EFFECTIVE TEACHING STRATEGIES FOR INTRINSICALLY MOTIVATING SECONDARY SCIENCE STUDENTS

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ABSTRACT

This paper examines current research in order to identify effective teaching strategies for intrinsically motivating secondary science students. Review of the history reveals that teaching practices have been largely based on behaviorist principles which fail to acknowledge the individual and their inner motivational resources when it comes to learning and schooling. Critical analyses of the literature resulted in numerous promising strategies with two major findings. First, teacher practices that support student autonomy are effective in intrinsically motivating secondary science students. Second, overall teacher practices that promote a mastery goal orientation are effective for promoting intrinsic motivation in secondary science students. The findings imply that teachers must move towards a more student-centered approach to teaching, allowing students to take on a more active role in their learning and the classroom. Suggestions for further research are provided in order to identify teacher strategies and practices that will promote and support the intrinsic motivation of secondary science students.

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CHAPTER ONE: INTRODUCTION

Rationale

> We will build the roads and bridges, the electric grids and digital lines that feed our commerce and bind us together. We will restore science to its rightful place, and wield technology's wonders to raise health care's quality and lower its cost. We will harness the sun and the winds and the soil to fuel our cars and run our factories. And we will transform our schools and colleges and universities to meet the demands of a new age. All this we can do. And all this we will do (Obama, 2009).

Throughout my experiences both as a student of science and as a practitioner, I have been struck by the discontinuity between what is taught in school and what one is expected to know and do in the field of science. From an early age, I was enthralled by the natural world and the way that science strives to make sense of it. Yet upon entering a science classroom, I was frequently confronted with a largely irrelevant, esoteric, and altogether boring experience. Indeed, recent observations in science classrooms sparked similar feelings as I watched students' individual curiosities, funds of knowledge, and motivation to learn seemingly dwindle away in the face of textbook laden instruction, emphasis on factual knowledge, and an overwhelming focus on passing tests or making the grade. Nevertheless, there have been a few isolated teachers that sparked my curiosity, supported my interests, and altogether stimulated my inner motivations for pursuing further scientific knowledge and experience. As I prepare to teach secondary science, I am determined to identify and embrace teaching practices and strategies that will incite in my future students those same internal motives for learning science that transformed my science education form a boring, irrelevant experience, to an engaging and fascinating one.

Since the formative years of schooling in the United States, improving methods for transmitting knowledge has been of utmost importance. Traditionally, research and improvements have been focused largely on ways to improve the cognitive aspects of knowledge transmission and learning. More recently, Pintrich, Marx, and Boyle (1993), and Laukenmann et al. (2003) have conducted studies highlighting the role of the individual and their associated social, emotional, and motivational functions in learning and achievement (as cited by Randler, C. & Bogner, F., 2007). As the role of science education has gained importance over the centuries, the motives for teaching it have involved a balance between conveying scientific knowledge to the layperson, as well as educating future scientists. The logic behind a focus on scientific knowledge, regardless of the driving theories behind the factors influencing the acquisition of it, was and is based on the idea that scientific knowledge is vital in creating a better society (Spring, 2005). As was mirrored in Barack Obama's inaugural speech, the need for a continued focus on scientific advancements has never been more important to the continued existence of the United States within a globally competitive market. With the current call for energy independence, efficient modes of transportation, communication, and an improved health care system, science promises solutions to many of our nation's concerns. Likewise, the growing research base focusing on students' motivational aspects of learning, promises to offer great insight into ways to improve and promote positive impacts on student learning and in turn scientific knowledge (Hidi & Harackiewicz, 2000; Pintrich, Marx, & Boyle, 1993).

Over the last 50 years, we have witnessed an alarming progression of scientific and technological advancements. Indeed, fields of science have grown so numerous and specialized, the task of preparing children for careers in these myriad scientific fields have become increasingly daunting. As schools aim to prepare children to pursue careers in science, the disparity between in-class content and real-life science careers has widened. As this was my experience during the transition from high school into college, I have been particularly intrigued by the disparity between in-school science content and out-of-school science applications. The ever expanding body of scientific knowledge makes it increasingly difficult for science educators to determine the best strategies for imparting a thorough and genuine understanding of science and its applications. According to the Condition of Education (United States Department of Education, 2007b, p. 140), approximately 46% of the nation's 12th graders scored below basic achievement levels in science in 2005.

There have been numerous studies calling attention to the marked drop in student achievement and motivation during the adolescent years (Jang, 2008; Randler & Bogner, 2003). More specifically, there has been a steady decrease in scientific academic achievement throughout secondary schools in America. According to the *Condition of Education*, from 1996 to 2005, the percentage of 12th graders performing at or above the national level of science proficiency decreased from 21% to 18% (DOE, 2007b, p. 38). Both of these numbers are daunting and cause for considerable concern. What is responsible for this decrease in secondary science performance? Among many possible explanations is a growing disinterest and lack of intrinsic motivation in learning science. The role of interest in learning has been shown to have profound positive effects on the quality of cognitive engagement that students exhibit while learning (Pintrich et al., 1993). Conversely, a lack of interest portends decreased cognitive engagement and would likely contribute to the decrease in academic achievement that has been so prominently noted. Despite some calls for more hands-on experimentation and teaching practices that are perceived by students to be meaningful, fun, and educational, science teaching has overwhelmingly continued to be teacher-centered, relying on single forms of intelligence (Wilson & Corbett, 2001). As I proceed into the teaching profession, I seek to determine effective ways to intrinsically motivate secondary level students in learning science.

Controversies

In addressing strategies for intrinsically motivating secondary students to learn science, it must be acknowledged that motivation, whether external or internal is invariably situated in a cultural context. Given the increasingly diverse student bodies in America's schools, the inner motivational orientations of students are likewise extremely varied. As such, while this research aims to identify effective teacher strategies and practices for promoting intrinsic motivation to learn science, it is recognized that there is likely no panacea for all students. That being said, the rich body of literature included in this research aims to yield a set of strategies that will enable teachers to adapt and modify their practices to support the inner motivational resources of a wide variety of students and their respective desires, interests, and needs (Alonso-Tapia & Pardo, 2006; Morling & Kitayama, 2008).

Another potential controversy is the benefit of intrinsic versus extrinsic motivation in learning. There has been extensive controversy over the relationship of extrinsic motivational factors on intrinsic motivation and deep learning, and more recent findings suggests that extrinsically oriented variables do indeed undermine intrinsic motivation (Deci & Ryan, 1985; Hidi & Harackiewicz, 2000). In the context of achievement motivation theory, mastery goal orientations have been closely linked to intrinsically-oriented motivational patterns (Ames, 1992). However, recent studies have suggested some positive benefits of certain performance oriented goals, particularly performance-approach goals (Butler & Shibaz, 2008; Hidi & Harackiewicz, 2000). Despite these suggestive findings, this study will focus on strategies for promoting mastery goal orientations in secondary science classrooms.

One final factor that warrants noting is the situated context of the science classroom, within the greater social, cultural, political, and economic society. As motivation is a construct that is fostered within the context of the individual's day-to-day life, the influence of the school, friends, family, and the greater community plays a highly influential role (Morling & Kitayama, 2008; Nieswandt & Shanahan, 2008). In particular, while grades and other assessment practices have been shown to influence goal orientations and other factors related to intrinsic motivation, they are an integral component of most public schools in America. As such, teacher strategies for intrinsically motivating secondary students to learn science will be considered in the context of current educational policies and other external influences. Nevertheless, teacher practices and strategies have been found to have profound effects on students' intrinsic motivation to learn, and rightfully deserve a prominent place in the search for best teacher practices for educating youth in America's schools (Reeve, 2006).

Definitions

At this point, it is necessary to define certain key terms that are relevant to this paper. While motivation refers to the general process that leads to behavior as a result of some needs or desires, intrinsic motivation involves an innate, internal source of energy and direction of behavior. This form of motivation relates to doing something for the sake of enjoyment, pleasure, or simply for the benefit of the action (Deci & Ryan, 1985). Being intrinsically motivated to learn science could be viewed as wanting to learn science for the sheer pleasure of attaining that knowledge and for the resulting satisfaction that would result from that newly acquired information. On the other hand, extrinsic motivation is a form that derives its energy and direction of behaviors from an external, environmental source. In other words, I would be likely to learn science for the goal of obtaining a higher paying career, an "A" on a test, praise from the teacher, or some other form of external reward (Deci & Ryan, 1985; Goetz, Alexander & Ash, 1992).

The concept of intrinsic motivation has been discussed in a wide variety of terms. While all overlap to some degree, they focus on subtle differences within the construct. Self-determination theory addresses intrinsic motivation in terms of an internal need to be autonomous. This approach to intrinsic motivation built on the theory of competence motivation described by White in 1959. Many research studies examine the intrinsic motivation of students by considering their perceptions of autonomy and competence in response to certain variables. Self-regulation is another component of self-determination theory that is frequently addressed in the research. This construct relates to the desires to be in control of one's own learning. In contrast, learning that is regulated by rewards and other external factors is frequently viewed as a counterpart to self-regulated learning (Ryan & Deci, 2000).

Another equally informed approach to intrinsic motivation is in the context of achievement theory. This collection of work approaches intrinsic motivation from the context of goals that students internalize in response to their perceptions of the environment. In particular, a mastery goal orientation has been shown to promote behaviors closely associated with intrinsic motivation. On the other hand, performance or task goal orientation has been shown to promote behaviors more closely associated with extrinsic motivation (Hidi & Harackiewicz, 2000).

One final mention involves the role of interest in the discussion of intrinsic motivation. Some researchers use the terms interest and intrinsic motivation interchangeably. However, some researchers have further delineated interest into components including situational and individual interest. Situational interest can lead to individual interest, while other times it is fleeting and fades away as the situation changes. While both of these can be positively influential in promoting intrinsic motivation, they are rarely distinguished in the research studies addressed in this paper. As such, it is important to recognize the potential for positive measures of interest in studies to be of a situational measure and therefore potentially incomplete in concluding positive effects on intrinsic motivation (Hidi & Harackiewicz, 2000).

Limitations

Through the journey of unraveling the research and knowledge in relation to intrinsic motivation and secondary science students, I have come across many intriguing and very important questions. However, for the sake of focus and the goal of addressing this question in totality, I find it necessary to define certain limits to this paper. While there are many controversial findings relating to other theories of motivation and behavioral drives in learning, I will focus on intrinsic motivation. Since intrinsic motivation has been cited in numerous research studies as being integral in the role of deep learning and cognitive engagement, it works well because the effectiveness of intrinsic motivation on learning is my focus. Rather, building on several well supported theories supporting the positive effects of intrinsic motivation on learning, I will search to identify ways that this form of motivation can be fostered and nurtured in my future classrooms.

With regards to specific ways to intrinsically motivate secondary science students, I will focus more on teacher practices and pedagogical strategies rather than learning tools. I chose not to focus on learning tools as a means of fostering intrinsic motivation for the simple, yet undeniable fact that many such tools are not readily available in some schools. Ultimately, how those tools are used may be more important than the tools themselves. Pursuing strategies and practices to intrinsically motivate secondary science students will better prepare me to provide equitable and adequate educational opportunities to students regardless of the financial and technological resources that are possessed by individual schools and districts.

Summary

As we proceed into the twenty-first century, with issues of global warming, energy, burgeoning populations and global strife at the forefront, students are in dire need of acquiring adequate scientific knowledge and skills in order to cope with, make sense of, and be part of the rapidly increasing scientific and technological advancements. Without the proper teaching practices and strategies in place, secondary science students will likely continue in their downward spiral into scientific underachievement and disinterest. As a major first step in reconnecting science and the plethora of knowledge possessed in the world with the prior knowledge and experiences of students today, it is important that teachers focus on creating pedagogies that foster student construction of knowledge in ways that are meaningful and relevant to their lived lives. I intend to elucidate the factors of intrinsic motivation and the ways to instill it in students of science classrooms as a key means with which to establish these connections. The following chapter looks at the historical development of intrinsic motivation within the realm of science education. Chapter three contains an in-depth analysis of a variety of primary research regarding the effects of teaching strategies and practices on the intrinsic motivation of students. Lastly, chapter four synthesizes the findings from the research in order to identify key teaching practices that will promote students' intrinsic motivation in secondary science classrooms, as well as some suggestions for future research.

CHAPTER TWO: HISTORY

Introduction

Throughout the history of schooling in the United States, there have been countless small changes and steps taken that promise to hold the answer to all our educational problems, or at least offer an improvement. This section, will take a closer look at some of the steps along the way that have led up to the current era of thoughts, ideas, and beliefs in relation to science education, an era that is interested in hearing the answer to the question, “what are effective teaching strategies that intrinsically motivate secondary science students?” Although the history of science education has followed a distinct path compared to that of the collective history of schooling, they share certain similarities within the greater social, cultural, and political contexts of the history of the United States. The entire histories of schooling, intrinsic motivation or secondary science education will not be described in detail as those topics would likely lead into far reaching territories and many more equally enticing research questions. Instead, focus will be given to the evolution of intrinsic motivation and its relevance in science education, a focus on the relationship between these two concepts.

Early Beginnings of Intrinsic Motivation

For centuries there have been ideas and concepts that eschewed the current definition of intrinsic motivation. Hidden under the guise of instinctual reactions, inner desires, or internal drives, philosophers have ambiguously referred to and sought insight into the inner workings of individuals whose actions were based on some nebulous internal mechanisms. There are multiple dialectical pathways that have led up to the modern concept of intrinsic motivation and its important role in learning and schooling. Nevertheless, a substantial portion of America’s history of schooling has proceeded without acknowledging the role of the individual’s inner motivational resources. As a young country, America sought ways to create a citizenry that was unified, obedient, and productive. In this sense, the needs and desires of society took precedence over the needs and desires of the individual. It was not until the needs and desires of the individual moved into the spotlight that a need for the term intrinsic motivation began to take form. This shift was not sudden, but rather has been evinced through the work of a number of professionals over the course of the history of schooling (Geotz, Alexander & Ash, 1994; Spring, 2005).

Debates and opposing ideas have fueled the progress that has led up to the current discussion on intrinsic motivation. One major source of divergence among the various theories related to motivation has been based on differing views of the nature of the individual. Since long before conversations about motivation began, there have been repeated and ongoing debates about the nature of and importance of the individual. While much of the history of schooling in America has shown little interest in the individual learner there were philosophers, psychologists, and educators that recognized the importance of the individual in learning and schooling long before the behaviorists of the 1900s emerged. For example, stemming from criticisms of influential philosophers such as Jean-Jacques Rousseau (1712-1778) and the educational trends of the time, Johann Herbart (1776-1841) called for a shift away from focusing on the citizen and toward a focus on the individual. Herbart's views were in a large way reactionary to the dominant goal of schooling and education, to efficiently train model citizens. In contrast to the views of the English philosopher John Locke (1632-1704), who viewed the newborn child to be tantamount to a "blank slate" (Spring, 2005, p. 39), Herbart believed that children differed in ability and disposition, each possessing a unique "individuality" (Blyth, 1981, p. 70; Geotz et al., 1994).

An alternative approach to Herbart's more humanistic view was to ignore the individual and their uniqueness and view them more as machines, passively behaving in response to certain stimuli, an approach referred to as behaviorism. This approach was built around the premise that behavior is observable and capable of scientific study, whereas drives or other internal mechanisms are immeasurable and of little or no value. In other words, this approach to motivation is not concerned with the source of motivation and the individual's perspective, but rather is interested in determining the external incentives or stimuli that lead to given behaviors. This school of thought found its beginnings in the work of E. L. Thorndike (1874-1949). Thorndike considered the nature of intelligence to be entirely innate and some of his resulting contributions to the educational community include increased emphases on intelligence tests and behaviorist teaching methods. Furthermore, he paved the way for subsequent work done by others behaviorists (Goetz et al., 1994).

During the same general time frame as Thorndike, John Dewey (1859 – 1952) was a proponent of a different form of education, one that acknowledged the individual and their emotional and cognitive aspects within the context of the greater social realm. Dewey advocated for a more experiential and authentic educational experience, one that would later give rise to the current educational practices of constructivism and student-centered teaching. Nevertheless, despite Dewey's early calls for a different kind of education, the first half of the twentieth century witnessed local and global events that created a climate that was more conducive to the widespread implementation of behaviorist teaching practices, as well as an increased demand for science education (Spring, 2005; Stipek, 2002).

Science Education

Although the first high schools in the U.S. were founded during the early 1800s, they did not become commonplace until the 1920s and 30s. While the primary goals of these early high schools were relatively unclear, they revolved around preparing students for life as obedient, moral citizens, a goal that was thought to be attainable through behaviorist teaching principles. During these early stages, science education sought to impart on students the outcomes of scientists' complex and elaborate discoveries and inventions apart from the processes that led up to them. In other words, science educators of the time were expected to teach students what was known in science at the time rather than how it came to be known. It should be mentioned that science at this stage was comparatively nascent. Indeed, prior to the technological boom of the early twentieth century, science was hardly considered a common citizen's subject, but rather something left for the few isolated specialists studying in prestigious universities or in the privacy of a monastic garden. From this perspective, it seemed unnecessary for high school students to occupy their time studying the details of processes resulting in scientific knowledge (Duschl, 1990; Glass, 1970; Reese, 2005; Spring, 2005).

