principle of excellence and equity for all students.

Strategies Supporting Motivation in Science Classrooms

Oakes (2005) suggests that what teachers do in the classroom is greatly influenced by the differences among their students in terms of attitudes, abilities, and interests. Teaching strategies in general science classes reflect the fact that these students are often reluctant learners who refuse to work simply because their teacher tells them they should (Daniels & Arapostathis, 2005). Research shows that teachers tend to assign their general science students tightly structured work with a focus on facts, basic skills, repetition, and worksheets (Yerrick, 2000), with few opportunities for critical thinking activities involving analysis, creativity, and independent learning (Haury & Milbourne, 1999). Designed for noncollege-bound students, general science classes are less likely to have a dedicated lab period as part of the class curriculum and also likely to have less money for lab equipment and supplies (Trautmann, Carlsen, Krasny, & Cunningham, 2000). In contrast, students in advanced science courses benefit from enhanced learning opportunities (Yerrick, 2000), more experienced teachers (Oakes, 1990; Trautmann et al., 2000), and instructional strategies involving reasoning and inquiry (Haury & Milbourne, 1999). Students in these classes are often allowed to work independently, and when they give incorrect answers in class, they are offered encouragement (Hallam & Ireson, 2005). These students also benefit from superior lab equipment and science resources due in part to the perception that such students have a greater potential to become scientists than their peers in general science classes (Lynch, 2000). Clearly there are significant differences in the resources available and approaches taken by teachers in different types of science classes.

Teacher Enthusiasm

One of the most important influences on student motivation in high school science is teacher enthusiasm (National Research Council, 1996). To some degree, teacher enthusiasm makes learning more enjoyable while also giving students the impression that mastering concepts is achievable (Coleman, 2001). Literature reveals that enthusiasm is conveyed to students when their teachers project excitement about the learning process (Lynch, 2000; Theobald, 2006). This excitement is associated with energy, involvement, and interest in the subject matter. In the face of such enthusiasm, students are more likely to become excited and thus, motivated to learn as they observe their teachers enjoying their work (Wiseman & Hunt, 2001). When teachers exhibit this kind of enthusiasm, they communicate confidence in their own abilities and in the abilities of their students to learn (Wiseman & Hunt, 2001).

Learning Environment

Teacher enthusiasm positively impacts the learning environment. A positive learning environment conveys to students the message that they can succeed. In other words, teachers should create an inviting physical atmosphere in their classrooms (Brophy, 2004) and strive to create classrooms in which students feel safe and comfortable. Ruggiero (1998) further suggests that the atmosphere in the classroom should emphasize problem-solving, issue analysis, data evaluation, and finding conclusions. Such an environment is conducive to student motivation and academic success.

Student Dialogue

Student dialogue is also an important component of the successful science classroom. Meaningful discussion enhances learning as students work together and realize that their opinions are valued (Theobald, 2006). Solving problem cooperatively not only enhances student motivation (Pintrich & Shunk, 2002), but also prepares students for the scientific world beyond the classroom where their careers will require them to work with others. Teachers who put an emphasis on the social and personal development of their adolescent students play a vital role in fostering engagement and motivation to learn not only science, but also in other academic subjects (McCombs & Whisler, 1997).

Relevant Lessons

Discourse in the classroom may also be used as a tool for promoting the relevance of lessons. For example, Atwater (1996) recommends communication in the classroom connecting the lesson to student culture using relevant stories. Teaching science should not be limited to the acquisition of facts, but instead it should take place within the larger context of student culture and community (Fusco & Calabrese-Barton, 2001). Making science lessons relevant to student interests and experiences is a practice supported strongly in the literature in an effort to educate all students in science (American Association for the Advancement of Science, 1990; Lynch, 2000; National Research Council, 1996; Sanfeliz & Stalzer, 2003). When teachers incorporate life experiences, hobbies, and other student interests into the lesson, motivation is improved significantly (Parsons, 2000).

Hands-On Learning

Another effective motivational strategy in the science classroom is the use of scientific inquiry. Inquiry often incorporates hands-on activities as students make observations and record data during science investigations. However, hands-on activities are not always inquiry-based such as when students construct models of DNA with beads or build muscles with clay. Still, such hands-on activities can be valuable learning tools in the science classroom. Unfortunately, the use of hands-on activities in any fashion is much less common among general science classes than the advanced classes (Yerrick, 2001) because many teachers of these classes prefer to limit student input in an attempt to control learning experiences and keep outcomes predictable (Fine, 1991; Lemke, 1990; Oakes, 1990; Page, 1991). Research indicates that because science teaching in general classes focuses on factual information, student learning is limited (Yerrick, 2001). Such a situation does not negate the fact that all students should be exposed to teaching that gives them an opportunity participate as active learners. Inquiry is key in the promotion of problem-solving activities, communication skills, and thinking processes these students will need to become productive citizens in our society (National Research Council, 2000). Additionally, there is substantial research supporting the impact of inquiry-based instruction on achievement in science for all students (Anderson, 1997; Burkam, Lee, & Smerdon, 1997; Freedman, 1997).

Context of the Study

Setting

The setting for this study was a large suburban high school in the Southeastern United States. The school, which consisted of students in grades ten through twelve, had a diverse student and teacher population. Although the school was located in an affluent community, it also served neighboring areas of lower socioeconomic status. Twelve percent of the student body was eligible for the free/reduced lunch program. Out of the 1,850 students attending this school, 78% were Caucasian, 18% were African American, and 2% were of another ethnicity. There were 110 teachers at the school, 89% of whom were Caucasian and 11% were African American. The school operated on a traditional 4x4 block schedule with each class period lasting 96 minutes. The school system was relatively small, with only one high school, but was growing rapidly in the past several years with the influx of government contract workers and their families. The community was highly educated, and had high academic expectations of the school system.

The science department at this school consisted of fifteen teachers, thirteen of whom held at least a masters certification in science. The school offered a wide variety of classes in order to meet the four required science courses for graduation in the state of Alabama. Each science teacher taught three 96 minute classes each day with a 96 minute planning period. Teacher morale appeared to be high, and the number of teachers in the department has grown consistently for the past sixteen years.

The researcher was a colleague of the teacher participants and was also the science department chair at the high school. Having had twenty years of experience as a science teacher, the researcher has noted that student motivation has been an issue of concern among her peers. Additionally, a principal's survey of the teachers at this school indicated that student motivation was a top concern by the faculty as a whole. This research addressed the issue of student motivation through the lens of a teacher who was immersed in the situation throughout the period of the study. Approaching the study from a constructivist perspective, the researcher collaborated with the participants in the data collection and analysis process to co-construct interpretations.

Participants

The first teacher, Mr. Benson (pseudonym), was a white male with ten years of teaching experience, primarily in biological science. A National Board Certified Teacher, he had complete his inservice teaching at the school in this study, and then taught for several years at a feeder middle school before returning to the high school. The students had a genuine affection for Mr. Benson as evidenced by the fact that over 120 students signed up for his AP Biology class the first year it was offered. During the semester of this study, Mr. Benson taught three classes of Advanced Placement Biology, an elective science class attracting high-achieving students primarily from the 11^{th} and 12 grades. Prerequisites for this class included successful completion of Chemistry I and an A in Biology. Each student in this course was expected to take the AP Biology test and to attend college. Mr. Benson had seven years of teaching experience in such advanced classes as AP Biology and Honors Biology.

The second teacher, Mrs. Hatch (pseudonym), was a white female with twelve years of teaching experience, primarily in physical science. She had been teaching at this school for three years, having moved from another state where she earned her Masters Degree certification. A former professional softball player, Mrs. Hatch not only coached at this school, but she also approached her classes with a team mentality. During the semester of this study, she taught three classes of Physical Science, a general science class designed to meet the basic graduation requirement for a physical science primarily for 10^{th} grade students. Most of the students in this class had made a grade of C or lower in Algebra I and were not ready to take Chemistry. Mrs. Hatch had twelve years of teaching experience in physical science, and had been teaching at this school for three years.

The two cases chosen for this study were selected because both teachers were experienced science educators who had taught more than five years and who expressed confidence during an initial interview in their ability to motivate their students to achieve in their classrooms. Also, the researcher, as department head at this school, knew that these teachers had a reputation for supporting student achievement in their classes. Additionally, each teacher was unique in that the class he/she taught was clearly described as an advanced course (Mr. Benson) or a general course (Mrs. Hatch) the school's science curriculum. The two different types of science courses were selected for this study so that motivational strategies in these different classes could be compared.

Mrs. Hatch's Physical Science class consisted of students who were low achievers overall, who lacked self-confidence in their ability to learn science, and who had taken the class to meet a basic graduation requirement for science. Mrs. Hatch's classroom was very structured, with expectations being clearly communicated to her students. The class rules and procedures were clearly posted in the classroom, and examples of student work such as illustrated posters and Science Olympiad projects were prominently displayed. Her desks were arranged in rows, with a whiteboard at the front of the room and a pull down screen available for Power Point presentations. There was also a bulletin board in the back of the room which displayed student achievements and school announcements. Mrs. Hatch's classroom reflected organization and preparation. A typical day in her classroom involved an introductory bellringer, background information on the topic of the day, a hands-on cooperative activity to illustrate that topic, and a discussion of the results and their relevance to the lesson. Throughout the period Mrs. Hatch encouraged her students to stay on task and interacted with them often as she walked around the room.