As the twentieth century dawned, and historical events including World War II, and the associated technological revolution occurred, what was once an esoteric field, largely restricted to the wealthy, burgeoned into a vital enterprise in American society. Indeed, around the turn of the century there were a scant 90,000 science related jobs in the U.S. Yet by 1950, there were roughly one million U.S. jobs related to science and technology. This stark trend has continued up into the current era, with a myriad of professions relying on scientific knowledge and experience. From this perspective, the need for a form of science education that goes beyond direct transmission of facts and principles into a more experiential, relevant model begins to take shape. Interestingly, intertwined in his arguments for a "new" type of education, John Dewey acknowledged the importance of a more experiential process of learning. Dewey was a strong advocate for a shift in the focus from teaching the pre-packaged ideas and information of science to the process of scientific inquiry. However, while a need for a new form of science education gained recognition, Dewey's ideas on how to accomplish such goals were quite discordant with the more prominent behaviorist principles of the time. As a result, changes in the goals of science education evolved while the means for accomplishing such goals remained largely unchanged. (Duschl, 1990; Glass, 1970).

As WWII came to an end, and the technological revolution gave way to the 1950s and the beginning of the Cold War, focus on science education continued to grow. Similarly, so did an emphasis on behaviorist teaching principles in high school classrooms as they offered a means for shaping a scientifically adept citizenry in an efficient and straightforward manner. All the while, psychologists and educational philosophers continued pursuing further insight into mechanisms that would both help explain the process of learning and offer improvements on the effective application of teaching and education in America's schools. These continued efforts would later gain recognition as achievement in high school age science students began decreasing quite noticeably over the course of the 1960s and 70s. In other words, it appeared that the general population of America's secondary students was showing signs of decreased science achievement and as a result it was only a matter of time before educators began looking into alternative ideas for possible solutions to this problem (Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S., 2007; Gibboney, 2006; Goetz et al., 1994; Spring, 2005).

Influence of Skinner

While much of the twentieth century witnessed the widespread adoption of behaviorist teaching methods based largely on the work of Skinner, it was not without some criticisms. While Skinner's theory of operant conditioning is quite palatable in the sense that the complex topic of learning can be simplified and addressed through the use of stimuli and responses, several shortcomings surfaced over time. First, E.C. Tolman (1886-1959), a behaviorist himself noticed that Skinner's theory failed to explain certain cases of learning that can occur in the absence of an external reinforcement, a process that has been referred to as latent learning (Stuart-Hamilton, 1999, pg. 152). Albert Bandura's social learning theory offers yet another critique of Skinner's theory in the sense that people learn and in turn behave differently through observing others, a concept known as "vicarious reinforcement" (Stuart-Hamilton, 1999, pg. 152). While these critiques certainly weakened the strength and popularity of Skinner's extreme forms of behaviorism, they also supported the notion that there was something more complex and worthy of attention going on inside the brain with respect to learning.

As science achievement in secondary students began decreasing, educators and psychologists sought explanations to this trend. Around the same time frame (and possibly in response), a number of psychologists were proposing new ideas in relation to motivation and learning. The negative trend in science achievement among secondary students, combined with the surfeit of new research regarding aspects of motivation and learning contributed to a critical review of the longstanding behaviorist teaching practices that had informed schooling in America. Perhaps most noteworthy is the critiques that developed in response to the use of external or extrinsic rewards and incentives for the purpose of promoting learning and performance.

Many critics of Skinner's theories recognized that many behaviors are carried out in the absence of external incentives or punishments, recognition that internal processes must be addressed within the discussion of motivation and behavior. Following an article published in 1959 by White, which posited that people have a need to gain a sense of effectiveness or feel competent, several other theories surfaced that formed the basis for our current understanding of intrinsic motivation. DeCharms composed his theory of personal causation in 1968 which states that humans inherently desire to be in charge of their own behavior. This theory lends itself well to the debate that arose in the 1970s regarding the potential undermining effects of external reinforcements used to motivate students to learn, a practice that stemmed largely from the teaching methods developed out of work done by Skinner and other behaviorists.

At this point in time there were a number of well developed theories alluding to the concept of intrinsic motivation. However, it was not until Edward L. Deci (among others) distinguished between external and internal forms of motivation that both behaviorist theories began to lose strength and intrinsic motivation began its rise to prominence in the educational arena. Beginning in 1971 and continuing up into the present, a number of psychologists and other researchers began publishing works highlighting the potential undermining effects of extrinsic rewards on the intrinsic motivation of people. Numerous studies were done to examine the effects of extrinsic motivators on the intrinsic motivation of people. This line of research is expansive and has yielded many findings. However, at a summative level, there have been studies showing both negative and positive impacts of extrinsically motivating factors on intrinsic motivation. Teaching practices that utilize strategies for extrinsically motivating students has long been embraced and continue to be practiced today. As many educational psychologists and other theorists suggest, this ongoing use of extrinsically motivating teacher practices helps explain the continued decline in achievement secondary science students, as well as math and other subject areas (Deci & Ryan, 1985; Vansteenkiste, Lens, & Deci, 2006).

Summary

Over time, teaching practices embracing rewards and other external means of control have seemingly grown less favored and are being replaced by practices considered by many to be more focused on the individual, their needs, and their desires. This notion is particularly promising for secondary science education, as it suggests aligning the diverse needs of the current global society with the needs and desires of the students in order to create a more fruitful, productive, and relevant educational relationship. While teacher-centered, rewards-based practices still persist and in many cases are still highly favored, the general direction that education is moving in is one focused on providing the learner with a high sense of autonomy, competence, and self-regulated learning. Intrinsic motivation offers some possible insight into the issues facing secondary science students nationwide, and promises to hold answers as to how to get students more interested and engaged in learning science. The following chapter reviews research on a variety of teacher strategies for promoting the intrinsic motivation of secondary level science students. An analysis and critique of each study is included in the chapter.

CHAPTER THREE: CRITICAL REVIEW OF THE LITERATURE

Introduction

Chapter one revealed that the quick pace of scientific and technological advancements is tantamount to the growing need for effective science education. Unfortunately, we are facing a downward spiral in the interest, engagement, and motivation of students to learn science. As discussed in chapter one, progression towards a more student-centered approach to teaching leads naturally into the current discussion of intrinsic motivation and secondary science students. Chapter two explained the early beginnings of intrinsic motivation and the historical pathway of thinking about learning, schooling, and teaching. Science education began as a more esoteric subject intended for transmitting knowledge about what scientists have learned rather than how they learned it. Due largely to World War II, the U.S. witnessed a shift in emphasis on science and technology which led to the expansion of science-related jobs and science education. Chapter 2 also discussed the rise of behaviorism and influence that Skinner and other behaviorist thinkers had on the evolution of intrinsic motivation. Chapter 3 reviews research studies pertaining to a variety of factors influencing the intrinsic motivation of students to learn. The chapter is divided into 10 sections addressing autonomy support, student choice, learning in a social context, student-centered teaching, providing rationales for learning tasks, promoting a mastery-goal orientation, assessment and evaluation practices, explicit teaching of learning strategies, use of computer-based learning environments, and the use of teacher enthusiasm. All of the following studies are summarized and the conclusions that are provided are analyzed and critiqued. The research from the studies is reviewed with a focus on identifying teacher strategies that are effective for intrinsically motivating secondary science students.

Autonomy Support: Providing Student Support for Autonomy

One significant factor in the discussion of intrinsic motivation is the need to be self-determining, to play an active role in negotiating their surroundings. Students are more likely to feel intrinsically motivated to learn when they perceive themselves to be in control of their learning or supported by their teachers’ interactions and practices. The entry into adolescence is frequently marked by increased social responsibilities and increased desires for freedom of choice and autonomy. Unfortunately, oftentimes these developmental changes are met in secondary schools by increased efforts to control and impede student autonomy. Within the classroom there are a number of strategies that can be employed to increase students' perceptions of autonomy, all of which aim to support and nurture students' needs, interests, and desires. The following section, will review several research studies that investigated both the effects of autonomy supportive practices on students' intrinsic motivation and specific teaching strategies that promote feelings of autonomy (Blackwell, L. S., Trzesniewski, K. H. & Dweck, C. S., 2007; Reeve, 2006).

Lavigne, Vallerand, and Miquelon (2007) tested a motivational model to see if teachers' autonomy support positively influenced students' perceptions of autonomy in science. Additionally, they investigated whether increased perceptions of autonomy promoted students' intentions of pursuing additional science education and careers. On both levels of analysis, autonomy support was shown to positively influence students' perceptions of autonomy and their intentions to pursue additional education and careers in science. This study, as it pertains directly to secondary science students is of particular importance to this paper. In this case, the authors were testing a motivational model that posited teacher autonomy support to positively influence self-perceptions of autonomy and competence which positively influenced students' levels of intrinsic motivation, which positively influenced students' intentions to pursue education and careers in science.

A one shot case study was conducted with 728 10th grade students recruited from three public high schools in Montreal, Canada. During normal class time, a trained experimenter administered a survey questionnaire pertaining to all science courses that they attended during the current school year. There were 31 items on the questionnaire measuring intrinsic motivation (16 items), perceived autonomy and competence (6 items), perceived support of autonomy by their teachers (3 items), and intentions to pursue education and careers in science (6 items). Intrinsic motivation as it was measured in this questionnaire identified four levels of self-determination, intrinsic, identified regulation, introjected regulation, and amotivation. All items were based on a 7-point Likert scale, with 1 representing complete disagreement with the item and 7 being highly in agreement with the item (Lavigne et al., 2007).

After collecting all data, the students were divided into two groups based on their intentions of future educations and careers in science. Four hundred and twenty five students had high intentions, while 303 had low intentions. Then an analysis of variance was conducted using intentions (high/low) and gender (male/female) as the independent variables and types of motivation (intrinsic, identified, introjected, and amotivation) as the dependant variable. Students with high intentions were more intrinsically regulated (M = 3.52, SD = 1.47, $p < 0.0001$) than students with low intentions (M = 2.39, SD = 1.27, $p < 0.0001$). Also, students with high intentions were more identified regulated (M = 5.51, SD = 1.27, $p < 0.0001$) than students with low intentions (M = 4.58, SD = 1.51, $p < 0.0001$) of pursuing education and careers in science. Students with low intentions were more introjected regulated (M = 5.15, SD = 1.58, $p < 0.0001$) and amotivated (M = 2.16, SD = 1.23, $p < 0.0001$) than introjected (M = 4.39, SD = 1.74, $p < 0.0001$) and amotivated (M = 1.68, SD = 0.91, $p < 0.0001$) students with high intentions. There was no significant difference between genders in relation to motivation and future intentions. Another analysis of variance was done with the same independent variables of intentions and gender, but using perceptions of autonomy and competence as the dependent variable. In this case, students with high intentions had higher self-perceptions of autonomy (M = 5.58, SD = 1.21, $p < 0.0001$) and competence (M = 4.98, SD = 1.24, $p < 0.0001$) than their low intention counterparts (M = 4.28, SD = 1.56, M = 3.26, SD = 1.34, respectively, $p < 0.0001$). On average, boys (M = 4.56) were found to have higher self-perceptions of competence than girls (M = 3.96). Another analysis was done, using perceptions of teacher autonomy support as the dependent variable. In this case, students with high intentions tended to perceive their teacher's as being more supportive (M = 3.18, SD = 1.31, $p < 0.0001$), while students with low intentions tended to perceive less support from their teachers (M = 2.82, SD = 1.22, $p < 0.0001$); (Lavigne et al., 2007).

Finally, using the previous data, path analyses were done in order to test the fit of the data to their hypothesized model. Since boys and girls differed in their levels of perceived competence, separate path analyses were conducted. Both sets of data had a marginal fit to the model ($p < 0.05$). In other words, according to the proposed model, providing teacher autonomy support may have contributed to increased student levels of perceived autonomy and competence, which in turn may contributed to an increase in students' intrinsic motivation, and even an increase in students' intentions to pursue education and careers in science. Additionally, while there were differences in gender with regard to self-perceptions of competence, the model still fit well for both genders, implying that this path held true for both male and female identified genders. However, it must be noted that the 12 students who did not specify their gender as male or female may have not been provided a choice that was relevant. In other words, this study did not include options for neutral or transsexual genders and thus potentially excluded a significant demographic population worthy of inclusion in this field of research (Lavigne et al., 2007).

Along those same lines of limitations or threats to the validity of these findings, there is no mention of the demographics of the sample population despite collection of demographic information including nationality, ethnicity, language spoken at home, and parent's working status. This could be of particular importance when discussing the value of autonomy as it relates to different cultures and social environments. Lastly, there is no concrete description of teacher support for student autonomy in the context of this study. In the case of this study, the description was entirely based on the perceptions of the students. However, it would be very beneficial to get a clearer picture of what students attend to when determining their teachers' levels of autonomy support (Lavigne et al., 2007).

Seidel, Rimmele, and Prenzel (2005) investigated whether having clear and coherent lesson goals resulted in higher student perceptions of teacher support for autonomy and increased levels of intrinsic motivation. Findings were supportive of their initial hypothesis although there were other potential extraneous variables that could have influenced the results. There were two components to this quantitative study, a multiple group comparison of teachers' clarity and coherence of lesson goals, and a post-test questionnaire measuring students' motivation and perceptions of the classroom learning environment. A total of 13 physics teachers (2 female, 11 male) and 344 students (48.4% female, 51.6% male) from German high schools participated in this study. All 13 teachers volunteered for this study, their respective students constituted the students sample.

Initially, all teachers agreed on teaching two introductory physics lessons, one on electricity, and one on force concepts. Teachers were videotaped during these two lessons, which occurred at some point over the course of the first six months of the school year. These videotaped lessons were watched and rated by three independent observers using a list of criteria as indicators and to help increase inter-rater reliability ($\alpha = 0.65$). Following each videotaped lesson, the students were asked to complete questionnaires. These questionnaires measured relevance of contents, quality of instruction, teacher's interest, social relatedness, support of competence, support of autonomy, levels of motivation (amotivated, externally regulated, introjected, identified, intrinsic, and interested), and cognitive learning activities. Analysis of the findings occurred once all 13 teachers had taught both lessons and students had completed questionnaires (Seidel et al., 2005).

First, the classes were divided into two groups based on high or low goal clarity and coherence. This distinction was based on a number of criteria including whether the teacher answered student questions, embedded experiments in the lesson, discussed findings of experiments with respect to the lesson goals, summarized lessons with respect to the goals, was transparent in their lesson goals throughout the period, addressed the goals in the course of the lesson, and carried out clear and comprehensible instructional phases during the lesson. In all, 5 of the 13 teachers were rated as having a high goal clarity and coherence in their instruction while the other 8 were considered to have low goal clarity and coherence. Next, students' responses to the questionnaires were compared with their respective teachers' level of goal clarity and coherence. Overall, students' perceptions of their learning environment were consistent and positive predictors of the level of goal clarity and coherence provided by their teachers. Specifically, teachers who were rated as having high goal clarity and coherence were also perceived by their students as presenting more relevant ($\tau = 0.016$, $p < 0.02$), higher quality ($\tau = 0.037$, $p < 0.01$) instruction and supporting autonomy ($\tau = 0.019$, $p < 0.02$) and competence than their low goal clarity and coherence counterparts ($\tau = 0.015$, $p < 0.03$). This correlation however cannot be attributed directly to goal clarity and coherence, as there were many other variables at play within each of the 13 classrooms. In other words, goal clarity and coherence in instruction was found to be one key component of teacher practices that lead to positive student perceptions of supportive learning conditions (Seidel et al., 2005).

While lessons were videotaped, which allowed for more objective interpretations of the lessons, the relatively small number of lessons observed and analyzed (n = 26) provided a small window into the entire classroom experience. Furthermore, one might question the initial levels of student motivation and other characteristics within and between the various classes. The authors' description of science education in Germany involved heavy use of teacher-centered, direct instructional practices, teaching practices that tend to treat students as passive learners and disengage students from the construction of knowledge (Nieto, 2007). One might be reluctant to generalize these findings to physics classrooms in U.S. high schools. However, the consistently positive correlations between high goal clarity and coherence, and positive student perceptions of supportive learning conditions support previous literature stating the benefits of having clear and coherent lessons (Seidel et al., 2005).

Garcia and Pintrich (1996) investigated the effects of autonomy on the motivation of college age students and found there to be a positive relationship. Students' perceptions of classroom autonomy were most positively correlated with mastery-goal orientation and task value. Path analyses revealed that students' positive perceptions of classroom autonomy fostered higher levels of mastery-goal orientation and perceived task value ($p < 0.001$). As it was defined in this study, autonomy supportive practices involved allowing students to choose topics for their reading and writing assignments, as well as participating in the construction of classroom norms and policies.

Although the pre-test/post-test design did not control well for threats to the internal validity of the findings, the comparison of 365 college students in 10 classrooms from 4 different colleges provided a solid basis for comparison. The schools where this study took place included a small private university, a community college, and two large public universities in the Midwest U.S. Of the 10 classrooms surveyed, three were biology courses. Beginning in the first two weeks of the semester, students were asked to complete a survey measuring goal-orientation, task value, self-efficacy, and test anxiety. These measures were taken from the Motivated Strategies for Learning Questionnaire (MSLQ) and were based on a 7-point Likert scale. In the last two weeks of the semester, the participants completed the same questionnaire, along with four items which measured perceived classroom autonomy as defined earlier. All participation was voluntary and no incentives were provided (Garcia, & Pintrich, 1996).

Following data collection two sets of analyses were done, correlational and path analyses. Correlations between students' initial beliefs and subsequent classroom experiences were most positive in relation to intrinsic goal orientation ($r = .58$, $\alpha = 0.05$), task value ($r = .67$, $\alpha = 0.05$), and self-efficacy ($r = .60$, $\alpha = 0.05$). In other words, students who self-reported to have a higher intrinsic goal orientation, possess higher task value, and have higher levels of self-efficacy were more likely to perceive the classroom experience to be autonomy supportive. The path analyses revealed that students' initial levels of intrinsic goal orientation ($\beta = .48$, $p < 0.001$), task value ($\beta = .16$, $p < 0.001$), and perceived classroom autonomy ($\beta = .15$, $p < 0.001$) were the best predictors for the posttest levels of intrinsic goal orientation Both sets yielded findings that loosely supported their initial hypothesis that perceptions of autonomy support in the classroom positively impacted students' motivation to learn. However, as mentioned previously, the design of the study warrants a closer look at possible threats to the internal validity. One of the more prominent threats involves the lack of information related to teacher practices and other classroom related factors that students experienced between the two measures. This large time span allows for a multitude of variables that could have influenced students' perceptions of autonomy and their subsequent levels of intrinsic motivation. The measures used (MSLQ) have been widely used and have gained support as a sound instrument for measuring levels of both perceived autonomy support and intrinsic motivation. Lastly, this study focused on college age students which are not readily generalized to secondary level students. However, findings from this study combined with other studies addressed in this section serve to increase confidence in generalizing these findings to secondary science students (Garcia, & Pintrich, 1996).

Lodewyk, Winne, and Jamieson-Noel (2009) investigated the differences in students' motivation and perceptions when performing a well-structured compared to an ill-structured task. They found that the students performing the well-structured task perceived the value of the task to be higher than those in the ill-structured task condition. Additionally, the students performing the well-structured task reported significantly better abilities in coping with the challenges of the task compared to students in the ill-structured task. Well-structured tasks as defined in this study involved routines that were connected and linear, well-laid out procedures with detailed goals and expectations, clearly defined right and wrong type answers, and involved more thorough and precise criteria for evaluating performances. While there is some overlap between the two types of structured tasks, ill-structured tasks generally involved more nebulous, unclear problems requiring students to connect or synthesize more information, consider multiple perspectives, and fewer goals, expectations, and criteria with which to gauge success or progress. In other words, well-structured tasks often provide fewer choices for students, potentially less challenge and skill requirements, and altogether less support for student autonomy. Conversely, while ill-structured tasks may offer more support for student autonomy, the unclear and frequently frustrating process of the ill-structured tasks may counteract the potential benefits of increased autonomy support. This study is included in this discussion for the purpose of exploring some potential misconceptions of autonomy-supportive practices (Lodewyk et al., 2009).

Ninety four tenth-grade students from four science classes volunteered to participate in this within-subject design study. All participants were from one urban private high school in Western Canada, and were all taught by the same male science teacher. Classes were randomly assigned to either the well-structured task (WST) or the ill-structured task (IST). Therefore, while two of the classes first completed the WST and then the IST, the other two classes completed the IST first, and then the WST. Both tasks were on the topic of cancer and were designed by the authors and teacher in accordance with existing theory on task structure. Each task spanned two 80-minute periods culminating in the administering of a Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia & McKeachie, 1991) by the first author. Six times over the course of the two 80-minute periods, students also completed short Self and Task Perceptions Questionnaires (STPQ). This entire process was completed for the other task in the two 80-minute periods following the first task (Lodewyk et al., 2009).

The motivational scale on the MSLQ contained 30 items based on a 7-point Likert scale which measured students' goal orientations, task value, beliefs on locus of control for learning, self-efficacy, and test anxiety. The SLPQ consisted of a self-report of ease and difficulties in the tasks, as well as a 20 item section based on a 5-point Likert scale which measured students' perceptions of the quality and value of the tasks. Results from these measures were processed and analyzed using a number of statistical methods. First the authors found that there was no statistically significant effect for the order in which the two tasks were performed ($p = 0.24$). Regression analyses were done on the responses from the MSLQ and no variables were found to differ significantly between the two learning tasks. The only significant findings from these analyses were from the quantitative responses reported in the STPQ regarding task value and task management or the students' perceived abilities to handle the challenges and difficulties of the work. Using a MANOVA, the authors found that students in the WST reported statistically significantly higher scores on all six measures of task value and task management than students in the IST ($p < 0.01$; Lodewyk et al., 2009).

The findings in this study are somewhat similar and supportive of the findings reported by Seidel et al. (2005) in the sense that both found positive benefits in classroom teacher practices that were based on well prepared, coherent, and connected lessons. However, the WST addressed in this study did not yield the same level of positive effects as those found in the clear and coherent lessons addressed in the study done by Seidel et al. (2005). This could be due to a number of reasons, first of which could be sources of internal invalidity. One potential weakness of the within-subject research design is an effect of the first treatment on the second treatment. However, there were participants that received the IST first, and other participants that received the WST first. This step controlled well for this threat to internal validity. As for the lack of difference in motivational characteristics between the two task structures, there was no pretest measurement given to determine the participants initial motivational levels. It is very possible that entire classes would vary greatly in levels of motivation compared to other classes taught by the same teacher. As for the generalizability of this study, the secondary level science students are directly pertinent to my focus population. However, given that they were from a private school in Western Canada, I am reluctant to draw direct generalizations to U.S. students in public schools. That being said, the implications of this study combined with those from Seidel et al. (2005) build a stronger argument for several key teacher practices that support students' autonomy and self-regulated learning. Namely, that classroom lessons and tasks are clear and coherent with respect to the goals and expectations of the classroom, relevant and meaningful to the students' everyday lives, and that there are ample resources to support students' autonomous exploration and investigation into the content of the lessons (Lodewyk et al., 2009).

Teacher autonomy support was shown to positively impact students' own perceptions of autonomy and competence. Furthermore, in college-age students autonomy support was shown to be positively correlated with high mastery goal orientations and high perceptions of task value. However, the specific teacher practices that are considered autonomy supportive are ill-defined and ultimately a matter of student perception. That being said, some strategies that were found to promote higher perceptions of student autonomy and competence include having lesson goals and expectations that are clear and coherent, lessons that are relevant and meaningful to the students' lives, and having ample resources to support students' autonomous exploration and investigation. One potential teacher strategy for supporting student autonomy is the provision of student choice. The following section will examine the effects of student choice on perceived autonomy and intrinsic motivation.

Student Choice: Increasing Student Autonomy by Providing Choice

This section focuses on the provision of student choice for increasing students' intrinsic motivation. This discussion is informed by self-determination theory (Deci & Ryan, 1985) and as such, regards choice as a motivational concept and not as a result of controlled reinforcements or contingencies. In other words, real choice involves being able to pick from the given options and experience the natural consequences of that option. Choice is an important aspect of an autonomy supportive classroom, as mentioned in the previous section. However, it is being addressed separately in order to focus on the effects of choice as an isolated practice, one that is theoretically detached from other aspects of autonomy support in the classroom. Although each of the following studies investigated the role of choice on intrinsic motivation in different contexts, all offer insight into the provision of student choice as a teacher strategy for effecting positive change in students' intrinsic motivation.

Cordova and Lepper (1996) found the provision of instructionally irrelevant, but genuine choice to increase students' intrinsic motivation (based on measures of enjoyment, perceived competence, and self-efficacy) in the context of 4th and 5th grade students in math. The study had a pre-/post-test control group design, involving 70 students from one elementary school in the San Francisco Bay area, California. Participants of the study, composed of 71% White, 13% Hispanic, 9% Black, and 7% Asian American students, were randomly assigned to three different groups: The control group (n=14), a fantasy-experimental group (n=28), and a fantasy/personalized-experimental group (n=28). Half of the participants in each of the experimental groups were randomly assigned and given choices during the treatment that did not affect the content or instructional relevance of the lesson.

As a means of controlling for external variables, all groups received the same computer-based math lesson, the variation in context, personalization, and choice were implemented within the computer programs. In other words, while the control group received a generic math lesson on the computer, the contextualized group received a math lesson that was framed around a fantasy space expedition. Likewise, the personalized experimental group was also framed in the fantasy context, but included various personalized references to students' names, friends, favorite games, toys, and foods (information collected during pre-test). Finally, as mentioned earlier, half of both the contextualized group and the contextualized and personalized group were provided with choices that affected the path of the spaceship in the computer program, but did not affect the questions or subject content of the lesson (Cordova & Lepper, 1996).

Measures of students' perceived competence before and after treatments showed that students in the choice-experimental conditions reported significantly higher levels of intrinsic motivation than those in the no-choice-experimental conditions ($p<.01$). Independent of the variables of contextualization and personalization, participants in the choice conditions showed statistically significant increases in measures of perceived competence, enjoyment, and self-efficacy compared to participants in the no-choice conditions. These findings suggest that providing students with seemingly inane choices that do not affect the nature of instruction or cognitive demand will likely increase students' intrinsic motivation (Cordova & Lepper, 1996).

There are two aspects of this study that need mentioning before consideration of generalizing the findings to secondary science students. First, the sample size was small and isolated. Although the sample was quite diverse with respect to cultural and ethnic backgrounds, each experimental group contained only 14 participants and the entire sample took place in one school. With that being said, these findings while significant should be generalized to other geographic regions and even other elementary age students with a reflective and cautious lens. Second, the sample population, while diverse, did not focus on secondary level students, or science. As 4^{th} and 5^{th} grade students continue in their education and transition into secondary schools, the issues of choice and autonomy become increasingly relevant. Likewise, given the interdependence of math and science, and the ease of which choice can be implemented into most, if not all subject content areas, I consider the findings of this study with regards to choice to be pertinent and worthy of generalizing to secondary science students. The following study demonstrates the importance of choice on intrinsic motivation in secondary science students (Cordova & Lepper, 1996).

Hanrahan (1998) conducted a qualitative study of 11^{th} grade biology students in Brisbane, Australia, and found that the lack of student choice inhibited the intrinsic motivation of students. Through participant observation, interviews, and surveys that spanned six weeks, Hanrahan (1998) gathered data from one classroom of 12 female students, 3 male students, and one female teacher. This study sought insight into the factors that either facilitated or prevented students' involvement in learning, with particular attention paid to the effects of a constructivist teaching approach on intrinsic motivation.

The author provided a candid explanation of constructivist biases held and other potential factors influencing the interpretation of data. Furthermore, the methods used in this study involved several steps to ensure credibility including member checks with students and teacher, peer debriefing, progressive subjectivity, negative case analyses, and triangulation of data collection. With regard to the latter measure, as a way of providing thorough descriptions, continuous classroom observations were conducted, as well as two teacher interviews (once at the beginning and once midway through) and seven student interviews (taking place throughout the six week observation period). Also, the Classroom Environment Survey (CES), which was given just before the observations and interviews, took place before the author became involved. This survey sought information on the students' and teacher's experiences of the classroom learning environment and what they perceived an ideal learning environment to look like. Questions in this survey were answered using a five-point Likert scale and related to levels of involvement in learning, perceived autonomy, perceived relevance, commitment to learning, and inhibitors to learning. The latter measure is of particular importance in this discussion (Hanrahan, 1998).

While Cordova and Lepper (1996) looked at the effects of more concrete strategies for intrinsically motivating students, work done by Hanrahan (1998) provided an emic perspective which shed some light on the potential negative impacts of lack of choice on intrinsic motivation. Despite being intrinsically motivated, students can still exhibit extrinsic goal orientation and be inhibited from learning due to a lack of classroom environmental factors including, but not limited to, student choice. Although the study took place outside of the U.S.A. (Brisbane, Australia), and demographics were not provided for the sample population, the nature of the study pertains directly to secondary science students. Furthermore, given the qualitative design of this study combined with the paucity of similar studies addressing teacher strategies and intrinsic motivation, this study provides rich insight into the role of learning environment factors, such as choice, from the perspective of the students.

In summarizing the data, Hanrahan (1998) combined all the student narratives from the interviews into one collective narrative. Particularly striking was an expression of the desire for more choice in this particular science class:

> All the same, this hardly happens at all in English, where we're allowed to choose our own topic to write about and negotiate our own assessment, or in art, where you can choose your own topic and your own colours [sic] and things like that. (pp. 745-746)

Based on this narrative, the type of choice that students want involves providing both instructionally irrelevant choices such as types of colors used in an art project, as well as choices that support autonomy for student learning. With that being said, the latter call for autonomy supportive choices involves other strategies encompassing culturally relevant classroom practices and the creation of a safe learning environment that fosters trust, student risk taking, mastery goal-orientation, and other key factors involved in intrinsically motivating students to learn. Nevertheless, for the sake of the current discussion, the former call for choices that have little or no influence on the nature of the instruction supports the previous study's findings of positive impacts on intrinsic motivation through the provision of instructionally irrelevant choices (Cordova & Lepper, 1996).

Ciani, Summers, Easter, and Sheldon (2008) conducted a quantitative study looking at the effects of student choice on intrinsic motivation, in the context of cooperative group formation. Using a static group comparison design, the authors purposefully selected six teachers from a research university in the Midwestern U.S. who responded to a mass mailing and claimed to use cooperative learning on a regular basis in their classrooms. Furthermore, of these six teachers, three allowed their students to choose their own groups during cooperative learning activities, while the other three teachers selected student groups. In all, a total of seven classes (two taught by the same teacher) containing 544 undergraduate-level students were given a one-time survey late in the semester. This survey which contained 29 items on a 7-point Likert scale, measured students' levels of intrinsic motivation (enjoyment and interest) and perceived autonomy support by the teacher.

Results from the analyses showed that students who were allowed to choose their own groups showed higher levels of intrinsic motivation ($M = 4.72$, $SD = 1.39$, $p < 0.001$) than students in classes where the teachers assigned students to groups ($M = 3.84$, $SD = 1.53$, $p < 0.001$). Another particularly striking result from the analyses suggested that the provision of choice in group formation was a statistically significant and positive predictor of intrinsically motivated students, even when autonomy support was controlled for ($\gamma = .65$, $p = 0.05$). While Deci et al. (1994) and Reeves et al. (2003) found choice to be positively related to intrinsic motivation only in the presence of other autonomy supportive factors (as perceived by students), findings from Ciani et al. (2008) showed the provision of choice alone to be positively related to intrinsic motivation (as cited in Ciani et al., 2008). This study suggests that allowing students to choose their own groups during collaborative learning activities is an effective strategy, in itself, for intrinsically motivating students.

Several aspects of this study must be mentioned in assessing the generalizability of this strategy for secondary science students in schools across the U.S. First, there were 23 students not included in the analysis due to missing information on the survey. Given the overwhelmingly White proportion of students in the sample (~87%), the loss of nearly 5% of the total sample size causes questions about what insight or underrepresented groups may have been contained in that lost data. While the sample did not involve secondary-level science students, the issue of choice likely plays a similar role in secondary students negotiating increased social responsibilities, developing identities, and issues of power and control. Also, in creating a multicultural classroom environment where differences are normalized and issues of power are addressed and downplayed, teachers must be aware and sensitive to issues of status, exclusion, and racism in the context of student selected groups (Ciani et al., 2008; Cohen, 1994, pp. 24-38).

Choice in the context of the previous studies is a readily applied teacher strategy for intrinsically motivating students. While the types of choice offered in the previous studies varied quite considerably, all proposed giving students choices in situations that did not alter instruction or require additional modifications to lessons. In a secondary science classroom there are myriad opportunities to provide students with choices including materials used, processes for completing student work, and group formation. While choosing groups is one important step in the process of collaborative group work, there have been numerous studies that have examined the relationship of entire practice of group work compared to other more teacher-centered models of teaching on student motivation. The following section, will discuss several studies that sought insight into this relationship.

Social Learning: Cooperative Models of Teaching

The following section, examines the use of teaching models that involve group work as a strategy for intrinsically motivating secondary science students. Included in this discussion are cooperative and problem-based teaching models. There are a multitude of ways to conduct group work, and each way serves different purposes and goals in the classroom. However, for the sake of this discussion, the benefits of working in groups in a collaborative rather than a competitive manner will be the focus of this section. As Cohen (1994) described, group work involves teachers handing over authority and allowing students to make their own mistakes, struggle with the content, and construct their own knowledge. As such, it tends to be a more autonomy supportive, student-centered approach to teaching. Additionally, cooperative and problem-based learning provides students with increased opportunities for developing important social and communication skills. However, this section will focus solely on the effects on student motivation.

Hanze and Berger (2007) studied the effects of cooperative learning versus direct instruction on students' perceptions of autonomy, competence, and levels of intrinsic motivation in 12th grade physics students. Results of the study showed positive impacts on students' in all measures related to intrinsic motivation. A total of 137 students from eight classes were conveniently recruited to participate in this pretest/posttest control group study. The study consisted of two learning units on electron scanning microscopes and microwave ovens. First, all students were given a pretest questionnaire on their self-concepts and goal-orientations. Then, all participants were given a general intro into the unit of study through direct instruction, after which they were given a questionnaire that included measures for intrinsic motivation based on degrees of interest and engagement. Next, four classes were randomly assigned to either the cooperative learning lesson or the direct instruction lesson. The questionnaire on intrinsic motivation was given again following the lessons.

The jigsaw method originally developed by Elliot Aronson in 1978 was used for the experimental cooperative learning condition, while the direct instruction condition involved sequential steps, a fast pace and ample teacher-student dialogue. Key phases in the jigsaw teaching method involved student groups of four to five students who gained 'expertise' in a subtopic, later tutoring students from other expert groups on their subtopic. With respect to the learning experiences of all participants, there was no description of the teachers and their experience or preferred teaching styles provided. This detail poses some threats to the internal validity of the study as the teachers involved may have possessed disproportionate skills and experience in one teaching method over the other (Hanze & Berger, 2007).