Mr. Benson's AP Biology class consisted of students taking the most advanced course in the science department. All of these students were considered to be college-bound, motivated to learn, and conscientious about doing their work. With ten years of experience in teaching biological science classes, Mr. Benson's teaching style was more informal and his class was less structured. His classroom was a biology lab consisting of small tables accommodating two students each with counters, cabinets, and shelves lining the sides and back of the room. The room was decorated with posters of plants, animals, and biological specimens, and live animals such as cockroaches, fish, and lizards inhabited containers on the counters. Students were free to ask questions at any time during class discussions, and they often left their seats to collaborate with other students during group activities. Mr. Benson indicated that he had to work diligently to stay ahead of his students academically by reading ahead in the textbook and keeping updated on current issues in the biological sciences. His students often entered the room asking questions about the lesson or about a current event in science. A typical day in this class started with Mr. Benson questioning students about what they had observed recently that pertained to biology. Generally a class discussion ensued, followed by a lecture, a video clip, and a book assignment covering that day's topic. About once a week the class would have a lab activity prescribed by the AP manual. The lessons were flexible with time allocated for discussion of significant issues in science whenever they arose in the classroom.

Despite the differences in their classes, both Mrs. Hatch and Mr. Benson identified student motivation as an issue of concern in their classrooms that they believed strongly in addressing. The similarities and differences between Mrs. Hatch's Physical Science class and Mr. Benson's AP Biology class provided an interesting case comparison of the strategies used by well-intentioned science teachers to motivate their students for achievement.

Methods of the Study

Data Collection

Taking place over the 2005-2006 academic year, the design of this research incorporated a case study approach (Merriam, 1998). Using only two cases for this study allowed the researcher to clearly focus on the unique differences of each case on the research questions (Stake, 1995) and to study the two cases in depth. By observing these teachers' individual classes, the researcher had the opportunity to address questions of student motivation in an inductive manner, by recording characteristics and details about students as they interacted with other students, the teachers, and objects in the classroom (Beghetto, 2004). Particularly noted were observations of literature-based indicators of student motivation such as the degree to which students appeared to be engaged in the lesson; their willingness to answer questions, their general attentiveness, and their time on task. The researcher recorded specific incidents of students requesting assistance, asking questions about the lesson, demonstrating creativity through comments, displaying a positive attitude, and verbally expressing an interest in learning (Beghetto, 2004).

These two teachers took part in an initial audio-taped, semi-structured interview asking about their professional backgrounds and thoughts on student motivation and their teaching practices supporting it (Appendix A). Additionally, this interview explored such motivational issues as how the teacher participants see themselves and their role as motivators of students, factors they feel affect student motivation, problems they encounter in motivating students, and strategies they believe are effective in engaging students including the use of inquiry and lab activities.

Following the initial interviews, the researcher made seven to eight observations in each teacher's classroom of lessons which the teachers felt were highly motivational or had elements that were highly motivational to students. For every observation, the researcher focused on the same classroom of students for each teacher. The purpose of these observations was to explore specific teaching strategies stated by the teachers and to observe the actual actions of the teachers and their impact on students' achievement oriented behavior in each level of class. During these observations, the researcher recorded field notes concerning classroom environment, teacher demeanor, teaching strategies, context of the lesson, teacher comments, nonverbal student responses, and specific student comments. Field notes made during classroom observations were organized in a chart form listing *Descriptive* and *Reflective* notations as the two main headings (Creswell, 1998). Descriptive notes detailed what the teachers and students said and did in the classroom as it happened. The reflective portion of the chart consisted of the thoughts, reactions, and interpretations of the researcher that occurred immediately after the observation. Particularly noted were observations concerning the degree to which students appeared to be engaged in the lesson; their willingness to answer questions, their general attentiveness, and their time on task (Beghetto, 2004).

Each classroom observation was followed by a debriefing conversation with the teacher concerning the teacher's perceptions related to the effectiveness of the motivational teaching strategies utilized during the observed lesson. Another intent of the debriefing conversation was member checking, giving both participants an opportunity to view the researcher's interpretations of the data and co-construct meaning from it (Lincoln & Guba, 1985).

At the end of the semester, the teacher participants were brought together to take part in a confidential audio-taped focus group interview with the other teachers in the larger study. The focus group discussion was intended to further discern teacher perceptions on motivation as the participants interacted with each other and to clarify data previously collected (Marshall & Rossman, 1999). Taylor and Bogdan (1998) suggest that a major advantage to group interviews is the researcher's opportunity to use group dynamics to gain new insights as the participants interact.

Near the end of the semester, student participants from the two teachers' classes were given a five-point Likert style anonymous survey developed by the researcher. The survey covered student views about motivation and learning, motivation in science class, and specific motivational strategies that emerged in their current science class (Appendix

B). Survey items also covered student perceptions of classroom atmosphere, teacher enthusiasm, and instructional variety; factors in the literature on motivation.

Data Analysis

Data were analyzed using the constant comparative method (Glaser & Strauss, 1967; Merriam, 1995; Strauss & Corbin, 1998) in which the data evolve gradually as they are examined repeatedly. Proceeding simultaneously with the data collection, data analysis began with the transcription of the initial interviews and focus group interview. Teacher interviews, the focus group interview, field notes of observations, and follow-up conversations were initially coded on the research questions using a descriptive method (Strauss & Corbin, 1998). Following the initial data analysis, preliminary categories for each case were set up in matrices to help organize the coded data for each research question (Miles & Huberman, 1994). For example, Mr. Benson discussed his love of the subject in the initial interview and also demonstrated it in the classroom. His love of learning Biology was described under a category labeled, "Enjoyment of Teaching." This category addressed research question one, which sought to identify motivational strategies used by the two teachers in their respective classes. The names of the categories were constantly revised as the data were examined in more detail. For example, the "Enjoyment of Teaching" category ultimately became "Teacher Enthusiasm" as it was refined to encompass specific teacher comments by Mr. Benson such as, "It's a beautiful, beautiful thing!" and, "This is so cool!" While the "Teacher Enthusiasm" category described teacher actions, field notes from the classroom observations described specific student responses to these teaching strategies. For example, Mrs. Hatch enthusiastically exclaimed, "Today I'm going to give you a present-it's a periodic table you can keep!" and her students laughed in response. Student actions in direct response to the teacher's enthusiasm were also listed under the "Teacher Enthusiasm" category.

Next, the researcher read through the data and cited recurring ideas as key words by making notes in the margins. For example, when reading through the classroom observations of Mrs. Hatch, key words included, "movement," "voice," "talking," "social," "positive feedback," and "questioning." In examining the interview transcripts of Mr. Benson, such ideas as "love of subject," "body language," "enthusiasm," and "relaxed atmosphere" emerged. The researcher repeatedly analyzed the data inductively in both cases in this fashion to seek ideas emergent in each case (Taylor & Bogdan, 1998).

As the data sources were examined further, additional categories for each case were identified, labeled, and refined for each case. Throughout the process of data analysis, each code was repeatedly compared to all other codes in an effort to identify patterns, similarities, and differences. Ultimately, final matrices were set up listing the categories as headings which included *Dialogue in the Classroom, Relevant Lessons, Classroom Environment, Inquiry Learning, Lesson Presentation, Building Rapport* and *Teacher Enthusiasm.* Each category was also defined to clarify its meaning. Initially, these seven broad categories were used to facilitate the emergence of differences between the cases. Under each heading, the researcher placed quotes and field notes of descriptively coded data from the various data sources that related to each category. Related data were identified by their data source such as, "initial interview," "classroom observation," or "focus group discussion," and were placed on the matrix under category headings.

Several recurrent ideas emerged through the data analysis process and these were further refined and labeled as themes characteristic to the individual cases. As these themes were identified within the common categories, all previous analyses were reexamined for similar themes (Guba, 1978; Marshall & Rossman, 1999). A new matrix containing the themes of both cases was set up so that the cases could be visualized side by side. Teachers' names were listed along the top of the matrix, and all common categories with supporting themes from each case were listed down the side of the chart. The researcher then examined the data again to highlight which themes emerged more frequently in the data for one case compared to the other. Organizing the data in this fashion allowed the researcher to easily identify individual themes for Mr. Benson and for Mrs. Hatch, all of which emerged strongly from the data.

Student Survey Data

Student survey responses were obtained to address the second research question which explored students' views on the effectiveness of teaching strategies in their individual science classes. The survey responses were examined separately from the other data. Survey data from each teacher's class were compiled separately so that responses from the two classes could be compared. The responses were coded as percentages of the total group of students from that case. For example, in Mrs. Hatch's class, eighteen students responded to the survey item on how interacting with friends makes learning more enjoyable. Out of these eighteen students, fifteen selected "Agree" or "Strongly Agree." These fifteen students represented 83% of the respondents, and this value was reported in the results as the number of students who responded positively to this item. Each survey response was analyzed in this manner to obtain a percent of students who agreed, who disagreed, and who were undecided from each case. The student responses to particular items were then compared to individual themes emergent from the other data sources.

Results

Upon examination of the data, seven significant differences in motivating students emerged between the two cases. From Mr. Benson's AP Biology class, the emergent themes included *Teacher Enthusiasm Excites Students, Promotes a Non-Threatening Environment,* and *Connects Adolescent World to Science.* Themes that emerged from Mrs. Hatch's Physical Science class included *Encourages Student-Student Dialogue, Makes Lessons Relevant Using Practical Applications, Builds Student Self-confidence, and Uses Hands-On Inquiry Activities.* All of these themes were strongly represented by the respective teachers. In each case, the theme was substantiated by at least two data sources including both interview and observational data. Triangulation of these data with student survey responses further validated many of the findings. Student survey data corroborated the motivational themes of teacher enthusiasm, connecting to the adolescent world, cooperative learning, and relevance of the subject. In addition, student survey data provided a general description of the students in each class. For example, in Mr. Benson's AP Biology class, 85% of the students considered themselves to be good students, 90% agreed that science is interesting to them, and 76% indicated that they enjoy science. However, only 48% of the students expressed a desire to pursue a career in science and only 52% agreed that they enjoy scientific challenges. In Mrs. Hatch's Physical Science class, 83% of the students considered themselves to be good students. However, only 50% agreed that science is interesting to them, 37% indicated that they enjoy science, and a mere 22% responded that they would like to pursue a career in science. Overall, the differences between the two groups of students were evident. Mrs. Hatch's students described themselves as good students overall who had little interest in science, while Mr. Benson's students enjoyed science, although most did not necessarily plan to pursue a career in the field.