Univariate analyses of variance were conducted with the method of instruction as the independent variable and the dependent variables including students' pre- and post-measures on experiences of autonomy, competence, and intrinsic motivation. For all of these dependent variables, the cooperative learning method of instruction yielded higher, although varying levels of significance than the control group conditions. Mean scores for the experience of autonomy were 3.4 ($SD = 0.97$) for the treatment group and 2.5 ($SD = 0.84$) for the direct instruction group ($p < 0.05$). Mean scores for the experience of competence were 4.4 ($SD = 0.68$) for the treatment group and 4.0 ($SD = 0.84$) for the DI group ($p < 0.05$).

For intrinsic motivation, the treatment group had a mean score of 3.5 (SD = 0.73) and the DI group had a score of 3.2 (SD = 0.92, $p < 0.05$). Several other statistical analyses were conducted to test the mediating effects of students' goal orientations and self-concepts in determining the effects of the two methods of instruction on students' experiences of competence, autonomy, and intrinsic motivation. Hierarchical regression analyses revealed that mastery orientation of students positively influenced competence ($\beta = 0.79$, $p < 0.05$), but the method of instruction was not significant ($p > 0.05$). That being said, the most salient findings which deserve focus in this discussion are the higher increases in students' reported levels of autonomy, competence, and intrinsic motivation (Hanze & Berger, 2007).

At face value, these findings strongly support the use of the jigsaw method of cooperative learning for the purpose of intrinsically motivating secondary science students. However, the generalizability of this study is limited given that the study took place in Germany, the demographics and diversity of the population was not described and the teaching styles that the students were most familiar with was not explicitly stated. That being said, the fact that this study looked directly at secondary science students suggests a similarity in the experiences of the sample population and those in science classes in the U.S. with respect to learning, social, psychological, and cognitive development. In terms of the internal validity of this study, the instrumentation used for measuring intrinsic motivation involved four items and as such lacked depth of understanding in terms of students' complex motivations for engaging in science learning. However, the more in-depth measures of autonomy and competence provided additional support in demonstrating positive effects of cooperative learning compared to direct instruction. At this point, the findings from this study suggest a positive relationship between one format of group work and intrinsic motivation in secondary science students. However, prior to drawing any substantive conclusions it is necessary to review other studies addressing similar teaching strategies (Hanze & Berger, 2007).

Sungur and Tekkaya (2006) examined the difference of effects of problem-based learning (PBL) and traditional instruction on students characteristics related to intrinsic motivation. The most salient findings included higher intrinsic goal-orientations and higher valuing of the learning tasks in the problem-based learning context compared to the traditional instruction context ($p < 0.05$). The pre-treatment/post-treatment control group design enabled the authors to compare the initial levels of students' motivational characteristics with their final levels in classes experiencing traditional instruction and problem-based learning instruction. Although the study did not take place in the U.S. (Ankara, Turkey), it did involve 61 (39 boys and 22 girls) high school level biology students. The participants were from two classes taught by the same teacher. Both the teacher and students were unfamiliar with problem-based learning. As such, both received handouts explaining the phases and theoretical background. In addition, the authors trained and contacted the teacher multiple times a week to offer guidance and support in implementing the PBL instruction, and also conducted observations to ensure proper implementation of the teaching model.

Initially, both classes completed a questionnaire taken from the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich, Smith, Garcia, and Mckeachie in 1991. 31 items assessed students' goal orientation, beliefs about the value of the tasks, self-efficacy, perceptions of autonomy, and test anxiety. All measures were based on a 7-point Likert scale ranging from 1 (not at all true of me) to 7 (very true of me).Following the pretreatment questionnaire, the two classes were randomly assigned to either the experimental or control group condition. Both classes studied topics on the human respiratory system and the excretory system. The control group was taught by lecture and student questioning with heavy reliance on textbooks and worksheets. The PBL group on the other hand consisted of five heterogeneous groups of six students with assigned roles such as scribe, reader, doctor, and patients. Each group worked with an authentic problem, based on actual patients. Groups were given seven page documents containing information about their case and additional data as needed. Over the course of four 45-minute sessions, the PBL class went through three phases. The first phase was an introduction phase where students read, took notes, and discussed ideas. Next, students conducted independent studies pertaining to their group's problem. The third and final phase involved groups reconvening, discussing and revising their hypotheses and proposed solutions. Following each phase, students completed self-evaluations of individual and group processes (Sungur & Tekkaya, 2006).

Following the four 45-minute class sessions, both classes completed the post-treatment questionnaire taken from the MSLQ. Results from the questionnaires were analyzed using multivariate and univariate analyses. First off, the mean scores of the pretest questionnaire did not vary between the treatment and experimental groups by more than 0.20 (SD ranged from 1.03 – 1.61). The same analysis was done for the posttest scores and a statistically significant difference was found between the two conditions ($p = 0.002$). Mean scores for the intrinsic goal orientation was 3.94 ($SD = 1.43$) for the control group and

5.23 (SD = 0.90) for the experimental group. Mean scores for task value measures were 4.52 (SD = 1.38) for the control group and 5.39 (SD = 0.90) for the experimental group. Mean scores for test anxiety was 3.44 (SD = 1.11) for the control group and 4.69 (SD = 0.86) for the experimental group. ANOVA results showed that mean scores for intrinsic goal orientation, task value, and test anxiety differed in a statistically significant way ($p < 0.05$). These results certainly suggest benefits in using problem-based learning as a strategy for intrinsically motivating secondary science students.

However, prior to accepting these results there are some aspects of the study that deserve mention. First, the lack of familiarity with problem-based learning in both the teacher and the students is a potential threat to internal validity with respect to instrumentation of the study. For instance, while the teacher may have been more experienced with traditional instruction, the use of a new model of teaching may have contributed to the increased levels of engagement and interest in the students. In other words, the novelty of a new approach to learning could serve as one potential extraneous variable in this study. Also, the authors did not factor in gender and other demographic characteristics as independent variables. Given the disproportionate ratio of female to male students (22:39), a difference based on gender could have largely influenced the results of this study. In synthesizing the results with the limitations of this study, problem-based learning may indeed be an effective strategy for promoting intrinsic or mastery-goal orientation and higher perceptions of task value. However, further research on the differential effects of problem-based learning on gender and other variables would clarify and potentially strengthen the support of this study's findings (Sungur & Tekkaya, 2006).

Shachar and Fischer (2004) investigated the effects of cooperative learning versus traditional whole-class instruction on the levels of intrinsic motivation in 11^{th} grade chemistry students from Israel. Quite contrary to similar studies, findings from this study showed a negative relationship between cooperative learning and intrinsic motivation. However, supplementary qualitative responses revealed that an emphasis on breadth over depth of content and achieving high grades may have contributed to the students' perceptions of this model of teaching. As will be discussed, these findings elucidate important factors to be considered when implementing cooperative models of teaching for the purpose of promoting intrinsic motivation in secondary science students.

In a sample of 168 students (89 male and 79 female) from five chemistry classes in two different six year high schools, the authors employed a pre-test/post-test control group design to test their hypothesis that students in a cooperative learning classroom environment would have higher levels of intrinsic motivation than students in a traditional whole-class environment. Each class was taught by a different teacher, all of which were unfamiliar with cooperative models of teaching. All five teachers participated in workshops on implementation of cooperative learning prior to the experiment. Two of the five classrooms were conveniently assigned to the experimental condition ($n = 70$) based on the teachers' schedules, while the other three classes were assigned to the control group ($n = 93$); (Shachar & Fischer, 2004).

To begin, all participants completed a 30-item questionnaire measuring students' initial motivational orientations. The nature of this questionnaire focused on goal-orientations, self-regulated learning, and attributions of success and failure. Then, over the course of eight weeks, a total of 32 hours were spent covering two topics in chemistry. The experimental conditions studied both topics using the group investigation method which is characterized by six clearly defined steps emphasizing investigation, interaction, and interpretation. Four observations in one class and three observations in the second experimental class were conducted to ensure proper execution of the group investigation methods. Conversely, the control conditions relied heavily on the use of the standard chemistry textbook and teacher lectures, although there was no mention of classroom observations having been conducted. At the conclusion of these two study topics, all participants completed the post-test questionnaire which was identical to the initial motivational questionnaire. Additionally, each participant in the experimental condition was asked to write anonymous letters expressing their perceptions of the group investigation experience. These letters were analyzed by two independent researchers and classified into positive statements, negative statements, or thoughts and suggestions for improvement. Inter-rater reliability on this analysis was 93% (Shachar & Fischer, 2004).

Descriptive statistics and multivariate analyses for variance were conducted for the motivational measures and both learning conditions. Findings showed that intrinsic motivation of participants in the cooperative learning conditions decreased significantly while participants in the control conditions maintained the same levels of intrinsic motivation over the course of the experiment ($p < 0.05$). The mean scores for the pretest and posttest motivation measures were 16.96 ($SD = 3.83$) and 15.79 ($SD = 4.19$) for the experimental group, whereas the control group had a pretest mean score of 15.47 (SD = 4.59) and a posttest score of 15.87 (SD = 3.78). As for the qualitative responses given by the participants in the experimental conditions a clearer picture began to take form. While 28.8% of the comments were positive regarding their experience with cooperative learning, 41.7% were negative (29.4% were suggestions for improvement). Of the negative comments, many pertained to the lack of breadth covered in the cooperative learning model. Additionally, there were comments suggesting that this method of learning was incongruent with the ulterior goal of attaining high grades. Considering the upcoming nationally mandated chemistry examination, it seems plausible that students in the experimental condition were under increased pressure to cover a wider breadth of content (Shachar & Fischer, 2004).

There are several details of this study that warrant closer examination. First, 11th grade chemistry students in the context of this study differ from 11th grade students in U.S. high schools. Namely, students in Israeli high schools have already decided on a major area of study, in this case it was chemistry. However, in the case of U.S. high schools many students taking chemistry are doing so for general education requirements and are not necessarily intending on majoring in chemistry. That being said, the academic identities, science self-concepts, and perceptions of ability could very likely differ quite drastically between these two student populations (Shachar & Fischer, 2004).

The research design implemented in this study was strong in controlling for potential threats to the internal validity. In particular, the presence of a pre-test and post-test controlled for differences in motivational orientations between the experimental conditions. The topics of study were the same for both experimental conditions, controlling for any threats based on level of interest in the content. One aspect that deserves mention is the presence of an upcoming standardized high stakes chemistry test. This factor could have greatly influenced the experiences of the students in the cooperative learning groups. Indeed, the presence of an outcome-based examination following the study is likely to influence any efforts to promote an intrinsic goal-orientation or other aspects of intrinsic motivation. That being said, one valuable insight that is provided by this study is the highly complex interaction between students' classroom learning experiences and the greater social and cultural environment. In particular, the heavy reliance on grades and standardized tests in U.S. schools suggests that the implementation of cooperative learning must be done so in a thoughtful and well-designed manner. Furthermore, any use of cooperative group work in the classroom is best preceded and integrated by numerous opportunities to foster social skills and strategies for working effectively in groups (Cohen, 1994; Shachar & Fischer, 2004).

Tan, Lee, and Sharan (2007) compared the effects of group investigation, a form of problem-based learning, and whole class instruction on the intrinsic motivation of 8^{th} grade geography students in Singapore, Malaysia. Overall, findings suggested that group investigation did not have a strong positive impact on students' intrinsic motivation, and in some cases suggested a negative impact when compared to whole class instruction. The findings in this study highlight the need for some important considerations when implementing a collaborative learning model in the classroom.

Two hundred and forty one students from seven classes in two different schools participated in this pre-test/post-test control group study. Three teachers that were unfamiliar with group investigation participated in the study. They were trained in the process of group investigation through 6-three hour workshops prior to conducting the experiment. To begin, each of the three teachers taught at least one class through group investigation and one class through whole-class instruction (one teacher taught to classes using group investigation). It was not described how the classes were assigned to each learning condition within each teacher's classes. All participants began by completing a motivational questionnaire which measured students' preference for challenge, desire for mastery, curiosity, judgment (independent versus reliance on teacher), and criteria (internal versus external criteria for determining success and failure). Each of these measures contained five items based on a Likert type scale. This same questionnaire was given to the participants following the treatments, with one additional open-ended item asking students in the group investigation condition to write about their feelings and opinions toward group investigation. These questions were interpreted by one of the authors and a researcher (inter-rater reliability = 91.3%); (Tan et al., 2007).

Both the group investigation and whole-class conditions covered two units on pollution and climate change over the course of six weeks. The authors worked in collaboration with the teachers in designing the units of instruction. Whole-class instruction relied on presentation and direct instruction teaching models, while the group investigation method relied on the six steps involved in problem-based learning models. Students in the experimental conditions were allowed to choose their own groups of 4-5 with which they worked together for all six weeks of instruction. Following completion of the six week treatment, all participants completed the post-test motivational questionnaire and were thanked for their participation. The authors then conducted a number of statistical analyses of covariance, with pretest motivation scores as the covariate (Tan et al., 2007).

The only statistically significant difference between the two learning conditions involved the criteria measure. High achieving students learning through group investigation reported higher use of independent criteria ($M = 13.87$, $SD = 3.10$) to determine success and failure than high achieving students learning through whole-class instruction ($M = 13.03$, $SD = 3.05$, $p < 0.05$). On the other hand, low achieving students in the GI group reported lower use of independent criteria to determine success ($M = 11.80$, $SD = 3.90$) than low achieving students in the control group ($M = 13.06$, $SD = 3.24$, $p < 0.05$). The open-ended question yielded twice as many positive statements as there were negative statements. However, the negative statements which were still quite numerous (31.8% of total statements) suggested a strong performance or ego goal orientation. The positive statements on the other hand, tended to pertain to higher levels of perceived competence and autonomy in response to the group investigation method. These qualitative findings suggest that the use of group investigation, as well as other forms of cooperative learning would be more likely to serve as an effective strategy for intrinsically motivating students when used in combination with strategies for promoting a mastery goal-orientation and additional autonomy supportive teacher practices (Tan et al., 2007).

While findings from this study did not appear to be highly favorable for one instructional method over the other, there are a number of concerns regarding internal validity that must be addressed. One criticism is the lack of a similar open-ended question in the post-test measure of participants in the control group. In this case the control group would have had the opportunity to reflect on their experience, potentially providing further insight into the differences in perceptions between students from the two groups. Furthermore, in terms of the motivation questionnaire used, there were aspects of motivation that were not addressed potentially leading to an inconclusive measure of students' true motivational orientations. For example, there may have been significant changes in students' perceived levels of autonomy and competence, as well as their goal orientations which would not necessarily have shown up from the results of the questionnaires in this study (Tan, et al., 2007).

The four studies examined in this section provide mixed results with respect to the value of their use for intrinsically motivating secondary science students. None of the studies took place in the United States. As such the generalizability of the findings is limited. That being said, these studies taken as a whole suggest that problem-based and cooperative learning could potentially be effective strategies for motivating students when external influences such as grades and high stakes assessment are taken into consideration. The varied results from these studies suggest that there are many external factors, including the goal orientation or learning environment of the classroom, that influence the effectiveness of group learning models. There are some strategies that serve to both support students' intrinsic motivation and to support the effectiveness of other strategies such as cooperative learning. The following section will examine the use of student-centered teaching practices to support the intrinsic motivation of secondary science students.

Student-Centered Teaching Practices: Students' Inner Motivational Resources

Culture is a shared set of beliefs, practices, knowledge, skills, attitudes, and other material artifacts that are passed on from one generation to the next. Schools are places where increasingly diverse cultures share classrooms and other public spaces in attempts to gain knowledge and skills that will prepare all students for successful and satisfying lives as adults. One important aspect of intrinsic motivation is the cultural and individual specificity with which it manifests itself. In other words, what is intrinsically motivating for one student will be perceived in an entirely different manner. Furthermore as Morling and Kitayama (2008) explained, while some students have knowledge and awareness of their inner preferences due to social and cultural practices that promote independent thinking, many cultures emphasize interdependence and do not promote expression of inner desires. Self-determination in many cases may be deeply interwoven with external motives and performance oriented goals. In other words, the classroom is a place where diverse students with diverse needs, preferences, and inner motivational resources come together. As such, it is necessary to embrace teaching practices that are centered on the students as wholes. The following section discusses a selection of studies that address the importance of enacting student-centered teaching practices and explore the potential benefits of various practices in positively impacting students' intrinsic motivation (Hidi & Harackiewicz, 2000; Huerta, 2009; Morling & Kitayama, 2008).

Lau and Roeser (2008) sought insight into the various cognitive, motivational, and affective characteristics of different types of students in relation to their achievement in high school science classes. This study suggests that some students are cognitively capable, but motivationally struggling, while others are cognitively struggling, but intrinsically motivated. Still yet, there are other types that fall somewhere in between. In essence, this study illustrates the complexity of students' motivational, cognitive, and affective characteristics, while attempting to establish a set of general personality types that will help teachers identify areas of needed focus in terms of motivation.

Three hundred and eighteen (158 boys and 160 girls) 10^{th} and 11^{th} grade science students were conveniently sampled using a static group comparison design based on gender type. Students were ethnically mixed, with 55% European American, 24.8% Hispanic, 6.4% African American, 6.4% Asian American and 7.4% other ethnic origins. Beginning in the first semester of the school year, participants were given two survey questionnaires in two separate sessions. The first survey measured a number of motivational characteristics including goal orientation (20 items), perceived value of science tasks (4 items), classroom emotions (10 items), test anxiety (5 items), students' beliefs about their own competence (11 items), perceptions of teacher support (3 items), relevance of content (5 items), perceptions of classroom goal emphasis (13 items), and use of self-regulated learning strategies (22 items). The second survey measured students' cognitive abilities and consisted of mathematics (20 items), vocabulary (20 items), hidden figures (16 items) and cube comparisons (21 items) tests. These two surveys provided the data for analyzing and determining personality types based on all the aforementioned variables (Lau & Roeser, 2008).

During the second semester, students took a science achievement test consisting of 30 multiple-choice questions which covered biology, physics, and chemistry. Additionally, students' science grades were collected from their teachers and included in the data as an additional comparison point. Analyses of the data involved determining the number of replicable personality types, classifying the participants into those types, and then interpreting and validating the identified types. Using multiple criteria to determine the number of distinct and replicable personality types, the authors identified a two-factor solution for each gender type to provide the highest correlations (rs = 0.85 and 0.73 for boys and girls, respectively). Ultimately, eight personality types, four for each gender type were identified.

Fifty one of 144 boys were characterized as anxious and ego-involved, also referred to as ego approach goal orientation (type two). Fifty boys were characterized as able and confident (type one). The third personality type consisted of 19 boys characterized as intrinsically motivated and task-involved. Twenty four boys were characterized as able but work avoidant (type four). Girls were similarly classified into four personality types. Forty six of 139 girls were characterized as confident and task-involved (type three). Thirty three girls were characterized as having positive perceptions of the classroom (type two). The last two personality types each consisted of 30 girls characterized as being able (type one), or anxious and ego-involved (type four). Overall, 91% of the boys and 87% of the girls in the sample were successfully classified into one of these eight personality types. Subsequent correlation analyses revealed that type 1 boys were highly correlated with type 3 girls and type 4 boys were highly correlated with type 4 girls ($p < 0.01$). Based on the motivational profiles, type 1 boys and type 4 girls fit a mastery oriented, intrinsically motivated pattern. Type 4 boys and girls on the other hand fit a helpless, work-avoidant pattern. Interestingly, participants in these two groups did not necessarily score low on the ability measures, suggesting a lack of interest or motivation rather than lack of ability (Lau & Roeser, 2008).

Considering the large amount of time that elapsed between the motivational (first semester) and the achievement measures (end of second semester) there is an issue of maturational threat to the internal validity. It is very possible that students' motivational orientations and achievement shifted temporally over the course of an entire school year depending on numerous factors including teacher, subject, and many personal variables. Additionally, the mortality of the sample with respect to classification into personality types poses an important consideration for the 9% of the boys and 13% of the girls that failed to fit into one of the eight categories. Twenty two percent of the sample is a significant proportion and the motivational, cognitive, and affective characteristics of those students are included in the scope of this paper (Lau & Roeser, 2008).

As for the generalizability of this study, it is of value that the participants were surveyed in the context of secondary science classes in the U.S. (general area was unspecified). However, given the nature of this study, it is not realistic to apply these same personality types to other student populations in other regions of the country. That being said, the presence of distinct personality types characterized by varying levels of motivation, cognitive abilities and affect is a concept that is applicable to any and all students.

While this study did not address any explicit strategies for intrinsically motivating science students, it does shed light on a key precursory component in this process. First getting to know students and identifying motivational characteristics that deserve special focus is one such component that would enable teachers to make optimal use of limited classroom time. The question remains, what teacher strategies will facilitate building such teacher-student relationships, enabling teachers to recognize individual students' motivational orientations and areas of needed focus (Lau & Roeser, 2008)?

In a quite different context Oldfather (2002) sought insight into how a culturally responsive classroom can help support 5th and 6th grade students to learn when they are not motivated. Although the focus of this study is quite removed from the subject focus of this paper, namely secondary science students, it offers a rare perspective on the issue of supporting students in learning about content that initially, they may not be intrinsically motivated to learn. Given the limited research on the effects of a culturally responsive classroom on secondary level science students' intrinsic motivation, this study is included as a starting point with which to build upon. Autonomy supportive practices are built around the engagement and inclusion of students' inner resources. These inner resources are products of students' out-of-school, culturally situated experiences and subject to individualized perceptions. In order for teachers to identify the inner motivational resources in students, there must be a classroom learning environment that invites and supports the whole student (Nieto, 2007; Oldfather, 2002; Reeve, 2006).

Oldfather (2002) observed 31 students from a whole language classroom in Southern California over the course of eight months. The sample classroom was purposefully selected for its emphasis on learning, social constructivism, and the ethnically diverse composition of the classroom (30% minority students from African American, Mexican American, and European American descent). Additionally, the practices and behaviors that were associated with the teacher included being friendly, caring, humorous, enthusiastic, having high expectations, providing specific feedback, use of alternative assessments, and general constructivist forms of teaching. Observations were done at different times of the day both in and out of the classroom (i.e. during recess, P.E., lunch, and computer lab time). Additionally, 8 male and 6 female students comprising a variety of motivational orientations and achievement levels were interviewed throughout the study. All of the interviews were conducted outside of the classroom. The interview questions related to situations where students were initially unmotivated to participate in classroom activities and were based on observations and on discussions from previous interviews. One of the main purposes of this qualitative, interpretive study was to engage the students in the research rather than viewing them solely as participants. This enabled the students to offer insights on the research questions, verify and elaborate on the collected interview data, and even gain valuable skills in conducting their own research and interviews with younger students. Beyond this initial measure to strengthen credibility, the author continually prepared questions prior to interviews based on her interpretive data as an additional source of member checks (Oldfather, 2002).

Data collected from the interviews were sorted into separate categories and properties and later checked for validity by two outside researchers. This was done through coding of random selections of the data. The author and researchers had a high initial degree of inter-rater reliability. Nevertheless, any discrepancies in the coding were negotiated and reconciled. Three major patterns emerged from these analyses. While all three patterns involved students' initially lacking motivation, they differed on how and whether they reconciled this lack of motivation. The first pattern was related to intrinsically derived motivation, resulting in eventually completing the tasks. Ways that this was accomplished included recognizing that other students were getting the task and figuring that they should be able to get it, pushing through the initial disinterest and gaining interest through the act of doing, and being cognizant or self-regulatory of their attention or lack of. The second pattern was associated with extrinsic forms of motivation and involved doing the task to get it over with, to meet the classroom requirements and expectations, and remembering the classroom accountability system. Lastly, the third pattern was associated with an avoidance approach to the lack of motivation and involved students saying that they just could not do it and giving up. One of the more profound findings from this study was the commonality among all three student patterns in that everyone experienced a lack of motivation at certain times despite considering the class to be interesting and engaging (Oldfather, 2002).

While this study does not provide insight into ways to intrinsically motivate students, it does offer insight into ways that students who feel supported and cared for are able to recognize and attempt to remedy a lack of motivation. Oldfather (2002) provided thick descriptions of the context of the study and of the methods used for gathering data. There were thorough explanations of her method of coding and the inclusion of outside researchers provided a credible source of peer debriefing and progressive subjectivity.

Additionally, the consistent member checks carried out between the author and the interviewees helped ensure that the messages being conveyed were of the students and not the researcher. Over the course of eight months, the author engaged in varied and detailed observations, combined with interviews which served as a strong source of both triangulation and prolonged, substantial engagement. Taken altogether, this study is quite credible and transferable at least to the extent that it warrants careful consideration in any classroom. Particularly, the high proportion of disinterest and amotivation in secondary level science classrooms suggests that culturally responsive teacher practices may help provide students with a forum for recognizing their lack of motivation and begin the process of identifying ways to remedy and build intrinsic forms of motivation (Hidi & Harackiewicz, 2000; Oldfather, 2002).

Skinner and Belmont (1993) further elaborated on the relationship between student motivation and teacher practices by looking at the relationship between teacher behaviors and student engagement. The authors used a time series design to study the effects of teacher involvement, classroom structure, and autonomy support on students' behavioral and emotional engagement over the course of a school year. Participants were conveniently sampled from a single rural-suburban elementary school in upstate New York. A sample of 144 children with equal numbers in grades 3-5 participated in the study. Gender ratios of the students were equal, while all 14 participating teachers were female.

Both students and teachers completed survey questionnaires in the fall (October) and spring (April) of the same school year. The student questionnaires measured perceptions of teacher involvement (8 items), classroom structure (28 items), and autonomy support (25 items), as well as students' self reported levels of emotional (29 items) and behavioral (36 items) engagement. All items were based on a 4-point scale. The teachers' questionnaire assessed the same measures as the student questionnaire but was based on their interactions with each child in their classrooms. The goals of the study were to test the interaction between students' engagement in the classroom and teacher behavior. Specifically, they posited that the students' engagement was mediated by the teachers' behavior, and reciprocally that teacher behavior was mediated by students' levels of engagement in the classroom (Skinner & Belmont, 1993).

Once all data was collected the means and standard deviations of all measures at both times were found and compared for differences over time. The stability coefficients for the change in variables over time ranged from 0.55 to 0.79, with an average $r = 0.66$ ($p < 0.001$). Differences between the fall and spring measures ranged from 0.08 to 0.11 on a 4-point scale ($p < 0.01$). The change in each measure over time was statistically significant but still relatively small making it difficult for the authors to detect significant predictive abilities in any of the measures. Nevertheless, correlational analyses were done between students' and teachers' responses as a way of determining how much consistency there was between students perceptions of teacher behaviors and teachers' self-reports of their own behavior, as well as the consistency with which teachers' perceptions of their students' behavioral and emotional engagement was in relation to students' self-reported levels of engagement. These analyses yielded little significance. However, when correlations between teacher behavior and student engagement were examined, some interesting correlations were found. Specifically, correlations between students' perceptions of teacher behavior and student engagement were statistically significant ($r = 0.35$, $p < 0.001$). Likewise, correlations between teachers' self-reports of their own behavior and teacher perceptions of student engagement were statistically significant ($r = 0.56$, $p < 0.001$), although less so for the teacher behavior of structure ($r = 0.23$, $p < 0.01$). In an attempt to determine whether student engagement mediated teacher behavior, teacher behavior mediated student engagement, or a mixture of both was responsible for this relationship, path analyses were done. By and large, the most statistically significant finding from this portion of the study was the strong predictive power of students' perceptions of teacher involvement on their levels of engagement ($p < 0.001$); (Skinner & Belmont, 1993).

Although the analyses were based on statistically small variations in reported measures between fall and spring, the findings suggest that teacher involvement and particularly how it is perceived by students may be influential in promoting both behavioral and emotional engagement in students. There are a number of potential threats to the internal validity. While the increases in both teacher-perceived and self-reported student engagement may in part be due to teacher involvement, structure, or autonomy support, there are numerous other teacher behaviors and practices that likely contribute to student engagement. Additionally, the study of student engagement seems to be highly dependent on variables outside of the classroom, as well as student-student interactions in the classroom. Furthermore, given the actively developing language and general cognitive abilities of elementary age students, it seems difficult for students to distinguish between these different aspects of teacher behavior. Lastly, with a focus on secondary science students it is not feasible to generalize these weak correlational relationships across both age groups and subject matter. That being said, the findings in this study do suggest a potentially hazardous relationship between students that lack engagement and motivation, and the behaviors that teachers may take on in response. Several studies have highlighted the importance of affective teacher-student interactions and overall teacher involvement in intrinsically motivating students (Alonso-Tapia & Pardo, 2006; Patrick, Hisley, Kempler, & College, 2000; Patrick & Ryan, 2008). In this case, there is reason to believe that general overall teacher involvement and other aspects of the affective classroom domain may be influential in promoting intrinsic motivation in students when viewing this construct from the context of engagement (Skinner & Belmont, 1993).

Given the diversity of students' inner motivational resources, a student-centered teaching approach is imperative in aiming to support the intrinsic motivation of all students in the classroom. The key strategies identified in this section involve taking time to get to know your students, identifying their motivational characteristics, creating a culturally responsive classroom to support students' lack of motivation, and being cognizant and mindful of the teacher's affective interactions with students. While these studies did not provide any concrete strategies for intrinsically motivating secondary science students, they provide some general guidelines for creating a classroom learning environment that is supportive of students' intrinsic motivation. The following section focuses on the more specific teacher strategy of providing rationales for learning activities and other tasks, a strategy that would likely be more effective in a culturally responsive, inclusive classroom.

Rationales: Highlighting the Value of Tasks and Other Classroom Learning Activities

According to self-determination theory (Deci & Ryan, 1985), when students consider a learning activity or other classroom content to be personally meaningful and relevant to their lives, there is a tendency to experience increased levels of motivation. Framing lessons around the intrinsic value of the content to be studied has been shown to positively influence students' perceptions of importance and value. Although this form of motivation, referred to as identified regulation is partially extrinsic due to the external source of information, it can lead to internalization by the individual and subsequently increased interest, engagement, and intrinsic motivation. As a strategy for increasing the intrinsic motivation of secondary science students, the provision of a rationale will be explored and discussed in this section. Although many motivation researchers have advocated the use of rationales in combination with other strategies for supporting students' autonomy and self-regulation, this section will examine the isolated strategy of rationales (Jang, 2008; Vansteenkiste, Lens, & Deci, 2006)

Jang (2008) investigated the relationship between students' intrinsic motivation during uninteresting tasks in the presence, and absence of a rationale. In a sample of 136 college students (108 women, 28 men) enrolled in an educational psychology course in a large Midwestern U.S. university, the author found that the provision of a non-controlling rationale that acknowledged potential negative feelings and contained explanations of the benefits of learning the content for the uninteresting activity enhanced motivation based on measures of perceived autonomy and perceived importance. Each of the measures was based on a 7-point Likert scale (1 – not at all true to 7 – very true). Nine items were used for measuring perceived autonomy which assessed perceived locus of causality, level of perceived volition, and perceived choice over one's own actions. With respect to perceived importance, the questionnaire contained four items assessing how important the participants considered the lesson to be to them.

Using a post-test only control group design, participants were randomly assigned to one of two groups. Both groups received a booklet presenting a lesson on statistics as well as instructions for the task, the experimental group ($n = 69$) received an additional set of instructions containing the rationale while the control group ($n = 67$) did not receive any additional information. After 20 minutes, both groups were stopped and asked to complete the post-treatment questionnaire, involving the aforementioned measures of perceived autonomy and perceived importance. The mean scores for perceived autonomy and perceived importance for the experimental group were 4.87 and 4.66, while the mean score for the group lacking a rationale were 4.28 and 3.89, respectively ($p < 0.014$). Given the score range of 1-7, the mean score for either group was not very high. However, the increase in the two measures is statistically significant and warrants further consideration as at least one of a set of strategies for intrinsically motivating students (Jang, 2008).

There are several aspects of this study that should be addressed. First, the sample population involved college level students in teacher preparation courses. This first deviation from the intended focus on secondary science students is important as the motivational factors, as well as developmental levels are likely very different between adolescent, high school and middle school students and college age students. Next, the topic of study was statistics rather than science. Both possess content that is likely perceived by many to be uninteresting, the difference likely being in the charisma of the task value that is presented in the rationale. Lastly, the design of the study controls well for possible threats to internal validity. In summarizing, it may be an overgeneralization that providing a rationale by itself is a strategy that will increase students' intrinsic motivation. That being said, in combination with some of the implied strategies addressed in other studies, the provision of a non-controlling, autonomy-supportive rationale may play an important part in a larger set of teacher strategies to help increase students' self-perceptions of autonomy and competence and in turn increase intrinsic motivation (Jang, 2008).

In a quite different context, Nieswandt and Shanahan (2008) investigated the goals adopted by 11th grade students and potential sources of those goals in a general science class deemed by the school as being for non-science majors. What they found was that many of the students internalized the administration's underlying message that the course was simply for the sake of earning credit. However, the authors found that the teacher positively influenced some students through emphasizing the relevance and value of the classroom content with respect to social and environmental issues in everyday life. In essence, findings from this study highlight the influence that the larger social and cultural environment can have on students' achievement goals and therefore their motivation, as well as the mediating effects that autonomy supportive teacher practices can provide.

The authors conducted a qualitative case study within a single 11th grade science classroom in a private all boys' school in Southern Ontario, Canada. Of the twenty students in the class, ten participated in the study on a volunteer basis. Eight were of European descent, one of Asian descent, and one of Middle Eastern descent. The teacher was female (ethnicity not stated) and possessed eight years of science teaching experience from several private schools. The authors worked in collaboration with the teacher in designing the content of the course which was student-centered, inquiry-based and approached the class with the intent of conveying to the students "the importance of science in everyday life" (Nieswandt, & Shanahan, 2008, p. 9).

In addition to weekly classroom observations throughout an entire school year, a sequence of three interviews (initial, mid, and final) was conducted with each of the 10 participating students, as well as the teacher. While the observations focused on the students' responses to the teacher's pedagogical strategies, the interviews were mainly focused around goal orientations, interest in the course, and perceptions of the course. Official school documents such as course calendars and websites were also analyzed in order to determine the school's mission and goals. Taken together, these three sources of data add credibility to the study by way of triangulation. Additionally, sustained engagement over the course of the entire school year adds further credibility to the qualitative nature of this study (Nieswandt, & Shanahan, 2008).

Upon transcribing all the student interviews, the authors descriptively coded the data and placed it into three categories: student perceptions of the course, student perceptions of the utility of the course and its content, and finally, student goals as an indicator for their motivation. With respect to the credibility of this study, there was no mention of member checks or progressive subjectivity during the qualitative data collection, two aspects of qualitative research that are important in ensuring that the interpretations of the participants' perspectives are accurately documented. That being said, one of the more salient findings was the how the students' general perceptions reflected the school's message and goal of the course as being solely for credit. Indeed the majority of the students' perceptions about the course and its utility revolved around extrinsic factors. However, there were periods, albeit transient periods where the students took on a more mastery, or learner-oriented goal. These periods of increased mastery-goal orientation and intrinsic motivation were due in large part to the relevance of the content to the students' everyday lives. Given the teacher's provision of a rationale for the class as having important and valuable everyday utility, this study provides additional insight into the effectiveness and challenges of increasing intrinsic motivation through the provision of rationales (Nieswandt, & Shanahan, 2008).