Mr. Benson's AP Biology Class

Theme 1: Teacher Enthusiasm Excites Students

Showing enthusiasm for the subject was by far the strongest motivational theme exhibited by Mr. Benson. In the initial interview he expressed his view that being excited about the subject is contagious as teacher interest sparks student interest. He stated,

> Well, if the teacher's bored, how are they going to encourage enthusiasm in the students? To me that's one of the most important things in being a good teacher- enjoying what you teach because the students can tell if you like it or not and they can tell if you're enthusiastic or interested in your own subject, and if you're not, you need to find another career.

Mr. Benson seemed to have no problem generating enthusiasm because of his genuine love of Biology. In a debriefing conversation he stated, "Being enthusiastic is easy for me because I love what I teach!" His enthusiastic energy was demonstrated when in a single class period he ran across the room to turn off the light while starting a video presentation, swung a meter stick to point out cell diagrams on a screen, and then used arm gestures to act out the process of DNA replication. In addition to his energetic presentation methods, he also made such comments as “That’s cool!” “Amazing!” and “This is a beautiful, beautiful thing!” in reference to controlling gene expression. The students responded to his enthusiasm, showing obvious engagement by smiling, asking questions, and participating in class discussions. In fact, although many of Mr. Benson’s students raised their hands to ask questions, others seemed too excited to wait their turn and proceeded to ask questions without the teacher calling on them. One student expressed her enthusiasm by exclaiming, “I’m so excited!” after she answered a question on genetic traits correctly. Other student comments were overheard such as, “This is SO cool!” while examining a tree frog, and “I always wondered why. . .” in reference to an observation made during the rolly polly lab. Such student comments verified the effectiveness of Mrs. Benson’s enthusiasm in support of motivation.

Student survey data also emphasized the importance of teacher enthusiasm in motivating science students. When Mr. Benson’s AP Biology students were surveyed, 86% indicated that teacher enthusiasm had a great influence on their motivation to learn. Only 9% of his students surveyed expressed disagreement with this view.

Theme 2: Promotes a Non-Threatening Environment

A safe environment was a major theme embraced by Mr. Benson. In the focus group interview he stated,

> I try to foster a risk-taking environment where students aren’t afraid to ask questions. That’s a really huge thing – if they feel comfortable enough to ask a question that maybe is a stupid question, then maybe they’ll ask it anyways.

In advanced classes like his, such an environment allows the students to expand their learning by questioning without fear of ridicule. For example, during a discussion on DNA replication, a student requested clarification by asking, “How exactly does the strand cut off the end?” Other students also questioned Mr. Benson for clarification on the topic until they understood the concept fully. While covering chromosomal disorders, a student asked, “Mr. Benson, couldn’t you fix the chromosome if you found something wrong with it?” and then, “Couldn’t you, like, remove an extra chromosome?”

Mr. Benson stressed that his personality set the tone for his classroom. In fact, his sense of humor elicited smiles and laughter when he instructed students to, “Open your favorite book!” in reference to their textbooks. His students often picked up on his sense of humor and this was reflected in their comments in class. During the initial interview Mr. Benson stated,

> My students know that I can take a joke and that I’m pretty laid back. And so I think they enjoy repeating things I say, like, “It’s a beautiful thing!” I’ll ask them about something and they’ll say, “It’s a beautiful thing!” It makes it a more relaxed atmosphere, a risk-taking atmosphere, which is good to have.

He also realized that the dynamics of the students can determine the class environment. Recognizing that his AP Biology students generally had few behavioral issues, he felt free to have a less structured classroom. In the final interview he stated,

> I try to keep things light and jovial, partly because that’s pretty much my personality. The class pretty much determines how relaxed I am—which is usually pretty relaxed with my AP classes. I’m probably a lot more flexible than most other teachers.

The relaxed atmosphere in his class was illustrated by students who were allowed to have a “pet” fish for good luck on the lab table during activities. One student even wore an orange paper “thinking hat” to “help” him in class. The “fun” factor was obvious in this class and student smiles and laughter communicated their enjoyment of learning.

Student perception of classroom environment was confirmed through survey responses in which 86% of Mr. Benson’s students indicated that classroom atmosphere had a great influence on their motivation to learn in the science classroom. Only 5% of the students surveyed expressed disagreement with this statement.

Theme 3: Connects Adolescent World to Science

Mr. Benson began every class by asking his students, “Have you seen, read, or heard anything interesting about life science lately?” He used this question to focus his students toward science and to connect the subject to their world outside of the classroom. Mr. Benson also sparked student interest by frequently using relevant stories. For example, while discussing diseases in animals, he told a story of how his cat named Amigo almost died from a parasitic infection, but then was saved by a diet of yogurt and eggs. The cat became fat and healthy, and the class discussed the relationship of this diet to the cat’s recovery. In the initial interview, Mr. Benson expressed the significance of storytelling stating,

> I think it’s (storytelling) very effective. You know, the longer you teach the more anecdotes you use, and the older you get the more they accumulate, and that can make things more interesting. Any time you can bring in a funny story that’s pertinent, it helps them stay awake and focused.

Mr. Benson also used stories to introduce new concepts. For example, during one classroom observation, he was beginning a unit on reptiles and he told the students a story about how his pet snake had escaped from a container in the car while he was driving. Unfortunately the snake hid and was not discovered until the next day on a trip to the store when his daughter discovered it under the back seat and began screaming. Mr. Benson then reached under his desk and produced the very snake in the story! Students showed visible enthusiasm as he allowed them to touch the snake while they examined it and discussed various characteristics of reptiles. This situation resulted in such student questions as, “How does it go to the bathroom?” and “How can you tell the sex of a snake?” Judging from the actions of the students, the combination of storytelling, demonstration, and discussion appeared to be quite effective in sparking student interest.

Another way in which Mr. Benson increased the relevance of his subject was in encouraging students to share their own personal stories. For example, during a lesson on the role of fat in the body, a student told the class that his mother had recently been diagnosed with having an excess amount of brown fat. This story was followed by a class discussion on the characteristics of different types of adipose tissue in the body. Allowing students to share personal stories such as this in the classroom promoted increased discussion and connected the lesson to student interests.

Mr. Benson also made an effort to connect the material to the everyday lives of his students by incorporating popular television shows and movies into his lessons. Students visibly perked up when Mr. Benson used stories related to popular media, many of which appeared to be spontaneously generated. For example, during a discussion on cell metabolism, Mr. Benson compared the abilities of the Keymaster character in The

Matrix to the action of insulin when it shuttles sugar into the cell. Such a comparison enabled the students to visualize an unfamiliar scientific concept in terms they could easily understand. Also, relating the material to popular media often prompted students to participate in the lesson by making comments or asking questions. For example, while discussing a murder/rape investigation on the popular television show, C.S.I., a student asked Mr. Benson, “With only one sperm, can they not make certain identification?” This question resulted in a lively classroom discussion with many students participating.

Student survey data reflected perceptions that corroborate the results of this study. For example, in Mr. Benson’s class, 100% of the students indicated that making the lesson relate to student interests outside of the classroom is a very important motivator. Obviously, this motivational strategy has significant influence in the minds of the students.

Mrs. Hatch’s Physical Science Class

Theme 1: Encourages Student-Student Dialogue

Mrs. Hatch was a big proponent of student-student classroom interactions because she saw the value in learning from peers. In a debriefing conversation, when asked about the use of cooperative learning, she stated, “Sometimes it takes a peer to say the exact same thing you’ve said for them to get it.” Recognizing that student talking was a necessary component of peer interactions, Mrs. Hatch encouraged dialogue in her classroom. In the focus group discussion she described student talking in her classroom saying,

> A lot of talking goes on in my classroom. I think one time I didn't get a job because somebody asked me, "If I walked by your room, what would I hear?" and I said, "A lot of talking." I should have clarified that a little better. But you know, that's what goes on in my room—a lot of talking. If you expect silence from bell to bell, then the interaction and making meaning of the lesson is lost.

To promote peer interactions, Mrs. Hatch encouraged her students to move their desks together to help each other on assignments and to discuss results of lab activities. Once the students understood that they were allowed to consult with each other, they collaborated consistently at appropriate times. For example, during an activity in the lab measuring the temperature of heated sand with a thermometer, a student asked her lab partner, "Why are we wearing goggles?" The partner answered, "Because glass is dangerous!" The two students then continued working cooperatively gathering data from the activity. After the class returned to the classroom, these two students collaborated on constructing a graph of time versus temperature and answering related questions given to them by the teacher.

The effectiveness of student-student dialogue was also revealed in the survey results. For example, 89% of Mrs. Hatch's students responded that they can learn better by working in groups with other students, while 6% disagreed. Additionally, 83% of her students indicated that interacting with their friends makes learning more enjoyable. Only 5% of the students disagreed with this view.

Theme 2: Makes Lessons Relevant Using Practical Applications

Mrs. Hatch stated that one of her favorite things to do in the classroom is to systematically gather background information on her students and integrate it into the subject matter. She questioned her students to gain insight into their world, and then provided them with relevant examples linked to the lesson. For example, in a lesson on speed and acceleration, Mrs. Hatch gave her students an application of the terms by relating the gas pedal in a car to forces of acceleration. She emphasized the scientific process behind speed and acceleration while linking this to something the students understood. However, Mrs. Hatch took her students beyond relevant examples and into the realm of, "Why are we doing this?" during a class activity in which students had to write an obituary of a famous scientist. She began the lesson by asking her students to select a newspaper from a stack in the front of the room, read the obituaries, and list five things common to all of them. Some students had difficulty in locating that section of the newspaper, while others wondered out loud why they were doing this activity. However, Mrs. Hatch finally explained the importance of searching for commonalities in outlining scientific procedures. She always tried to present practical applications for her lessons.

In the final interview, she indicated that she can often be heard telling her students, "This is useful for. . ." For example, she asked her students why we need units and standards of measurement. Students did not know, so she asked the class what they would do if their computer crashed and they had no backup disk. They understood the significance of this example when she explained that standards of measurement are important in the same way that a "backup measuring tool" is needed so that everyone is working with the same tools and the same sizes. In response to this issue, a student brought up the topic of the problems that NASA has had with the Hubble Space Telescope. Mrs. Hatch reminded the students that problems emerged when it was discovered that the scientists who designed and built the Hubble used different measuring systems. This example allowed students to visualize a practical application of scientists working with standard measurements in the real world. In fact, Mrs. Hatch repeatedly emphasized the relevance of her subject in ways that let the students know why the material was important for them to know. Although she used stories and examples, she expanded the discussion to explain to her class why they needed to know the material.

Student survey data also revealed the importance of making lessons relevant to life outside of the classroom. While 56% of Mrs. Hatch's students agreed that making the lesson relate to student interests is a very important motivator, 39% of the students were undecided on this topic. Yet, only 5% of the students expressed disagreement on this issue.

Theme 3: Builds Student Self-Confidence

A major challenge faced by Mrs. Hatch was overcoming students' preconceived ideas about their academic abilities in science. Over many years of teaching, she discovered that her Physical Science students had very low expectations of themselves in terms of academic performance in science, most likely rooted in their prior experiences in the classroom. In the final interview she expressed the view that,

> Students show up with a lot of baggage. If we can get them to put that aside to make their head clearer to focus on classroom matters, we can definitely motivate them. Building rapport is the first step in that direction. Maybe they're willing to try a little more because maybe they think you care.

Mrs. Hatch approached this problem aggressively by clearly communicating her high expectations to her students and by verbally expressing her confidence in their abilities. For example, she gave specific instructions in her grading rubric for solving math problems in physical science, "no unit=no credit, wrong unit=1/2 credit, Got to have units!" so that her students knew exactly what to expect in terms of grading. Also, she communicated high expectations to her students by purposely setting a successful tone prior to a lesson on nuclear decay equations by stating, "You can do this and I'm going to show you how!" Offering encouragement when she observed her students struggling with calculations following a lab on density, Mrs. Hatch exclaimed to the class, "I know you can do this!" Similarly, she praised students for their participation in class by saying, "Good question Jenny, maybe you can be a teacher someday!" when the student asked a question about the previous night's homework on chemical equations. These efforts to boost student self-confidence appeared to show results over the period of this study as students became more visibly confident in their abilities. For example, they began to consult each other for answers rather than the teacher. They also expressed to the teacher a concern for "getting" the material and a need to understand, which are indicators of motivation.

In the focus group discussion Mrs. Hatch expressed personal satisfaction in the success of her students, saying,

> It's amazing to see kids excel in class who've always done poorly in science. So many students hear and feel that they are not capable. I want them to know that the sky's the limit! The best way to motivate students is by convincing them that they can—once you can convince them they can do it, you've got them.

Unlike many documented cases of low expectations for general science students, Mrs. Hatch exhibited high expectations for her students' achievement.

Theme 4: Uses Hands-On Scientific Inquiry

One theme that was reflected by both teachers in different ways was the use of scientific inquiry to enhance student learning. In philosophy, both Mrs. Hatch and Mr. Benson believed that student-directed inquiry was a valuable tool for motivating students in science. However, Mrs. Hatch more clearly demonstrated the use of hands-on student directed and teacher-directed inquiry with the students in her Physical Science class. Recognizing that inquiry was effective in motivating science students, Mrs. Hatch discussed her use of this tool during the initial interview, stating,

> Ideally, it (inquiry) should be when you give students some parameters and they design the method of learning about it or they would set up their own scientific method. We wouldn't give it to them on a piece of paper like, "do this, do this, do this." They should be in charge of designing and we should also incorporate a chance for them to redo the activity.

However, Mrs. Hatch indicated that her biggest challenge to incorporating student-directed activities into her lessons is low self-confidence among her students. During the focus group interview she stated,

> My students don't have a lot of confidence in themselves, so they don't think that they could design an experiment. Most of my problem in motivating students in physical science is that they don't believe that they're good students.

Still, Mrs. Hatch met this challenge and incorporated both student-directed and teacher-directed inquiry activities, primarily investigations performed in the science lab, extensively into her Physical Science class. She noted that her students particularly enjoyed going to the science labs and compared lab activities to gifts for her students.

Desiring to make her students' lab experiences meaningful and relevant to "real" science outside the classroom, Mrs. Hatch encouraged her Physical Science students to take an active role in their own learning. Understanding that student-led inquiry was a valuable, yet uncommon learning experience in general science classes, Mrs. Hatch was determined to expose her students to the process by giving them a few student-directed activities during the semester. For example, she incorporated her view of scientific inquiry, that "kids are in charge of the design," during a lab activity in which the students were given marbles, a stopwatch, and materials with different viscosities. Students then designed a demonstration to illustrate the viscosities of the materials, made observations, collected data, constructed data tables, and shared results with classmates. As students interacted with each other in this activity, they asked each other, "How can you tell when the marble hits the bottom (of the fluid)?" and "What if it doesn't move?" Mrs. Hatch indicated that labs such as this are her most effective student motivator because they provide a chance for students to see and experience a topic instead of just imagining the concept. Rather than telling her students exactly what to do and to expect, Mrs. Hatch stated that she "leaves the door open" for them to make discoveries on their own. Most of the lab activities in this class were teacher-directed. For example, an activity that compared heat to temperature required students to follow a procedure given to them by Mrs. Hatch. In this activity, students measured the temperature change of different masses of water after heating each amount for three minutes. Students were required to take measurements, modify the procedure, and then take more measurements. Mirroring the work of "real" scientists, Mrs. Hatch required her students to gather data, record observations, answer questions, and share results for virtually every hands-on activity, thus incorporating inquiry-based instruction into her Physical Science class on a regular basis.

Discussion

Motivating students to learn is a significant challenge encountered by virtually every high school science teacher. The situation is further complicated by the different behavioral characteristics of students and expectations of teachers of general and advanced science classes. This paper sought insights into the problem of student motivation in different science classes in order to provide effective strategies to deal with the challenge. Utilizing these two cases, the researcher was able to explore individual classes on a deeper level by observing teachers' motivational strategies in practice and student responses to them as well as student surveyed perspectives on them.

Motivating Students in AP Classes

In the area of enthusiasm in the classroom, Mr. Benson exhibited excitement on a regular basis with his AP Biology students. Although Mrs. Hatch also communicated an appreciation of showing enthusiasm in lesson presentation, her Physical Science students expressed more frustration during class and seemed less excited to learn. Her enthusiasm was restrained in part to limit her students' potential for misbehavior, so she channeled her excitement into positive reinforcement for her students by giving them verbal encouragement. Mr. Benson indicated that because his students made the choice to take this advanced class, they did not require such reinforcement, so he used enthusiasm to communicate excitement to his students by teaching in an energetic manner every day. This contagious nature of teacher enthusiasm is supported by the literature as studies have shown that students respond to their teachers' demonstrated love for learning (Theobald, 2006; Wiseman & Hunt, 2001). In fact, Mr. Benson's excitement and obvious love of Biology produced observable achievement-oriented behavior in his students as they smiled, laughed, answered questions, and participated in class discussions. The affinity between Mr. Benson and his AP Biology students resulted in a classroom atmosphere that was relaxed, non-threatening, and risk-free. Mr. Benson's enthusiasm was a definite factor in the informal atmosphere of his classroom (Meyer & Turner, 2002; Theobald, 2006). Mr. Benson worked to make his classroom inviting and non-threatening so that students would feel free to contribute to the lessons (Evans, 2004; Theobald, 2006). Such an environment is conducive to motivation because it allows students an opportunity to become a part of the learning process without fear of derision by their peers (Brophy, 2004; Lynch, 2000). It was quite evident that Mr. Benson's laid back personality contributed to this environment. In fact, interview data supported this perception. Mr. Benson also used what he called "anecdotes" or stories as supplemental material and to connect his lessons to the adolescent world. Comparing cell metabolism to a popular movie, relating genetics to a television series, and soliciting student input were all ways in which Mr. Benson connected his material to life outside the classroom. Often these connections were spontaneous and not completely related to scientific principles. However, Mr. Benson's goal was to enhance student understanding of concepts, and he realized the value of relating these concepts to student interests. While Mr. Benson's class curriculum was largely defined by the AP standards, he showed more daily spontaneity and flexibility in his lessons through the use of stories and humor while connecting the material to events beyond the classroom. Research supports the concept of relating lessons to the "real world" of teenagers in an effort to engage students (McCombs & Whisler, 1997).

An interesting finding in the AP Biology class was the conspicuous lack of significant scientific inquiry as part of the curriculum. Mr. Benson explained that while hands-on inquiry activities—both student-directed and teacher-directed—are valuable learning tools, he felt that for his AP Biology students it was more important to cover the required content and standards he was responsible for teaching in the course. He also felt that book work and discussion were adequate for his students to comprehend the material in the time allotted. Although Mr. Benson explained that the majority of his class is dictated by time constraints and strict AP laboratory requirements, it is conceivable that other factors contributed to the lack of inquiry in his classroom. Possibly, these students, who were so focused on grades, were more comfortable with knowing exactly what they needed to do in order to get an A in the class. In other words, easily copied step-by-step procedures with known outcomes are easy to control, and these students were probably accustomed to controlling their own grades in the classroom. Additionally, survey results indicated that these students preferred to take the easier and more familiar step-by-step route in the science lab. The use of inquiry, with its investigative nature, adds a facet of uncertainty to learning.