First, while the teacher's rationale promoted temporary increases in mastery-goal orientation and intrinsic motivation among her students, the overarching rationale provided by the school appears to have had stronger, more lasting impacts on the students' motivational orientations. As such, it is imperative as a teacher striving to positively impact students' intrinsic motivation to be cognizant of external messages and goals being conveyed to students in relation to the classes that they take. These conclusions are made with the awareness of the qualitative nature of this study and the respective issues revolving around the credibility and transferability of the research. The authors included several steps to increase the credibility of this study including peer debriefing in the case of coding the students' responses to interview questions and negative case analysis both in the introduction and discussion of the research article. In the case of transferability, the specific context (i.e. private, all boys' school) of the study suggests that this research is not intended to be generalized to other situations. Indeed as the authors noted, this research serves as a call for further qualitative research investigating the relationship between motivation and science educators (Nieswandt, & Shanahan, 2008).

At this point, providing students with rationales for the classroom activities that they experience may contribute to an increase in perceived importance and value of the content being learned. Given that high perceptions of importance and task value have been shown to promote intrinsic motivation, this strategy can be considered worthwhile. However, as some researchers have suggested, rationales are most effective when given in a way that is non-controlling and supportive of students' autonomy (Jang, 2008). Additionally, while a teacher's rationale may likely have an impact on students' perceptions of importance and value there are frequently other sources of rationales that may be incongruent or detracting from the intended goal. Frequently, discussions about the use of rationales as a strategy for intrinsically motivating students involve other teacher practices that serve to strengthen the message and create a more conducive learning environment for fostering intrinsically motivated students. Indeed, the provision of rationales is commonly included in practices aimed at promoting a learning or mastery-goal orientation, the subject of the following section (Nieswandt, & Shanahan, 2008).

Goal Orientation: Strategies for Promoting a Mastery Goal Orientation

One approach to discussing intrinsic motivation is in the context of goals. One contributing factor for the decrease in students' intrinsic motivation in adolescents is a shift in goal orientation from one that is focused on mastering or learning classroom content to a performance or ego-orientation. While a mastery-goal orientation reflects desires to increase competence through gaining knowledge, increasing understanding, and mastering new skills, a performance-goal orientation is more concerned with looking smart, or receiving positive evaluations of competence while avoiding negative evaluations. Numerous factors have been identified that influence what kind of goal orientation students embrace, many of which pertain to teachers' pedagogical practices and affective interactions with students. Although performance goals have been shown to have positive effects on the use of learning strategies, student self-efficacy, and overall enjoyment, it is widely accepted that a mastery-goal orientation is more positively related to increased intrinsic motivation (Ames, 1992; Dweck, 2000). As such, this section will focus on strategies that promote a mastery-goal orientation and therefore support the development of intrinsic motivation in secondary science students.

Song and Grabowski (2006) found that intrinsic motivation was stimulated in 6th grade students through the use of goal-oriented contexts. Ninety students (47 boys, 43 girls) from four whole classrooms in a rural middle school in Northeast U.S. participated in this study. Over the course of three separate 45-minute sessions, participants completed a problem-solving tutorial working in groups of two, wrote an individual report on the activity, and completed a survey questionnaire measuring perceived goal-orientation of their group, individual goal orientation, and intrinsic motivation. The four classes were randomly assigned to either a learning-oriented or a performance-oriented goal context. Then the respective classes received one of two goal-oriented versions of the same web-based tutorial adapted from a problem-based learning science curriculum. The two different versions were manipulated to influence a particular goal-orientation based on task value, distribution of authority, and evaluation practices. The learning-oriented context emphasized the challenge and personal value of learning the content, offered choices to the students and evaluated students' work privately so as to protect the identities of each student. The performance-oriented context on the other hand emphasized the importance of performing well with as few mistakes as possible, offered no choices, and evaluations were done publicly in order to promote peer comparison of performances.

Measures of the children's academic intrinsic motivation inventory (CAIMI) included 24 items on a 5-point Likert scale. Results from this measure showed that students in the learning-oriented context ($M=3.49$, $SD=.69$) had significantly higher levels of intrinsic motivation after the experimental treatment than students in the performance-oriented context ($M=3.16$, $SD=.66$; $p=.02$). While this study addressed a combination of strategies to intrinsically motivate students in the context of science, potential threats to the validity of these findings must be considered. One potential threat to the internal validity of this study involves the differential selection of the experimental groups. Considering that the two experimental groups consisted of whole classes with different teachers, there is a strong possibility that the two groups could have differed in their initial levels of intrinsic motivation due to differing teacher practices, as well as other external influences. Inclusion of pre-treatment measures of intrinsic motivation would have controlled for this extraneous variation (Song, & Grabowski, 2006).

One consideration that must be noted prior to addressing the generalizability of this study to secondary science students involves the limited scope of the sample population. Given the use of one rural middle school in the Northeastern U.S. composed of predominantly White students (96%), the findings of this study are most valuable when taken as part of a larger body of research on similar strategies. While this study suggests that intrinsic motivation in students can be increased by incorporating teacher practices that influence a learning-goal orientation, this practice is composed of a number of different sub-strategies including the provision of student choice, evaluative practices that downplay peer comparison and competition, as well as an overall focus on the intrinsic value of learning and the importance of challenging work. This study provided insight into the effects of a set of teacher practices on influencing a learning-goal orientation in students. However, it would be advantageous to understand the effects of the individual practices addressed in this study so as to gain a clearer picture of what is involved in setting up a learning or mastery-goal oriented classroom (Song, & Grabowski, 2006).

Blackwell, Trzesniewski, and Dweck (2007) conducted an intervention study examining whether teaching incremental theory to 7th grade math students would positively impact their motivation to learn. Findings showed that teaching incremental theory indeed had benefits over the control group with respect to students' motivation and achievement. The pretest/posttest control group design of this study controlled well for many possible threats to the internal validity of the findings. Likewise, the diversity (54% African American, 45% Latino, 3% White or Asian) and size (n = 91) of the sample population served to increase the generalizability of this study's findings. The participants of the study were from an urban junior high school in New York City, New York; 79% of which were eligible for free lunch. Participation in the study was voluntary, upon consent of both parents and students.

Beginning in the fall term, the participants completed the initial questionnaire which assessed students' initial theories of intelligence (6 items), goal orientations (3 items), beliefs about effort (9 items), and reactions to failure (1 item) and was based on a 6-point Likert scale. Then, students were randomly assigned by the school to advisory classes of 12-14 students. At this point, each advisory class was randomly assigned to either the experimental or control group condition. Beginning in the spring term, a series of eight 25-minute periods, one per week, were administered to the participants where students from both groups received lessons on the physiology of the brain, study skills, and negative effects of stereotypic thinking. In addition to these lessons, the experimental groups received additional instruction on the malleability and adaptability of the brain through science-based readings, activities, and discussions. All of these lessons were conducted by a team of 16 undergraduate assistants, with two (1 male and 1 female) teaching each workshop. Additionally, in each two person group, one was either African American or Hispanic. Immediately following the eight sessions, all students completed a multiple-choice quiz on the content covered in the sessions. Then, three weeks later, students completed the theory of intelligence portion of the initial questionnaire in order to determine any changes in the students' theories due to the intervention. Lastly, the students' math teacher (did not know who was in which experimental conditions) was asked to document in writing any changes in the students' motivation and behavior. These comments were coded by authors and focused on whether a comment was made for each students and whether the comments were positive or negative in nature (Blackwell, Trzesniewski, & Dweck, 2007).

Findings from the analyses showed that the students in the experimental conditions showed a significantly larger change in their theories of intelligence than students in the control group ($p < 0.05$). In fact, students in the experimental conditions endorsed an incremental theory more so after the intervention than before (4.36 to 4.95, $p < 0.05$)), while the control group showed virtually no change (4.62 to 4.68, p = *ns*). With respect to the teacher's comments on students' motivation, 17 students were reported to show improvement, of which 13 were from the experimental condition. Therefore, 27% of students in the experimental group were said to have shown positive increases in their motivation as compared to 9% of students in the control group conditions (Blackwell, Trzesniewski, & Dweck, 2007).

These findings have strong implications in the context of teacher strategies for intrinsically motivating secondary students. Although the study did not pertain to science, but rather math, the intervention pertains to the general process of learning and should therefore be well transferred to students in the context of science classes. Some limitations to this study include the length of time that was observed. It is not known whether the intervention had any lasting effects on students, or if the changes in students' intelligence theories was an ephemeral effect and would diminish over time. Another possible limitation relates to the teacher's citations of improvements in student motivation. All comments provided by the teacher were related to increased effort and interest in students. These observations seem somewhat superficial and do not necessarily reflect the internal thoughts and beliefs held by the students participating in the study. Furthermore, while this study did not assess changes in goal-orientations of students, the two frameworks of intelligence theories have been shown to be strongly correlated with goal-orientations, with incremental theorists focusing more on learning goals and a mastery goal-orientation, and entity theorists focusing more on performance and ego-oriented goals. However, it seems reasonable to conclude that the students' experiences and perceptions of the classroom are ultimately what determine the effects of such teacher strategies on goal-orientations and motivation. In other words, it is necessary to determine what students attend to when deciding what type of goal-orientation to employ (Blackwell, Trzesniewski, & Dweck, 2007).

Alonso-Tapia and Pardo (2006) found that classroom activities associated with learning-or mastery-oriented classroom environments had positive effects on students' intrinsic motivation. Using a one shot case study research design, the authors of this study sought to identify specific teacher practices that students considered supportive of a mastery-goal orientation. From three schools with varying levels of urbanization in Madrid, Spain, 758 (405 males, 353 females) secondary level students participated in this study. Two separate questionnaires were administered to students two to five days apart, followed by correlation and regression analyses.

First, students were measured on 11 motivational factors using the Motivations, Expectations and Value-Interests Related to Learning scale (MEVA) developed by Alonso-Tapia (2005). This measure focused on motivational factors that help determine students' goal orientations, including but not limited to student desires for gaining competence, demonstrating competence, avoiding negative judgments of competence, dispositions to effort, and desires for social acceptance and recognition. Between two and five days later, the Environment Motivational Quality (EMQ) developed by Alonso-Tapia and Lopez (1999) was given to the participants. This questionnaire measured the amount of interest or learning motivation that each particular teaching/learning activity aroused in students. Teaching patterns that were addressed in this questionnaire involved ways that new topics are introduced, teachers' planning and development of activities, ways that students' are prompted to participate in class, student support, assessment, and time management practices (Alonso-Tapia, & Pardo, 2006).

Analyses were done to test for correlation between teaching practices attributed by students to be supportive of a mastery-goal orientation and students' goal orientations. Eighty one percent of the correlation coefficients were found to be statistically significant ($p < 0.05$). In other words, the more mastery-goal oriented the student responses, the more value attributed to teaching patterns associated with mastery-goal orientation. Alternately, less mastery-goal orientation in students was negatively correlated with the values attributed to mastery-goal oriented teaching practices. It should be noted that in some cases, teaching practices that were shown to be attributed positively to mastery-goal orientation by some students were also attributed negatively in other students. This exception highlights the diversity of individual differences in students, and emphasizes the necessity of getting to know your students and their respective motivational beliefs. On a slightly different note, the set of teaching practices surveyed in this study were limited and therefore did not span the entire set of possible teaching practices that could be employed in order to effect positive changes in students' goal and motivational orientations. This highlights the need for further research in identifying the effects of teaching practices designed to effect positive changes in students' goal orientations and subsequently increase intrinsic motivation (Alonso-Tapia, & Pardo, 2006).

Next, the authors looked at specific teaching practices, and identified those that were most commonly attributed to mastery-goal orientation, as well as those that were negatively associated with mastery-goal orientation. Regression analyses were used to determine the weight that students' goal orientations and motivational factors contributed in determining the effects of specific teaching practices. Sparking curiosity through novel situations, providing rationales for the utility of learning content, messages that showed the relationship between learning and assessment, time devoted to helping students carry out their work, use of images and illustrations for the sake of clarity and organization of explanations, taking steps to stimulate classroom participation, and asking students to conduct projects after the theory has been explained were some of the more salient teacher practices found to be positively attributed to mastery-goal orientations in students. Alternately, setting time limits for assessment tasks, being assessed on the basis of one exam, using technical vocabulary, suggesting supplementary readings, and assigning projects with no effect on grades were shown to have negative effects on students' mastery-goal orientation and motivation (Alonso-Tapia, & Pardo, 2006).

Given the nature of the research design, there are certain criteria that must be examined in order to determine the internal validity of this study. There were several steps taken in order to control for external variables. These included a relatively short interval of data collection (2-5) providing limited opportunities for maturational or historical changes in the sample studied. However, on all occasions the MEVA questionnaire was administered prior to the EMQ questionnaire. It is difficult to know whether the items in the first questionnaire may have influenced student responses on the second questionnaire. With respect to the sample population, there was little mention of the larger systems in place at the participating schools. For example, it would be of interest to know whether the students surveyed were in schools that employed tracking or other practices that may influence the goal-orientations of the students surveyed. Lastly, the findings in this study are not well suited for generalizing to secondary science students in the U.S. Indeed, as mentioned by the authors, this study is intended to serve as part of a larger collection of research addressing teacher practices and the impacts that they have on students' goal orientations (Alonso-Tapia, & Pardo, 2006).

Patrick and Ryan (2008) explored what types of teacher behaviors young adolescents from a rural middle school in the Midwest U.S. attended to when deciding how much mastery-goal orientation their teacher promoted. In general, findings from this study provide additional insight into the work done by Alonso-Tapia and Pardo (2006). Patrick and Ryan (2008) found that students who perceived their teachers to be friendly and approachable, concerned that students both enjoyed and understood the content while showing patience when they did not, and used multiple approaches and examples to teach the classroom content perceived their teachers to have a high mastery goal structure. Findings from this study highlighted the affective domain of teacher-student interactions and its influence on students' perceptions of the goal structure of the classroom. In other words, while work done by Alonso-Tapia and Pardo (2006) yielded insight into specific pedagogical practices that are influential in creating a mastery-goal oriented classroom, Patrick and Ryan (2008) focused on more affective interactions between teacher and students.

Through a quantitative one shot case study (with a qualitative component), the authors elicited 197 6^{th}-8^{th} graders from one rural public school to voluntarily complete a questionnaire on classroom goal structure taken from the Patterns of Adaptive Learning Survey (PALS; Midgley et al., 1996). In the case of this study, the items on the questionnaire referred to the students' math teachers. There were three math teachers that taught all the participating students (2 female, 1 male) although this study was not focused on the teachers themselves but rather how the students perceived their teachers with respect to mastery goal structure. With none of the students' teachers present, a trained experimenter administered the 5-item questionnaire during the students' homeroom period. Participants were asked to state how true they felt the following five statements were for their math teacher: wants us to understand our work, not just memorize it; thinks mistakes are okay as long as we are learning; really wants us to enjoy learning new things; gives us time to really explore and understand new ideas; and, recognizes us for trying hard. Each item was based on a 5-point Likert scale (1 - not at all true; 5 – very true) and required a qualitative response explaining their reasoning following each item. Analyses of the data involved descriptive statistics of the quantitative portion along with systematic coding of the qualitative responses by one of the authors and a research assistant. With an inter-rater reliability ranging from 81-84% across all five items, the researchers separated the responses into nine categories pertaining to the nature of the teaching practice referred to in the students' responses. These categories included task, authority, recognition, grouping, evaluation, time, social interaction/pedagogical, affective, and teacher says (Patrick & Ryan, 2008).

Analyses of the quantitative portion found the mean score ratings for four of the five items to be around 3.5, with the item, "my math teacher wants us to understand our work, not just memorize it" (Patrick & Ryan, 2008, p. 111) having a mean score of 4.04. Variation among students' perceptions were examined and found to be quite substantial. Seventy percent of the variation in perceived classroom goal structure was at the within-class level. In other words, students perceived the same teachers to have very different levels of classroom mastery-goal structure. This finding has important implications in that teacher practices that may be effective in creating a mastery-goal orientation in some students will be ineffective or even defective for other students (Patrick & Ryan, 2008).

Qualitative responses were analyzed first by examining the reasons that students gave for each of the 5 items of the mastery-goal structure questionnaire. Then students who rated items as a 4 or 5 were compared with students who rated the same item as a 1 or 2. This analysis enabled the authors to investigate whether students who perceived their teacher to have a low mastery-goal structure attended to the same teacher practices as students who perceived their teacher to have a high mastery-goal structure. Overall, student responses were mainly focused on various aspects of affective and pedagogical teacher-student interactions. While there were no individual teacher practices that were overwhelmingly associated with conveying a mastery-goal classroom structure, the collective general practices of being friendly, showing interest in helping students, having patience when students do not understand content, and having the persistence and dedication in helping students understand and enjoy classroom lessons consistently demonstrated a mastery-goal classroom structure. Interestingly, when the authors compared students who perceived their teachers to have a low mastery-goal structure with those that perceived a high mastery-goal structure, they found that both groups attended to the same types of teacher practices (Patrick & Ryan, 2008).