Motivating Students in General Science Classes

In her Physical Science class, Mrs. Hatch consistently expected her students to do their best. Mrs. Hatch created an environment of support and caring so that her students understood that she expected them to succeed (Noddings, 1995). Interview data consistently revealed her perception that her students lacked self-esteem and confidence in their academic abilities. However, she never treated her students as if they were somehow inferior to students in other classes. In fact, she made a concerted effort to build student self-confidence by clearly communicating her high expectations to the class and helping her students achieve them. Although research suggests that general science teachers are less qualified and offer less challenging instruction (Oakes, 1990), this was not the case in Mrs. Hatch's Physical Science class. Although her students did express frustration with the material at times, they were never ignored or made to feel stupid. An interesting observation from this study was that there was never any indication from the teacher that this group of students was in a general science class. This fact alone conceivably increased the self-confidence of these students. Evidence of Mrs. Hatch's effectiveness was verified near the end of the semester by the survey results in which her students (83%) described themselves as "good students."

Another motivational tool used by Mrs. Hatch was to present practical applications for the concepts she taught by providing relevant examples and explaining to her students the significance of the activities assigned in her class. It was interesting to note that Mr. Benson's AP Biology students generally participated in class activities without asking for an explanation of the significance. Perhaps his students, accustomed to making good grades, were "trained" to complete tasks for those grades without questioning the importance or relevance of the activities. Although his students appeared to appreciate and enjoy the stories that Mr. Benson used to supplement his lessons, they most likely would have been engaged regardless of this strategy. On the other hand, Mrs. Hatch anticipated problems in convincing her Physical Science students to participate, so she took a proactive stance and explained the importance of activities and relevance of concepts. Her students were less likely to complete tasks or to participate solely for a grade. In addition to the grade, they wanted to know when they would ever use the material and why it was important to learn. Clearly they were more motivated when Mrs. Hatch gave practical applications for scientific concepts. Literature indicates that student motivation is increased when teachers take the time to explain to students the value in a lesson (Daniels & Arapostathis, 2006). This study indicates that while making lessons relevant is an effective motivational strategy for both groups of students, the Physical Science students may obtain a greater benefit from the use of this strategy. While the AP Biology students generally responded to Mr. Benson's anecdotes by smiling, laughing, or nodding their heads, Mrs. Hatch's strategic and practical use of relevant lessons resulted in students who were more seriously engaged in the lesson.

Mrs. Hatch also encouraged her students to work cooperatively. While Mr. Benson also allowed student talking in his classroom, Mrs. Hatch used student-student interactions as a motivational tool. Interview data revealed Mrs. Hatch's perception that student talking in the classroom is beneficial to learning. This view is in contrast to the literature on tracking which indicates that general students are taught to conform and to work alone quietly (Hallam et al., 2005). In fact, the student-student discussions in the Physical Science class were more evident than in the AP Biology class. Mrs. Hatch promoted cooperative activities on numerous occasions both in the laboratory and in the science classroom. Often, she had her students pull their desks together to form groups as they worked. It was intriguing to watch as her students asked each other questions, responded to each other, and made discoveries together. Pintrich & Shunk (2002) recognize the value of these peer interactions on student motivation. However, literature also indicates that general science students have fewer opportunities to interact with each other due to the teacher's fear of potential disciplinary problems (Hallinan, 1994). Possibly teachers are wary of the noise factor or the nature of the in case students veer away from the subject matter and end up discussing something such as the upcoming school dance.

Another interesting finding from this study was the extensive use of inquiry in the Physical Science classroom. Literature suggests that students in advanced level classes are exposed to more reasoning and inquiry activities (Haury & Milbourne, 1999) than general science classes which emphasize learning basic skills, drill and repetition and completion of worksheets (Hallam & Ireson, 2005). Mrs. Hatch's instruction was clearly not in line with this literature. In fact, not only did she use hands-on inquiry activities routinely in her classroom, but student survey results indicated that her Physical Science students had a more positive view of inquiry than did the students in Mr. Benson's AP Biology class. Student survey responses showed surprising results in the area of inquiry. For example, the AP Biology students had a more negative view of student-directed inquiry learning than students in the Physical Science class. 86% of Mr. Benson's students agreed that they would prefer labs with a step-by-step procedure, while only 55% of the Mrs. Hatch's students gave the same response. Of the AP Biology students, 43% preferred a scientific investigation over a worksheet, while 61% of the Physical Science students gave the same response. Additionally, while 33% of the Physical Science students agreed that they enjoyed science investigations that don't have a preset procedure, only 19% of the AP Biology students responded the same way. Overall, these student responses showed consistent differences between the two cases with the Physical

Science students expressing a more open and positive view of student-directed inquiry than their peers in AP Biology.

The findings from Mrs. Hatch's Physical Science class were consistent with literature on teaching strategies to motivate students in more advanced classes. In was interesting to note that her expectations for her students were much like those that Mr. Benson had for his AP Biology students. Equally intriguing was the fact that both groups of students described themselves as good students when they were surveyed near the end of their science courses. However, there were definite differences in how the two groups of students perceived themselves as revealed in the survey, with the Physical Science students having less interest in science and the AP Biology students indicating that they enjoyed science. Perhaps this difference accounts for the varying strategies used by the two teachers in this study.

Implications

The results of this study suggest that students in the Physical Science class respond to such motivational strategies as student-student discussion and hands-on inquiry activities, both of which involve student socialization—a practice that teachers of lower ability students tend to avoid. Perhaps such students have not been given adequate opportunities for learning because teachers are apprehensive of disciplinary problems that may result if they allow students to play a more active role in their own learning. Additionally, these same students responded when the teacher explained the relevance of lessons and communicated confidence in their abilities to succeed in science. The study also confirms the view that AP Biology students respond to such motivational strategies as an enthusiastic lesson presentation, subject matter related to their interests, and a positive learning environment. Comparing motivation in the two types of classes validates the view that the AP Biology students enter the classroom with a higher degree of perceived ability and greater self-esteem than the students in Mrs. Hatch's class. However, the data gathered in the Physical Science class produced surprisingly effective strategies that research indicates are not often used with these students. Given the current state of science education in the United States today, and the looming shortage of scientists in our country, it would be beneficial for teachers of general science students to incorporate some of the strategies in this study into their own science classrooms.

This study showed Physical Science students engaged in the learning process through discussion and scientific inquiry—strategies that are effective with all students, but often not used by general science teachers. Further research is needed in the area of student motivation in general science classes to highlight effective strategies specific to these students. Additionally, the effectiveness of these strategies should be examined related not to only self-esteem, as was indicated by this study, but also to students liking science, developing an interest in science, and pursuing scientific careers. In particular, research is needed on how teacher expectations impact students in different types of classes. Ladson-Billings (1995) suggests that such research should be carried out in the natural setting of the classroom and from the unique perspective of the teacher. If it is true that proven strategies in advanced science classes also work in general science classrooms, one must ask whether such strategies are being used in the lower level classes, and, if not, why this is the case. Perhaps general science teachers avoid the use of these strategies for reasons of classroom management and discipline. In that case, such teachers would benefit from special support and training in how to implement effective strategies in classes that are perceived to be more “unruly.”

Scientific inquiry was used rarely in the AP Biology class in this study due to the time constraints of the AP program and teacher beliefs that for these students, book work and discussion is sufficient for them to understand the material. With abundant research supporting the value of inquiry-based learning, it is surprising that students in the most advanced classes at this school are not consistently experiencing the practice. Further research is needed to determine if this situation is common to other advanced classes, and if so, why this is the case. Additional study of AP science teachers and their use of inquiry would be beneficial to see if AP students are being cheated out of an instructional tool that mirrors the work of real scientists, a situation which could ultimately result in fewer students choosing careers in science.

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Appendix A

Initial interview questions for teachers

1. How many years have you been teaching?

2. What subjects have you taught?

3. Tell me about your professional accomplishments (advanced degrees, certifications, etc.)

4. How do you see the teacher's role in motivating his/her students?

5. What strategies do you use that motivate students? Which ones are the most effective?

6. How do you know when a student is motivated? Give a few examples.

7. Comment on the importance of motivation among your science students.

8. How are you an effective motivator? What do you do? Give examples.

9. What factors influence student motivation in your classroom?

10. What should be the teacher's role in engaging his/her students?

11. What are some problems associated with motivating your students?

12. What strategies have worked for you? Why?

13. What strategies have not worked for you? Why not?

15. What is your definition of scientific inquiry?

14. Have you ever used scientific inquiry in your lessons? How often have you used this strategy?

15. Was the use of inquiry effective in motivating your students to learn science? How could you tell?

16. If you have not used inquiry in your science class, is there a particular reason? (discomfort with the strategy, classroom dynamics, lack of training, etc).