The fact that students interpreted the same types of teacher practices differently in the context of mastery-goal structure along with the finding that students tended to use the same teacher behaviors and practices to determine the level of mastery goal structure implies a complex relationship between both the teacher and whole class, as well as the teacher and individual students. However, the design of this study warrants a closer examination into aspects of internal validity, as well as credibility with respect to the qualitative component of the study. In terms of the internal validity of this study, the entire school was recruited for participation on a voluntary basis, an attempt at controlling for potential differential selection in the sample population. Also, given that students completed the questionnaire without teachers being present increased the chances that student responses would be honest and candid. With respect to the qualitative component of this study, few steps were taken to ensure credibility. While student explanations were likely incomplete due to the difficulty in recognizing and articulating all aspects of teacher practices that contributed to their perceptions, there were no member checks or other opportunities for participants to revise, modify, or elaborate on their explanations. That being said, the qualitative aspect was intended to supplement and enrich the quantitative design of this study, and in so doing provides valuable insight into the ways that teacher practices are perceived by those students who are part of the classroom. Also, as mentioned by the authors, this study was not intended to be generalized or transferred to other populations, but rather to be one of many needed perspectives on a complex topic. Indeed this study adds to previous research in an attempt to increase our understanding of how to promote a mastery-goal orientation in the classroom. The findings from this study in part support the findings of Alonso-Tapia and Pardo (2006) in the sense that students from both studies considered teachers that provided ample time for mastering new things, encouraged participation, employed a variety of teaching approaches in order to make learning more pleasurable, and provided opportunities for students to develop understanding to be supportive of a mastery-goal structure and orientation (Patrick & Ryan, 2008).

Butler and Shibaz (2008) studied the effects that teachers' achievement goals have on their students' perceptions of teacher support for asking questions and seeking help. Students' achievement goals play a large part in determining how students will respond to challenge and difficulty in the classroom. Additionally, teachers' own achievement goals have been shown to influence how and the extent that their classroom structure supports a mastery-goal orientation in their students (Ames, 1992). This study has been included in this section because it suggests that possessing a mastery-goal orientation is one teacher strategy that may positively influence students' question asking and help seeking, integral components of classroom behavior associated with mastery-goal orientation.

Static group comparisons were made between 1287 students and their 53 associated teachers. This study was conducted in three middle schools and six six-year secondary schools in Israel. Classrooms taught by the 53 teachers included 12 in science and math, the remainder being in humanities, and social sciences. Teachers were surveyed during the first half of the school year on their achievement goals for teaching. The measure contained four 4-item subscales pertaining to mastery, ability-approach, ability-avoidance, and work-avoidance goals. Students were surveyed during the last two months of the school year on their perceptions of teacher support and inhibition in asking questions and seeking help (9 items), and their behaviors pertaining to seeking help and cheating (8 items). Both questionnaires were based on a 5-point Likert scale. Correlation and hierarchical linear modeling (HLM) was used to analyze the data (Butler, & Shibaz, 2008).

Students that reported having positive perceptions of teacher support for help seeking and asking questions was positively correlated with teachers that held mastery-goal orientations ($r = 0.22$, $p < 0.001$). Also, those same teachers were negatively correlated with student perceptions of teachers as inhibiting those behaviors ($r = -0.12$, $p < 0.001$). Less correlated but still significant was students' help seeking and teachers with mastery-goal orientations ($r = 0.07$, $p < 0.01$). As for the HLM analyses, results were not strikingly significant. Teachers' possession of mastery goals were found to be significant positive predictors of students' perceptions of teacher support ($\beta = 0.30$, $p < 0.001$) and a negative predictor of students' perceptions of teacher inhibition ($\beta = -0.17$, $p < 0.01$). However, there was a large percentage of between teacher variation in each of the students' perceptions of teacher support (71%) and inhibition (84%); (Butler, & Shibaz, 2008).

The findings from the HLM analyses were not overwhelmingly convincing, while the correlations were somewhat more significant. That being said, there are several additional factors that weaken the validity of this study's results. First, although the sample was rather large and diverse with respect to content areas, there were no distinctions made as to which grades and subject areas the teachers who responded as having mastery goal orientations taught. This is particularly problematic due to the possibility of differentiation of the teacher goal orientations and student responses in isolated content areas or grades. Second, the large amount of time that elapsed between the teachers' completion of questionnaires and the students' completion leaves a substantial amount of time in which participants (teachers especially) could have experienced a change in measured responses. Lastly, 49 (4%) of the original student sample population declined to fill out surveys or handed in blank ones. This is a threat to the internal validity in the sense that there was no mention of which classes those students were a part of. In the end, this study points out the likelihood that teachers' goal orientations can and do influence students' perceptions and behaviors. How and what effects result from those goal-orientations cannot be concluded from these findings. However initial findings suggest that teachers who possess mastery-goal orientations are more likely to be perceived by students as supporting students' question asking and help seeking. Additional studies in different demographic areas, grade levels, and content areas are needed to substantiate and generalize these findings to secondary science students in the U.S. (Butler, & Shibaz, 2008).

The majority of the results were positive in concluding that teacher practices that support a mastery goal orientation support students' intrinsic motivation. In order to promote mastery goal orientation in students, it is important that teachers demonstrate a mastery goal orientation and conduct lessons in a manner that supports learning over performance. One way that was identified in these studies was to be friendly and approachable, and to demonstrate to students that you are concerned for their success and enjoyment. Another strategy was to teach incremental theory in order to expose and address conceptions about the way we learn. One component of a mastery goal oriented learning environment that deserves specific mention is the use of assessment and other evaluation practices. The following section discusses the results of several studies investigating the effects of various assessment practices on the intrinsic motivation and goal orientation of students.

Assessment and Evaluation: Promoting a Mastery Goal Orientation and Supporting Students' Intrinsic Motivation.

One of the more significant factors in promoting mastery-goal orientations and intrinsic motivation involve ways in which students are evaluated. There have been a multitude of studies looking at the effects of feedback and different assessment practices on students in various capacities. In particular, the ways that different goal-orientations are promoted through the use of specific types of feedback and assessments is the focus of this section. While this topic is integral in the discussions of goal-orientation and autonomy support, the nature of teacher assessment practices can have profound effects on the social atmosphere of classrooms, individual teacher-student interactions, and students' self-perceptions of competence, autonomy, interest, and many other important motivational factors. As such, this section is designed to allow an in-depth exploration into types of feedback and assessment practices that have been found to be most effective in supporting students' intrinsic motivation to learn in the context of secondary level science (Ames, 1992).

Stefanou and Parkes (2003) sought some insight into the relationship between assessment practices and motivational factors including goal orientation and attitudes towards science. Seventy nine 5th grade science students from a rural elementary school in Northeast U.S. participated in a counterbalanced design study. Consisting of three classes taught by the same teacher, the students participated in three instructional units on water during the second half of the school year. Three different assessment practices were used, one for each unit of instruction. The assessments were counterbalanced so that each class performed all three assessment types during different instructional units. The assessments used were a paper-and-pencil test, a laboratory-based test, and a performance assessment. While the paper-and-pencil test involved multiple-choice, true or false, matching, fill-in-the-blank, and essay questions, the performance assessment involved group collaboration, provided students with choices, and focused on higher order thinking skills. The laboratory test was intended to fit somewhere between the two other assessments and involved group work, with detailed instructions and steps. Following completion of each assessment, students completed a questionnaire measuring students' attitude toward science (12 items), goals (12 items), and cognitive engagement (15 items). Once all three classes completed the instructional units and assessments, the authors conducted taped-whole class interviews seeking insight into which assessment they preferred, how the performance assessment could be improved, and which assessment they would prefer if grades were not a factor (Stefanou & Parkes, 2003).

Results from the quantitative data showed that both paper-and-pencil tests and performance assessments produced statistically significant increases in mastery-goal orientation compared to the laboratory tests. However, there were no statistically significant differences between the paper-and-pencil tests and the performance assessment on goal-orientation measures. Taken together with the qualitative data from the interviews, a more lucid picture formed. Although 54 of the 79 students reported preference for the paper-and-pencil test, familiarity with that form of assessment combined with the assignment of grades were the most common reasons given. When asked which type of assessment they would prefer in the absence of grades, many students commented on the challenge and enjoyment of the performance assessment. However, students persisted that without grades there would be no way of demonstrating competence and no reason to work hard. In general, results from this study brought up multiple layers to the challenges of implementing performance assessments and promoting a mastery-goal orientation. While previous research showed benefits of performance assessments and other alternative assessments on the promotion of mastery-goal orientations and intrinsic motivation, this study suggests that assessment practices must work in accordance with the consequences or outcomes connected to the assessments. In other words, in order for students to perceive performance assessments providing choice and autonomy, they must foster the positive perceptions that stakes related to those assessments will not result in penalties or negative consequences, but rather further opportunities for learning (Stefanou & Parkes, 2003).

As a quantitative study, potential threats to the internal validity have been well controlled for. The counterbalanced design ensured that there was no differentiation among treatment groups, and while the mortality rates (22 students) were high, there was no difference in numbers of students completing each assessment type. As for the qualitative portion, one must be critical in accepting this portion as credible, given the heavy reliance on this component for the conclusions that were drawn. One concern involves the whole class format of the interviews. This type of interviewing allows social dynamics in the classroom to influence the responses made by the students. One potential outcome is that lower status students remain silent or conform to the preferences of higher status students. Also, there was no mention of whether the teacher was present during these interviews. It is very likely that the teacher's presence would have influenced students' responses to the interviewer's questions. Taken altogether, it seems safe to conclude that alternative forms of assessment, such as performance assessments are not prepackaged teacher practices ready for employment. Rather they are more likely to be effective as part of a larger set of teacher practices that as has been shown in previous studies involve providing ample time for students to develop understanding, promote positive teacher-student interactions, teach and promote incremental theories of intelligence, and de-emphasize competition and outcomes as a means of demonstrating competence and ability (Stefanou & Parkes, 2003).

Butler and Nisan (1986) studied the effects of providing feedback, providing task-related comments, and the use of grades as feedback on students' intrinsic motivation and performance. In this quantitative study, a mixed research design where each class was randomly assigned to one of three experimental conditions was used. All classes performed the same tasks but received different types of feedback depending on the group in which they were assigned. Following completion of the tasks, all participants completed a post-test questionnaire measuring motivation based on interest (2 items), attributions of effort (4 items), and attributions of success (6 items), all on a 7-point Likert scale. There was an additional multiple-choice item asking which of the three forms of feedback the students preferred. In all, 261 6th grade students (145 girls and 116 boys) from nine classes in three urban elementary schools participated in this study (Butler & Nisan, 1986).

The experiment was conducted in classrooms during regular school hours and consisted of three separate sessions. The second and third sessions took place two hours apart and were conducted two days after the 1st session. The first session involved working on two experimental tasks - one quantitative and one qualitative - in which the students were explained the rules and criteria for success prior to beginning the tasks. At the beginning of the second session, two days later, the students received their work book containing feedback on their performance based on their respective experimental condition. Group 1, consisting of three classes (n = 88), received one sentence of task-related feedback. This feedback involved one positive phrase, and one constructive phrase. Group 2, also consisting of three classes (n = 90), received grades based solely on the performance criteria for success. The third group, also consisting of three classes (n = 83), received no feedback, the work books were simply returned to them. Following this step, the participants were told that they were going to be doing another set of tasks, and would receive the same type of feedback as before. Two hours later, during the third session the students were given their feedback based on their second set of tasks. The students looked over their feedback, and then were given a third set of tasks. The experimenter explained that these tasks would not be evaluated and would not be returned. Nevertheless, upon completion, all work books were collected. The experiment finished with administering of the motivation questionnaire (Butler & Nisan, 1986).

Using ANOVA, the authors tested the levels of performance on the first set of tasks to test for any initial differences between groups and gender. There were no significant differences found between the groups. However, upon comparing group means and standard deviations of the three experimental conditions based on their performance in the third session, a statistically significant effect was found. Groups receiving feedback (task-related and grades) performed better on the quantitative task than the group receiving no feedback ($p < 0.001$). On the qualitative task, the groups receiving task-related feedback performed better than the other two experimental groups ($p < 0.001$), while there was no significant difference between the groups receiving grades and no feedback. Analyses of the motivational measures revealed several statistically significant findings, particularly with respect to interest. Students in the task-related feedback group expressed higher levels of interest than students in both other experimental groups ($p < 0.001$). As for the measures on attribution of effort, the group receiving task-related feedback attributed more of their effort to interest compared to the other two groups ($p < 0.001$). Interestingly, while students in the no feedback group tended to attribute their success to the examiner's mood and to neatness ($p < 0.001$), the group receiving task-related feedback tended to attribute success more to effort and interest ($p < 0.02$, $p < 0.005$, respectively). Lastly, the item on the questionnaire pertaining to students' preferred mode of evaluation yielded a striking preference for written feedback. Altogether, 73% of the students preferred written, task-related feedback, 25% preferred grades, and 1% preferred no feedback (Butler & Nisan, 1986).

While these findings suggest a positive impact on students' motivation through the use of task-related feedback compared to the sole use of grades or no feedback at all, limitations must first be considered. One possible source of internal invalidity comes from the differential selection of the participants in the three experimental conditions. While initial performance levels were the same, and preference for the task-related feedback was found in all three experimental groups, the initial levels of intrinsic motivation were unknown for the three groups. This lack of information presents a possibility that the groups differed in initial motivational orientations, therefore influencing all subsequent effects of the experimental conditions. Furthermore, this study tested the effect of these three forms of feedback in isolation. In reality, the vast majority of public schools are heavily reliant on the use of grades as a major source of assessment. That being said, it would be beneficial to see research addressing the interactional effects of multiple forms of feedback on student motivation. Finally, the sample population in this study consisted of upper elementary students from Israel. Therefore, the findings from this study can only be tenuously generalized to secondary science students in the U.S. That being said, other studies looking at the effects of similar feedback and assessment practices on motivation in different student populations will elucidate and potentially widen the scope with which these findings apply (Butler & Nisan, 1986).

Corpus and Lepper (2007) sought to determine the effects of three different types of praise, in the face of both success and failure, on the motivation of male and female elementary students. In general, findings showed that girls exhibited the highest levels of intrinsic motivation in response to product and process praise, while there was no particular type of praise that was more salient for promoting intrinsic motivation in boys. Using a between-subject design, 93 fourth- and fifth-graders received different types of praise in response to a successful and failed task. Following the experimental manipulations, the participants completed a self-reported motivation questionnaire and experienced a behavioral and long-term observation.

All students in grades four and five from two elementary schools in the San Francisco Bay area were asked to participate in this study. In the end, 44 girls and 49 boys participated. Within each gender, participants were randomly assigned to receive one of four types of feedback: Person-praise ($n = 25$), product-praise ($n = 22$), process-praise ($n = 24$), and neutral feedback ($n = 22$) serving as the control group. This study began with participants completing a puzzle that was intended to be interesting and successfully completed, after which the experimenters scored the puzzle and provided the appropriate feedback. Immediately following this step, participants completed a short questionnaire (3 items) assessing interest in the puzzle, desire to keep working on the puzzle, and perceived competence. Then, a second puzzle was given to the participant that was designed to be interesting but too difficult to successfully complete. Following this step, participants were asked to complete another motivation questionnaire which was the same as the first one, but also contained an item measuring attributions for failure (Corpus & Lepper, 2007).

The authors also provided a behavioral measure of short-term motivation where students were left alone for five minutes with five different puzzles and activities including the puzzles that were involved in the experiment. In addition to this behavioral measure, a long-term motivational measure was included. This step involved showing the students a selection of six gifts of which they were asked to rank order them and choose which one they would prefer to receive by mail once all students in their school had participated in the experiment. Several weeks later, the experimenters returned to the school and informed the students that their rankings had been lost, asking them to once again rank order the six gift choices. The behavioral measures were included in the study to provide a more ecologically valid assessment of motivation and were based on the frequency in which students selected the puzzles to play with over the other games in the face of the successful and failed experiences (Corpus & Lepper, 2007).

Using the feedback conditions and gender as the independent variables and students' measures of motivation as the dependent variables, the authors performed a series of ANOVAs. Based on the self-reported motivation questionnaires, girls reported higher levels of motivation than boys following the successful phase of the experiment ($p < 0.05$). As for the failure phase of the experiment, there were no significant findings. Results from analyses on the short-term and long-term behavioral measures showed that girls had the greatest preference for the experimental puzzles following product and process type praise, with person praise being the least preferred ($p < 0.05$). In all aspects of the analyses, there were no significant effects for feedback conditions on motivational levels in boys (Corpus & Lepper, 2007).

Steps taken to ensure internal validity include random assignment of students into experimental conditions following equal division by gender and the use of the same questionnaire to measure motivational levels following both successful and failed experiences. The inclusion of behavioral measures of motivation increased the likelihood that the findings are symbolic of those occurring in natural settings, therefore controlling for threats to the ecological validity of the study. The only limitation that results from this study is due to the fact that the sample population did not directly pertain to secondary science students. This study further elaborates on findings from Butler and Nisan (1986) which supported the use of task-related feedback over the use of grades or no feedback. Within the context of task-related feedback, this study suggests that feedback based on the product and process of the task is more likely to be conducive to increased motivation than feedback based on the person carrying out the task. That being said, these findings cannot be readily generalized to either boys or secondary science students as a whole. Instead, these studies combine to elucidate the potential effects of different forms of feedback on students' motivation. At this point, it seems reasonable to conclude that feedback based on the students' process and product is a good place to begin. However, these preferences are subject to individual student preferences and as such, warrant ongoing reflection and revision on behalf of the practicing teacher (Corpus & Lepper, 2007).

While all three of these studies pertained to elementary age students and some did not address science, or students in U.S. schools, there were some salient trends that emerged from the findings. One important finding that resulted from these studies is that providing feedback focused on the task or process rather than the person is a particularly promising place to start when informing decisions on assessment and evaluation practices. Furthermore, given the common use of grades and high stakes assessment on a systemic level, the use of performance assessments in promoting mastery goal orientations and intrinsic motivation must be considered as part of a larger web of assessment that secondary students experience. Another possible strategy for supporting the intrinsic motivation of secondary science students is the explicit teaching of learning and studying strategies. In striving to promote learning and mastery goal orientations, the knowledge and skill of learning strategies may be an important step in promoting positive student perceptions of competence and autonomy and ultimately higher levels of intrinsic motivation.