17. How do you use laboratory activities to motivate your students? Is this effective for you?

18. Do you feel that it is easier to motivate students in science than in other subjects? Why/not?

Appendix B

Student Survey

Please darken the circle to select the response that best represents your reaction to each statement.
5 = strongly agree
4 = agree
3 = undecided
2 = disagree
1 = strongly disagree

1. I enjoy science.
5 4 3 2 1

2. I am normally motivated in science class.
1 2 3 4 5

3. I am motivated in this class
5 4 3 2 1

4. I enjoy scientific challenges
1 2 3 4 5

5. You have to be motivated to learn.
5 4 3 2 1

6. It is my teacher's responsibility to motivate me.
1 2 3 4 5

7. It is my responsibility to become motivated.
5 4 3 2 1

8. I can learn better by working in groups with other students.
1 2 3 4 5

9. Classrooms discussions are a good way to motivate students.
5 4 3 2 1

10. I believe that achievement is related to motivation.
1 2 3 4 5

11. I enjoy learning more now that I'm in high school than I did in earlier grades.
5 4 3 2 1

12. I would like to pursue a career in science.
1 2 3 4 5

13. I feel that I am a good student.
5 4 3 2 1

14. It's hard to pay attention in this science class.
1 2 3 4 5

15. I am a better student now than I was in elementary school.
5 4 3 2 1

16. Science is interesting to me.
1 2 3 4 5

17. My science teachers have used scientific inquiry in the classroom.
5 4 3 2 1

18. When we do labs, I would prefer a step-by-step procedure.
1 2 3 4 5

19. I expect to do well in this class.
5 4 3 2 1

20. I think my teacher should reward me for doing my work.
1 2 3 4 5

21. I enjoy project-based assignments.
5 4 3 2 1

22. Teacher enthusiasm has a great influence on my motivation to learn.
1 2 3 4 5

23. Classroom atmosphere has a great influence on my motivation to learn.
5 4 3 2 1

24. Making the lesson relate to student interests is a very important motivator.
1 2 3 4 5

25. I would prefer that my science teacher use a wide variety of instructional strategies rather than just one or two.
5 4 3 2 1

26. It's easier for me to learn from a teacher who makes an effort to get to know me.
1 2 3 4 5

27. Memorization is an effective learning tool for me.
5 4 3 2 1

28. I would rather do a worksheet in class than a scientific investigation.
1 2 3 4 5

29. I learn effectively by taking notes.
5 4 3 2 1

30. I enjoy taking notes.
1 2 3 4 5

31. I often wonder how things work.
5 4 3 2 1

32. I enjoy scientific investigations that don't have a preset procedure.
1 2 3 4 5

33. My science teacher allows us to have classroom discussions.
5 4 3 2 1

34. Interacting with my friends makes learning more enjoyable.
1 2 3 4 5

35. Having a teacher who really cares about me makes me want to do better in class.
5 4 3 2 1

36. It's important to me that my teachers attend extracurricular events at our school.
1 2 3 4 5

37. Defining vocabulary terms from the back of the textbook is an effective way of learning for me.
5 4 3 2 1

38. My science textbook is interesting.
1 2 3 4 5

Appendix C

Final Semi-Structured Interview Questions

1. Having read over the observational notes I made from your classes, do you feel that they accurately portray what happened in your classroom? Please comment.

2. Do you feel that my interpretations of the events in your classroom are accurate? Explain.

3. How do you feel about what I observed during the study period in light of my original research questions?

Appendix D

Teacher Focus Group Questions

1. Has your view on student motivation changed since the study began? How?

2. Have your motivational strategies changed during this study? How?

3. What do you think is the very best way to motivate students in science? Why?

4. List several factors that have a direct impact on student motivation in your classroom.

5. Do you think about motivation in your classroom more often now than before this study started?

6. Do you now attempt to use more different motivational strategies in the quest for engaging your students? Do you use more of the ones that work for you now? What about others?

Appendix E

Field Note Format

Teacher: **Date:**	**Class:** **Period:**
Descriptive	**Reflective**

CHAPTER FIVE

CONCLUSIONS

Motivating students in science is a challenge faced in practically every high school across the nation. This study sought to explore both teacher and student perceptions of motivation and to identify successful motivational strategies used by teachers in the science classroom. The qualitative nature of this study allowed results to emerge that could only be described through such an in-depth case study approach. The first part of the study explored effective practices used in common by four science teachers who described themselves as being highly motivational. In the second part of the study, the issue of tracking in science and its relationship to student motivation was examined. Specifically, this focus on tracking provided insight into the similarities and differences in motivation for both advanced and general science students and strategies used by the teachers of these different classes.

Commonalities Among the Cases

Student motivation in science is a multi-faceted issue. While such influences as prior academic experiences, student home life, and socioeconomic status cannot be altered by the classroom teacher, other contextual influences such as classroom environment and teaching style can be modified to meet the motivational needs of students. In this study, teachers who used hands-on activities, communicated high expectations to their students, projected enthusiasm in their presentations, used questioning effectively, built caring relationships with their students, and incorporated a variety of activities into their lessons, were effective motivators of their students. Each one of these strategies came up in this study.

The overall classroom environment is a contributing factor to the support of student motivation. The teachers in this study all recognized that students who feel comfortable in the classroom are more likely to participate in the lesson and to be engaged in lab activities. Mr. Benson’s relaxed personality set a non-threatening tone in his classroom as he joked with students, related stories during the lesson, and allowed students to comment freely. Similarly, Mrs. Ray’s students demonstrated their comfort in the classroom when the entire class sang to her on her birthday. All of the teachers expressed the view that classroom climate plays a vital role in whether or not students feel free to ask questions, contribute to class discussions, and participate in lab activities.

Hands-on activities were found to be an effective motivator when they were used to help students understand concepts. Because science is inherently a hands-on subject, science teachers are in a unique position to use this strategy to enhance learning and mirror the work of real scientists. All of the teachers in this study used hands-on activities to promote student learning, particularly in the science lab.

Effective teachers also recognized the value of communicating high expectations to their students. Mrs. Oliver’s goal was to clearly state her expectations through the use of rubrics so that students understood exactly what she wanted them to do. Similarly Mrs. Hatch clarified assignments by posting lab safety rules, classroom procedures, and due dates in her classroom. Mrs. Ray and Mr. Benson primarily used verbal comments to support and encourage their students during class discussions. All four teachers anticipated the academic success of their students and communicated these expectations clearly to the students in their classrooms.

Another successful motivational strategy used by all the teachers in this study was enthusiasm in lesson presentations. The enthusiasm exhibited by these teachers was reflected in student actions and comments. Mr. Benson's love of learning science seemed to be uncontained and he communicated this excitement effortlessly to his students through body language and exclamations made during the lesson. Mrs. Ray's enthusiastic comments were used to spice up her presentations and students responded with smiles. Mrs. Hatch used enthusiasm to celebrate success in the classroom when her students gave correct answers. Her students visually responded to her comments by actively participating in classroom activities. Each teacher used enthusiasm in the classroom to support student motivation.

The use of questioning by all four teachers was effective in engaging students in the lesson. Mrs. Oliver consistently asked her students questions to keep them awake and focused on the lesson. She also felt that questioning required her students to think more critically about scientific concepts. Similarly, Mrs. Ray often asked her students "why" questions to stimulate higher order thinking and to expand classroom discussions. All of the teachers provided adequate time for students to respond to questions, and students were also encouraged to ask their own questions.

Building caring relationships with students was another effective motivational strategy used by all the teachers in this study. Communicating a caring attitude was expressed by teachers learning the names of their students, greeting them at the classroom door, and referring to them by name during class discussions. Mrs. Ray, in particular, fostered a relationship with her students by verbalizing her feelings to them. They appreciated her concern and responded to her welcoming comments as they entered her classroom each day. Rapport with students was also demonstrated beyond the classroom by Mrs. Hatch who discussed horses with a student who shared that interest. All of the teachers demonstrated caring for their students, and each considered the fostering of student-teacher relationships to be an integral part of motivating their students for academic success.

A final motivational strategy used by these teachers was the incorporation of variety or multiple event changes in their lesson presentation. All four teachers reported that variety was key to student engagement. Changing teaching strategies allowed teachers not only to lesson student boredom, but also to create an atmosphere of expectancy in the classroom. Mrs. Oliver indicated that meeting the different learning styles in her classroom necessitated a variety of activities. Similarly, Mr. Benson expressed the view that students prefer multiple approaches, and that he did not want to become stale in his teaching by using only a few teaching strategies. All four teachers kept students engaged by consistently incorporating several activities into each class period.

Strategies in Different Tracks

This study showed different motivational techniques used by teachers in advanced and general science classes. The advanced class, AP Biology, was taught by Mr. Benson.

His classroom demeanor was relaxed, informal, and spontaneous. The general science class, Physical Science, was taught by Mrs. Hatch, whose classroom was more structured and organized. Both teachers successfully motivated their students to learn, although there were clear differences in their approaches.

The AP Biology Class

The students in Mr. Benson's class had all met academic prerequisites for AP Biology, were all planning to attend college, and most were scheduled to take the AP test at the end of the semester. These students were generally competitive for grades and were motivated to succeed academically. Still, Mr. Benson indicated that keeping them engaged on a day to day basis was a challenge.

Overall, the AP students responded to Mr. Benson's enthusiastic lesson presentation, the non-threatening atmosphere of his classroom, and his anecdotal stories that added relevance to the material. By far the most obvious characteristic of this advanced class was Mr. Benson's obvious love of the subject and the enthusiasm he regularly communicated to his students. His excitement for the material elicited smiles from the students upon several occasions as they exhibited similar enthusiasm. The affinity between Mr. Benson and his AP Biology students resulted in a relaxed classroom environment. It was evident that the students felt free to ask questions and to share their opinions during class discussions. Mr. Benson was skilled at encouraging abundant student expression in the classroom without allowing the atmosphere to become chaotic. The students in this class were social, but not to the point of being disruptive. The demeanor of the students allowed Mr. Benson to use anecdotal stories to supplement his lessons. Often spontaneously incorporated into the lesson, Mr. Benson indicated that storytelling was one of his favorite motivational tools. Referring to these stories as "anecdotes," Mr. Benson brought increased relevancy to his lessons by making connections to the adolescent world by using examples from movies, television shows, and everyday life. The students responded positively to this strategy. In fact, they sometimes contributed their own "anecdotes" to classroom discussions.

A key finding in this study was the lack of scientific inquiry used in this AP class. Although Mr. Benson appreciated the value of inquiry learning, he expressed frustration with the time constraints placed upon him by the rigid AP curriculum. He also perceived that his students could sufficiently learn the required concepts through class discussion and book work. Although he was open to using inquiry activities, he felt pressured to complete the AP curriculum and did not see sufficient time to implement inquiry-based activities. Surprisingly, his AP students also expressed a negative view of inquiry as indicated by the survey results. Conceivably, the investigative nature of scientific inquiry adds a facet of uncertainty to learning, and these students were uncomfortable with the practice.

The Physical Science Class

Mrs. Hatch's Physical Science class consisted of students who were attempting to meet the basic graduation requirement for a physical science, and some had previously failed the course. Many of these students were not college-bound, and Mrs. Hatch indicated that they suffered from a lack of academic self-confidence. Recognizing her students' low expectations of themselves, Mrs. Hatch confronted them with her own high expectations for their performance and achievement. In contrast to much of the literature on what goes on in general science classes, Mrs. Hatch treated her students as if they could succeed, and they did not disappoint her. In fact, as the semester progressed, these students gained enough self-confidence that most of them described themselves as good students in the survey administered near the end of the semester.

While many general science teachers deal with discipline problems and rarely allow their students to experience hands-on lab activities, Mrs. Hatch made an effort to engage her students in hands-on activities on a regular basis. Her instruction was extremely lab-oriented and inquiry-based, with her students consistently engaged in such activities as density determination, metric conversions, viscosity comparisons, and pressure changes, all in the science laboratory. Mrs. Hatch consistently required her students to gather data, make observations, manipulate variables, interpret findings, and share results. Her students responded positively to inquiry-based instruction and seemed comfortable with the practice. All hands-on activities were cooperative in nature and student discourse was used as a motivational tool for learning science. In fact, the student-student interactions in the Physical Science class were more evident than in the advanced class. It was intriguing to watch as these students asked each other questions, responded to each other, and made discoveries together. Mrs. Hatch recognized the value of these peer interactions on student motivation and promoted them both in the lab, and in the classroom.

Mrs. Hatch methodically explained to her students the significance of her lessons and often provided practical applications for scientific concepts. It was interesting to note that while Mr. Benson's advanced students participated in class activities with little encouragement, Mrs. Hatch anticipated motivational challenges and took a proactive stance by explaining the relevance of concepts. Her students visually responded to the examples she used to supplement her lessons by participating in discussions and asking relevant questions. Her emphasis on the scientific applications of concepts was very focused and organized. In contrast, Mr. Benson's approach included spontaneous stories related to the lesson that emerged during classroom discussion. His presentation was more flexible, as he took time to expand on comments and questions from his students. In both cases, student motivation was enhanced by teachers making the lessons relate to student interests outside the classroom.

Trustworthiness and Rigor

While quantitative researchers use a variety of methods to establish validity and reliability of a study, qualitative studies require the establishment of credibility throughout the research process. Consistent with the objectives of qualitative research, the work of Lincoln and Guba in the 1980's has resulted in the subtle replacement of the terms "validity" and "reliability" with "trustworthiness" and "rigor." These newer terms encompass four aspects of qualitative research: the credibility of the study, the transferability of research, the dependability of the findings, and the confirmability of the results (Lincoln & Guba, 1985). Because qualitative research has a unique philosophical base and different data collection methods, rigor is established using methods consistent with a qualitative study design. To attain trustworthiness, Guba and Lincoln (1981) recommend such specific strategies as repeated observations, peer debriefing, prolonged engagement, and member checks. Similarly, Merriam (1998) suggests that the credibility of a study may be enhanced through the use of triangulation of the data by which findings are confirmed by multiple methods, and the incorporation of member checking, in which the participants affirm the credibility of the results.

This study incorporated many of these strategies to increase trustworthiness. At least seven classroom observations were performed of each teacher participant, reducing the possibility of artificiality among the teachers. Each 96 minute observation was followed by a debriefing conversation in which the researcher shared her field notes with the teacher and accuracy of representations was discussed. For example, in one lesson the teacher repeatedly referred to a guest speaker from the previous week. A debriefing conversation revealed that the speaker was a nurse who had made a presentation about her career in the medical field. Several informal conversations also occurred during which the researcher asked for clarifications on such issues as a teacher's perception of the nature of scientific inquiry. Data from the numerous observations and conversations enabled the researcher to clearly triangulate what the teachers said with what they did. Although the study took place over a period of four months, the researcher's position as a science teacher at the school allowed for continuous engagement before, during, and after the study. Throughout the process of data collection and analysis, the participants were encouraged to review the researcher's preliminary interpretations to incorporate member checking of the results. Throughout the study, the teacher participants had access to the researcher's transcripts and field notes. Triangulation of the data was also used as a tool for enhancing credibility as different data sources were compared for consistency. For example, comments made by the teacher participants were often reflected in classroom observation data. Also, student survey responses generally mirrored effective teaching strategies described and demonstrated by the teachers during instruction.

Lincoln and Guba (1985) recommend a focus on the consistency of the findings obtained from the data rather than an emphasis on a replication of the results in other studies. In fact, the very nature of a case study approach limits the ability to generalize the findings to other settings (Yin, 2003). However, Stake (1995) indicates that the constructivist view does not eliminate generalizations altogether. Instead, a constructivist approach in case studies provides the readers with rich, thick descriptions (Geertz, 1973) allowing them to make their own generalizations in similar situations. Ensuring that the study's results make sense based on the data should be the main focus for the qualitative researcher (Merriam, 1998). According to Yin (2003), case studies use direct observation and interviews to provide a more comprehensive view of the particular situation and these sources of data may be used to support reliability in the study through the use of data source triangulation (Stake, 1995). No generalizablity is expected in such an approach except that which fits similar contexts with the reader.

Limitations of the Study

One limitation of this study was that the researcher was a science teacher and department chair at the school and a colleague of the teacher participants in this study. Although the student participants were not members of the researcher's class, some of the students knew the researcher by name from having been in her class the previous year. As science department chair, the position of authority that the researcher had over the participants was a limitation of this study. The department chair position entails class scheduling decisions, teaching assignment decisions, and control of money for purchasing equipment. The teachers might have been subtly intimidated, resulting in a more artificial environment as teachers avoided negative comments during interviews and put on their best performances during classroom observations. This situation possibly impacted the trustworthiness of the data.

Another limitation of this research was the small number of participants. However, the purpose of this study was to examine teacher and student perceptions and behavior in detail, and this was best accomplished by focusing closely on a small number of participants (Patrick & Yoon, 2004). As suggested by Padgett (1998), becoming saturated with information about the subject is accomplished by an emphasis on quality rather than quantity. Although the results of this study cannot necessarily be generalized to the larger population (Guba & Lincoln, 1985), the foundation of case study research is particularization rather than generalization because the goal of the researcher is to understand and emphasize the uniqueness of a particular case (Stake, 1995). To address this objective, a holistic approach was used, including classroom observations, field notes, interviews, a focus group discussion, and surveys, all of which were compared to obtain a comprehensive view of student motivation strategies at this school. Merriam (1998) indicates that in qualitative case studies, rather than providing a general perspective, the researcher should extrapolate data from the context-bound situation and ensure that the results are true for that particular situation. Additionally, these results could be generalized to other classrooms in this school setting due to the same context and population of students.

Final Recommendations

All science students can benefit from instructional strategies that have been shown to increase motivation. In the implementation of these strategies, teachers must recognize the diverse learning styles of the students in their classes, and use a variety of motivational tools to meet these different needs. By incorporating the strategies shown to be effective in this study, teachers have the capability to motivate students in all science classes.

There is a definitive need to replicate this study at other high schools so that the results could be compared to those from other populations. Specifically, motivational research is needed in rural settings and in schools with large Hispanic and African American student and teacher populations. Results from such studies of more diverse classrooms would provide valuable information for teachers hoping to increase motivation among students of diverse populations.

In every science class, teaching should be approached with enthusiasm. An energetic presentation by the teacher shows students that the material is neither stale nor boring. In fact, when teachers project enthusiasm in their lessons, science can be perceived as exciting. Incorporating enthusiasm into the presentation is not a difficult or time-consuming strategy for teachers who genuinely appreciate the subject.

All science students should be expected to succeed academically. Not only should teachers clearly communicate this expectation to their students, but teachers should also give them every opportunity to meet this goal. One way to accomplish this task is by using a variety of strategies in the classroom. This study revealed that not only do effective teachers incorporate variety into their lessons to reach students with different learning styles, but also that variety adds an atmosphere of expectancy to the class, thus alleviating student boredom. Because the class atmosphere is an integral factor in student motivation, teachers should strive to create a class environment in which students feel free to participate in discussions and activities. This study emphasized the fact that a non-threatening environment in the classroom supports student motivation to learn.

Effective science teaching would not be complete without hands-on activities. As this study showed, hands-on learning is not only highly motivational, but also an ideal way to mirror the work of real scientists. Hands-on learning requires students to become involved in the lesson and gives them an opportunity to experience the material in a more kinesthetic manner than traditional lecture. Laboratory activities in particular should be used by teachers to generate interest in science among their students.

This study showed that all the teachers questioned their students consistently. In the science classroom, effective teachers should make use of questioning techniques not only to keep students on task, but also to check for understanding and to expand the thinking of their students. Classroom discussions can be greatly enhanced by teacher questions, and student responses allow teachers to gauge the effectiveness of their instruction.

Finally, one of the most important reasons for teaching is to positively impact the lives of our students. The first step in that direction is building relationships with students and letting them know we care. The teachers in this study placed great emphasis on the motivational value of teacher-student rapport. All teachers should strive to develop positive relationships with their students and thus earn the right to be heard.

This study showed that students in the advanced classes respond to motivational strategies specific to their needs. While these students may enter the classroom with a certain drive to succeed, they are still teenagers who face the same distractions common to their peers. Effective science teachers should be enthusiastic in their delivery of the lesson and genuine in their love of the subject. In this study, the AP Biology teacher's enthusiasm was communicated easily to the students and they responded with their own excitement for learning. Such enthusiasm supports a positive learning climate and a non-threatening atmosphere which is also key to supporting student motivation. Advanced level teachers are in a unique position to tailor their instruction to students who have chosen to take their class. Because these students have at least some prior interest in the material, the teacher should take full advantage of whatever curiosity may be present. In fact, the effective advanced class teacher makes use of student interests by incorporating them into the lessons. With AP students generally presenting few discipline problems, the teacher has the flexibility to add material, such as relevant stories, to the lesson when topics come up in class discussions.

Although the AP Biology teacher in this study did not incorporate significant scientific inquiry into his lessons, the value of this practice cannot be overlooked. All students should have the opportunity to have a stake in their own learning through the use of inquiry. As college-bound students and potential science majors, students in advanced classes would particularly benefit from inquiry-based lab activities that mirror the work of real scientists.

Among the Physical Science students in this study, one particular characteristic noted was a lack of self-confidence. It is reasonable to conclude that general science students face this issue to a greater degree than their peers in advanced classes. Addressing low self-esteem is a special challenge for the general science teacher. In this study, the Physical Science teacher clearly communicated high expectations to her students and the students responded positively. Ideally, all general science teachers should express confidence in their students' abilities with the expectation of success. Once this positive attitude is communicated to the students, they often respond with increased motivation to learn.

The Physical Science students in this study responded to specific strategies that are not commonly used in general science classes. Ideally, teachers in these classes should incorporate more student socialization into their classrooms. As this study showed, general science students respond positively when they are allowed, even encouraged, to talk to each other constructively in class. This idea may cause discomfort for teachers with classes having the potential to be "unruly." However, with proper training, general science teachers can learn how to manage the behavior of their students and provide them with learning opportunities they may not have experienced in previous science classes. For example, the use of scientific inquiry is even less common among students in general classes than those in more advanced courses. The teacher in this study used hands-on inquiry activities routinely and her students responded. Effective teachers of general science classes should consider implementing inquiry instruction into their lessons. Assuming that these students have not experienced this type of learning in past science classes, it is conceivable that they will be more motivated to learn as they are exposed to this new strategy.

This study showed similarities and differences between the motivational strategies used by high school science teachers in different types of classes. It was evident that the teaching strategies used by these teachers were effective in motivating students to become engaged in learning which can support overall academic achievement in science. From these similarities and differences, effective strategies have been identified that can be used by high school science teachers to motivate their students.

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APPENDIX A

Initial interview questions for teachers

1. How many years have you been teaching?

2. What subjects have you taught?

3. Tell me about your professional accomplishments (advanced degrees, certifications, etc.)

4. How do you see the teacher's role in motivating his/her students?

5. What strategies do you use that motivate students? Which ones are the most effective?

6. How do you know when a student is motivated? Give a few examples.

7. Comment on the importance of motivation among your science students.

8. How are you an effective motivator? What do you do? Give examples.

9. What factors influence student motivation in your classroom?

10. What should be the teacher's role in engaging his/her students?

11. What are some problems associated with motivating your students?

12. What strategies have worked for you? Why?

13. What strategies have not worked for you? Why not?

15. What is your definition of scientific inquiry?

14. Have you ever used scientific inquiry in your lessons? How often have you used this strategy?

15. Was the use of inquiry effective in motivating your students to learn science? How could you tell?

16. If you have not used inquiry in your science class, is there a particular reason? (discomfort with the strategy, classroom dynamics, lack of training, etc).

17. How do you use laboratory activities to motivate your students? Is this effective for you?

18. Do you feel that it is easier to motivate students in science than in other subjects? Why/not?

APPENDIX B

Student Survey

Please darken the circle to select the response that best represents your reaction to each statement.
5 = strongly agree
4 = agree
3 = undecided
2 = disagree
1 = strongly disagree

1. I enjoy science.
5 4 3 2 1

2. I am normally motivated in science class.
1 2 3 4 5

3. I am motivated in this class
5 4 3 2 1

4. I enjoy scientific challenges
1 2 3 4 5

5. You have to be motivated to learn.
5 4 3 2 1

6. It is my teacher's responsibility to motivate me.
1 2 3 4 5

7. It is my responsibility to become motivated.
5 4 3 2 1

8. I can learn better by working in groups with other students.
1 2 3 4 5

9. Classrooms discussions are a good way to motivate students.
5 4 3 2 1

10. I believe that achievement is related to motivation.
1 2 3 4 5

11. I enjoy learning more now that I'm in high school than I did in earlier grades.
5 4 3 2 1

12. I would like to pursue a career in science.
1 2 3 4 5

13. I feel that I am a good student.
5 4 3 2 1

14. It's hard to pay attention in this science class.
1 2 3 4 5

15. I am a better student now than I was in elementary school.
5 4 3 2 1

16. Science is interesting to me.
1 2 3 4 5

17. My science teachers have used scientific inquiry in the classroom.
5 4 3 2 1

18. When we do labs, I would prefer a step-by-step procedure.
1 2 3 4 5

19. I expect to do well in this class.
5 4 3 2 1

20. I think my teacher should reward me for doing my work.
1 2 3 4 5

21. I enjoy project-based assignments.
5 4 3 2 1

22. Teacher enthusiasm has a great influence on my motivation to learn.
1 2 3 4 5

23. Classroom atmosphere has a great influence on my motivation to learn.
5 4 3 2 1

24. Making the lesson relate to student interests is a very important motivator.
1 2 3 4 5

25. I would prefer that my science teacher use a wide variety of instructional strategies rather than just one or two.
5 4 3 2 1

26. It's easier for me to learn from a teacher who makes an effort to get to know me.
1 2 3 4 5

27. Memorization is an effective learning tool for me.
5 4 3 2 1

28. I would rather do a worksheet in class than a scientific investigation.
1 2 3 4 5

29. I learn effectively by taking notes.
5 4 3 2 1

30. I enjoy taking notes.
1 2 3 4 5

31. I often wonder how things work.
5 4 3 2 1

32. I enjoy scientific investigations that don't have a preset procedure.
1 2 3 4 5

33. My science teacher allows us to have classroom discussions.
5 4 3 2 1

34. Interacting with my friends makes learning more enjoyable.
1 2 3 4 5

35. Having a teacher who really cares about me makes me want to do better in class.
5 4 3 2 1

36. It's important to me that my teachers attend extracurricular events at our school.
1 2 3 4 5

37. Defining vocabulary terms from the back of the textbook is an effective way of learning for me.
5 4 3 2 1

38. My science textbook is interesting.
1 2 3 4 5

APPENDIX C

Final Semi-Structured Interview Questions

1. Having read over the observational notes I made from your classes, do you feel that they accurately portray what happened in your classroom? Please comment.

2. Do you feel that my interpretations of the events in your classroom are accurate? Explain.

3. How do you feel about what I observed during the study period in light of my original research questions?

APPENDIX D

Teacher Focus Group Questions

1. Has your view on student motivation changed since the study began? How?

2. Have your motivational strategies changed during this study? How?

3. What do you think is the very best way to motivate students in science? Why?

4. List several factors that have a direct impact on student motivation in your classroom.

5. Do you think about motivation in your classroom more often now than before this study started?

6. Do you now attempt to use more different motivational strategies in the quest for engaging your students? Do you use more of the ones that work for you now? What about others?

APPENDIX E

Field Note Format

Teacher: Date:	Class: Period:
Descriptive	**Reflective**

APPENDIX F

Category Matrix

Lesson Presentation Def: Varying instructional approaches and strategies creates increased student interest.	**Dialogue in the Classroom** Def: Discussion between students and teachers and between students and students promotes motivation	**Teacher Enthusiasm** Def: Student motivation is enhanced when teachers exhibit enthusiasm for the subject matter they teach.	**Building Rapport** Def: Impacting student motivation by developing relationships with students, communicating high expectations, and offering encouragement, thereby allowing teachers to connect with their students	**Classroom Environment** Def: A positive, non-threatening class atmosphere can spark student interest.	**Relevant Lessons** Def: When teachers make their instruction relevant to the real world of the adolescent, more students will be engaged	**Inquiry Learning** Def: Allowing students to experience science as a dynamic process through questioning, investigation, discovering, and sharing to tap into the natural curiosity of students and thereby increase their motivation.

APPENDIX G

Cross Case Theme Matrix

R	B	O	H	THEMES	CATEGORIES
				1. Uses a variety of approaches	**Lesson Presentation** Def: Varying instructional approaches and strategies creates increased student interest.
				2. Changes strategies often each class period	
				3. Adjusts the pace of covering the material	
				1. Promotes cooperative learning	**Dialogue in the Classroom** Def: Discussion between students and teachers and between students and students promotes motivation
				2. Uses questioning effectively	
				3. Facilitates meaningful class discussion	
				4. Encourages student participation	
				1. Teacher comments convey enthusiasm	**Teacher Enthusiasm** Def: Student motivation is enhanced when teachers exhibit enthusiasm for the subject matter they teach
				2. Presentation is energetic	
				3. Encourages students to be enthusiastic	
				4. Demonstrates a sense of humor	
				1. Provides feedback to students	**Building Rapport** Def: Impacting student motivation by developing relationships with students, communicating high expectations, and offering encouragement, thereby allowing teachers to connect with their students
				2. Promotes student academic success	
				3. Builds relationships with students	
				4. Communicates high expectations	
				1. Promotes non-threatening atmosphere	**Classroom Environment** Def: A positive, non-threatening class atmosphere can spark student interest
				2. Manages student behavior	
				3. Physical environment of the classroom	
				1. Supplements lessons with relevant stories	**Relevant Lessons** Def: When teachers make their instruction relevant to the real world of the adolescent, more students will be engaged
				2. Incorporates current events in science	
				3. Makes connections to the adolescent world	
				4. Provides real-world examples	
				1. Definition of inquiry	**Inquiry Learning** Def: Allowing students to experience science as a dynamic process through questioning, investigation, discovering, and sharing to tap into the natural curiosity of students and thereby increase their motivation
				2. Teacher-directed activities	
				3. Student-centered activities	
				4. Value of inquiry	