Learning Strategies: Explicit Teaching of Learning and Studying Strategies for Intrinsic Motivation

Being intrinsically motivated to learn has been shown to have positive impacts on the quality of student learning. One influencing factor is the motivation to practice and utilize learning strategies that result in deeper learning. This relationship requires both the knowledge and skill of certain learning strategies associated with deep learning and the motivation to put it to use. However, it is unclear whether the knowledge and skill of metacognitive and other deep learning strategies results in higher intrinsic motivation in students, or alternately it is the intrinsic motivation to learn that results in the use of deep learning strategies. The following section explores the interaction between learning strategies and intrinsic motivation. Specifically, this section seeks insight into the use of explicit learning strategy instruction as a strategy for supporting the intrinsic motivation of secondary science students (Nolen & Haladyna, 1990; Young, 2005).

Nolen and Haladyna (1990) quantitatively studied the relationship between studying and motivation in high school science students from a single suburban high school in the Southwest U.S. More specifically, they sought insight into science students' perceptions about the utility of a variety of study strategies in relation to their motivational orientations toward science. Findings showed that there were significant differences between different age groups and different motivational orientations in the kinds of study strategies that were perceived to be valuable. A total of 391 students, with approximately equal numbers of males and females, participated in this one shot case study. Twenty seven whole science classes were asked to participate in this study and less than one student per class chose not to participate. The participating school where the study took place was conveniently sampled because of a school-wide practice of "ability" tracking based on college bound and non-college bound courses. Three groups were distinguished in this study: a) college bound freshman ($n = 117$), b) non-college bound freshman ($n = 61$), and c) college bound juniors and seniors ($n = 103$).

Survey questionnaires administered to the participants measured the value of study strategies, motivational orientations, and students' perceptions toward science. The studying strategies questionnaire focused on students' use of memorization, self-monitoring of comprehension, elaboration on connections between prior knowledge and new content, and organization in the form of note-taking or outlining in learning new content. Measures in the motivational questionnaire focused on determining students' task, ego, or work avoidant orientations. The questionnaire measuring students' perceptions toward science focused on perceived task value and competence in learning science (Nolen & Haladyna, 1990).

Once all data was collected, analyses focusing on descriptive statistics and correlations were conducted. Findings showed a statistically significant positive correlation between both groups of freshman level students, task orientation, and the valuing of study strategies. Freshman level students who showed more of a task orientation valued all four study strategies (rs ranged from 0.32 to 0.48, $p < 0.001$) rather highly while ego-oriented freshman showed no positive correlations between beliefs in the value of study strategies (rs ranged from 0.09 to 0.33; $p = ns$). Comparisons made between the different age groups showed that younger task-oriented students tended to consider memorization to be a valuable studying strategy ($r = 0.48$, $p < 0.001$) whereas older task-oriented students tended to devalue this strategy, preferring the other deeper processing types of study strategies ($r = 0.21$, $p < 0.05$). Although not made explicit in this study, the findings suggest two potential teacher strategies for intrinsically motivating secondary science students, those strategies being the promotion of a task orientation in the classroom and also teaching deep processing study strategies such as meta-cognitive monitoring, elaboration, and organization (Nolen & Haladyna, 1990).

However, prior to making any conclusions on strategies for motivating students, issues of internal validity and generalizability must first be considered. The design of this study reduced threats to internal validity in terms of history, maturation, instrumentation, and selection. In particular, the one shot survey reduced any chances that outside variables would influence the responses given by the participants. Additionally, the inclusion of entire science classes - of which the majority participated, helped control against any differential selection in the sample. Given that the sample population involved secondary science students in a U.S. public school increases the likelihood that these findings are generalizable to other secondary science students in the U.S. However, given that this study involved a single school, it is recommended that other similar studies are sought in order to increase the generalizability of this study's findings (Nolen & Haladyna, 1990).

Young (2005) studied a similar relationship in the context of college level students. Through a one shot case study, 257 marketing students completed questionnaires measuring a variety of motivational characteristics, classroom environment characteristics, as well as self-reported uses of various studying strategies. Young (2005) found similar results to those of Nolen and Haladyna (1990) in that students who were more intrinsically motivated were more likely to value and use deep- and meta-cognitive studying strategies, while extrinsically motivated students were more likely to employ superficial strategies. This study builds on the previous study by considering the independent variables of perceived autonomy and perceived competence on the use of various studying strategies.

The sample in this study was purposefully selected from marketing classes in a large Midwestern university for the sake of gathering data from a variety of instructional practices and classroom experiences. All students in four classes were sampled reducing the chances of any differential selection. The questionnaire used involved three scales measuring learning strategies, motivational orientations, and the classroom environment. The learning strategies scale assessed students' self-reported use of superficial cognitive, deep-cognitive, and meta-cognitive learning strategies. Seventeen items on a 5-point Likert scale were included in this scale. As for the motivation scale, measures addressed intrinsic versus extrinsic motivation, perceived competence, perceived autonomy, and goal-orientation. The majority of the items in this scale were based on a 7-point Likert scale, with a few items based on a multiple choice composite index. Lastly, the classroom environment scale measured students' perceptions of the learning climate, the instructor climate, and the performance climate. This scale was intended to determine the level of active versus passive learning, as well as the degree of autonomy support and goal-orientation provided by the instructors (Young, 2005).

The mean scores and standard deviation of the seven learning strategies that were addressed in this study are 10.15 (SD = 2.41) for rehearsal, 8.83 (SD = 2.03) for organization, 10.67 (SD = 1.69) for elaboration, 5.22 (SD = 1.42) for critical thinking, 6.26 (SD = 1.49) for planning, 6.59 (SD = 1.39) for regulating, and 7.25 (SD = 1.41) for monitoring ($p < 0.05$). Path and regression analyses were conducted once these data were found. In general, the path analyses showed strong positive relationships between the learning climate, intrinsic motivation, and both deep-cognitive and meta-cognitive learning strategies ($p < 0.05$). Additionally, analyses showed a positive relationship between task-orientation, extrinsic motivation, and superficial learning strategies (rehearsal, memorization; $p < 0.05$). The selection of the sample population, the thorough nature of the measures, and the collection of data in one session helped control for threats to the internal validity of this study. The self-report nature of the questionnaires leave room for interpretation and are built on the assumption that students were well informed on the use of the various learning strategies. Additionally, while this study focused on college level marketing students, it is not very generalizable to secondary science students (Young, 2005).

That being said, this study in combination with the findings reported by Nolen and Haladyna (1990) provides a more generalizable set of conclusions. While this study treated the use and valuing of deep- and meta-cognitive learning strategies as an outcome of being intrinsically motivated, it contends that explicit instruction of those learning strategies, as well as opportunities to practice and master those strategies should be a part of the instructional practices that teachers provide in striving to intrinsically motivate students. However, this connection is tenuous and would benefit from research directly addressing the effects of such an intervention (Young, 2005).

Taken together, these two studies show a strong relationship between being intrinsically motivated and valuing metacognitive learning strategies such as monitoring, elaboration, and organization. Also, Nolen and Haladyna (1990) found that students who were task oriented tended to value deep learning strategies more than those that were ego or performance oriented. This supports findings from the previous section on promoting a mastery goal orientation. However, the study samples from these studies were either small or pertained to college age students. As such, these findings should be considered tenuous and the use of such strategies should be done in a reflective manner. Along those same lines, the following section addresses the use of computer-based learning to support the intrinsic motivation of secondary science students, a strategy that also requires reflection and introspection.

Computers-Based Learning Environments: Integrating Computers into the Classroom

Most adolescents today have access to a veritable endless source of information, social networks and communications through the use of the World Wide Web. In striving to create a more student-centered classroom learning environment, it is necessary to capitalize on students' out-of-school practices. One integral and increasingly common component of these out-of-school practices involves computers in one form or another. Unfortunately, schools are not equal with respect to access to computers and the internet. Additionally, many schools and teachers have been slow to capitalize on the use of computers as a way to engage students' out-of-school identities and to enrich learning experiences. This section focuses on the integration of computers and web-based learning as a means for intrinsically motivating students to learn science. Motivation in the context of this section will be largely based on increased student engagement.

Wang and Reeves (2006) studied the effects of using a Web-based learning environment on students' motivation in tenth grade Earth science classes. Using a mixed methods research design, the authors interviewed, observed, and surveyed 27 students from two classes, both of which were taught by the same male teacher. This sample was purposefully selected to enable the authors to collaborate with the teacher in designing the Web-based learning program. All students from the two classes participated in the experiment which took place over the course of three days. It should be noted that the school involved was a private school in the Southeastern U.S. and was highly equipped with laptops and wireless networks. The topic of the Web-based lesson involved fossilization and was especially designed to challenge the students while stimulating their curiosity and fantasy. There were a number of components in the program that provided students with choice, aimed at promoting active engagement in the learning process. Through a problem-based model, the students had to interact with the program in order to determine the conditions for creating fossils.

Prior to this study, the first author spent a prolonged amount of time in the classroom and at the school in order to gain familiarity with the students and teacher, as well as increase the reliability of the study. The authors used multiple measures of motivation in order to triangulate reliable evidence to either support or refute the benefits of Web-based learning environments. Observations were conducted on all three days for six students in each of the two classes, resulting in a total of 36 observations. Observations focused on documentation of student learning behaviors, indications of student engagement, evidence of cognitive engagement, and signs of student interest. Two different researchers conducted separate observations and compared notes following each class in order to increase reliability of the data. The student interviews also involved six students from each class, and focused on levels of enjoyment, perceived utility, and comparisons between the experimental condition and their more familiar forms of classroom instruction. An additional interview was conducted with the teacher, focusing on his perceptions of the students' levels of engagement and interest with the Web-based learning environment compared to the normal classroom learning environment. The last measure of motivation was a questionnaire completed at the end of the 3-day learning experience. This questionnaire which contained 15 items and was based on a 5-point Likert scale was designed by the authors especially for this study (Wang & Reeves, 2006).

Findings from the observations were relatively positive with respect to students' motivational levels. Most of the students observed took advantage of additional applications in the program that were not necessary for completing the assignment but rather were intended to spark curiosity and interest. Observers also reported that students showed high levels of engagement based on concentration, enthusiasm, and limited distractions over the course of all three days. From the interviews, students expressed higher perceptions of autonomy and increased interest in learning about fossilization as compared to other topics covered in class. Furthermore, ten out of the twelve students interviewed expressed preference for this type of learning environment due to the visual component and felt that science as well as other classes would be improved with more implementation of this form of learning. The teacher also expressed positive feelings about the Web-based learning environment. He stated that students appeared to be more motivated using this form of instruction compared to previous classroom experiences. However, he noted the novelty of this program as being one major factor influencing their interest and engagement. This observation is important and deserves further consideration in terms of the effects of regular implementation of Web-based learning in the classroom. Lastly, results from the questionnaire showed that the majority of students considered this form of instruction was more intrinsically motivating compared to other units of instruction. However, a considerable percentage of the responses were neutral pertaining to the quality of information received (29.4%) and the general motivation to learn using this format compared to other forms of instruction (33.3%); (Wang & Reeves, 2006).

Conclusions from this study are relatively positive. However, one key consideration regarding the credibility of this study is the lack of member checks regarding the interview and observational data. Considering the authors' theoretical position in support of Web-based learning, the lack of member checks poses a threat to biased interpretations of the data. However, the inclusion of a self-report questionnaire helped control for threat to the credibility. As for the transferability of this study, there are several limitations that must be addressed. First, given the affluent private school setting which was well equipped with technology, it may be problematic to transfer these findings to students in public school settings that frequently have a much more limited access to computers and the internet. Additionally, as mentioned in the teacher interview, the influence of novelty could have played a large part in the students' reactions to the treatment. That being said, using Web-based learning environments as one of a variety of classroom instructional practices promises to increase the novelty and therefore student interest and engagement in the tasks (Wang & Reeves, 2006).

Liu (2006) investigated the motivational effects of a Web-enhanced problem-based learning model on sixth grade science students. Through a one group pre-test/post-test research design, the author found significant increases in students' levels of intrinsic motivation following the treatment. This study took place in four middle schools in the Southwestern U.S. A total of 437 students (222 female and 215 male) from 22 different classes participated in this quantitative study. The treatment was Alien Rescue, a computer application designed to engage students in learning about our solar system and some of the equipment scientists use in studying it. The entire treatment took place over the course of fifteen 45-minute class periods.

This study began with the administering of a questionnaire measuring students' motivation and attitudes toward science. The Motivation scale involved 8 items focusing on students' goal orientations, while the attitudes toward science scale involved 14 items. All items were based on a 7-point Likert scale. Following the use of Alien Rescue, students completed the same questionnaires, although science in the post-test questionnaire referred to science taught similarly to Alien Rescue. Lastly, 30% of the students were interviewed towards the end of the 15 days. The focus of these interviews was on what students learned and their like or dislike for the computer program. Data from the interviews was transcribed, coded, and separated into categories, although there was no mention of any steps taken to ensure reliable and objective interpretations of the data. Following collection of all data, ANOVAs were conducted to test for significant variations between pre-test and post-test measures. Results showed that both male and female students showed a statistically significant increase in intrinsic goal-orientation following the completion of Alien Rescue ($p < 0.01$). Additionally, students' attitudes toward science increased significantly over the course of the treatment ($p < 0.01$). Results from the interviews showed that over 95% of the interviewees enjoyed using Alien Rescue. Reasons given for enjoying the program were varied and did not suggest any strong overwhelming trends. Given the unclear process for coding and categorizing the data from the interviews, the results from the questionnaires provide more valid and reliable measures (Liu, 2006).

The design of this study would have been greatly improved through the inclusion of a control group. However, without the use of a control group there are possibilities that events may have occurred during the treatment that influenced the results of the study. Additionally, without a control group there is a chance that the participants experienced some influential factors as a result of the time or maturational factors. With respect to the testing and instrumentation of the study, the measures used for assessing motivation are suspect. In particular, the delineation between an extrinsic and intrinsic goal orientation appears to oversimplify the complexity of students' motivational characteristics and their goal orientations. In other words, there is reason to believe that students could have grown "test-wise" to the intended outcomes of the measures based on the wording and limited number of items. It may have been beneficial to include some additional measures of perceived autonomy and competence, as well as some filler items to help blind the participants from the purpose of the questionnaires. One positive aspect of this study is the large sample size specifically focusing on secondary level science students. While the generalizability of this study is limited due to the specificity of the computer program and the geographical isolation of the sample size, it does provide positive support for the implementation of computer-based learning programs in science classrooms for the sake of increasing interest, engagement, and potentially a mastery-goal orientation. Indeed, in combination with additional teacher strategies for promoting a mastery-goal orientation (Liu, 2006).

The use of computers as a strategy for intrinsically motivating secondary science students has been shown to be effective and a worthwhile effort. However, the novelty of such learning activities must be considered when planning and implementing such learning models. Furthermore, given the specificity of the computer programs used in the studies it is difficult to generalize these findings to any of the endless possible computer programs possible. Much like the previous section, it is advisable to use this strategy with a reflective lens. One final strategy that is much more applicable to any and all classrooms regardless of the school resources is the use of enthusiasm. The following section examines the use of enthusiastic instruction as a strategy for motivating students.

Enthusiasm: Teacher Enthusiasm and its Effects on Student Motivation

This paper has addressed some potential teacher strategies that support the intrinsic motivation of secondary science students. Some of those strategies however, require other prerequisite strategies, practices, or tools in order to effectively execute in the classroom. The use of enthusiasm is a strategy that stands alone. Unfortunately, this section consists of two studies conducted by the same authors and addressing college age students. Nevertheless, these studies will elucidate the powerful effects that using enthusiastic gestures, tones, and inflections can have on the motivational levels of students. Furthermore, while much of the research has focused on contextual influences on students' perceived autonomy and competence, there has been less focus on the influences of teacher interactions with students on a more general level. This section addresses teacher enthusiasm as one influential factor of intrinsic motivational levels as a result of teacher-student interactions.

Patrick, Hisley, Kempler, and College (2000) investigated whether or not a teacher's level of enthusiasm influences students' intrinsic motivation, and if so, in what ways? The authors conducted two separate studies to test this relationship. In both studies, teacher enthusiasm was found to positively impact students' intrinsic motivation by way of increased perceptions of autonomy support and increased levels of engagement. While I feel that enthusiasm is clearly a beneficial teacher practice and should be considered prerequisite to teaching secondary level science, support in the form of quantitative research is helpful and much needed.

Both studies took place in a small liberal arts college in the U.S. The first study consisted of a one shot case study. At the end of the semester, 93 undergraduate psychology students (80 women and 13 men) completed a questionnaire measuring their motivational characteristics and some of their teacher's classroom behaviors and strategies. The questionnaire was subdivided into 15 subscales, with one pertaining to the students' intrinsic motivation and one to students' psychological vitality. The remaining 13 subscales measured teacher behaviors including level of enthusiasm, autonomy support, competence feedback, and relevance promotion. All items were based on a 7-point Likert scale. Upon completion of the questionnaire, all participants received one extra credit (Patrick et al., 2000).

Following data collection the means, standard deviations, and reliability coefficients were found for all variables. All the variables had acceptable reliability with intrinsic motivation subscale being the highest ($\alpha = 0.96$). Next, correlational analyses were done between the intrinsic motivation scale and each of the teacher variables. Autonomy support ($r = 0.69$) and enthusiasm ($r = 0.64$) had the higher correlations ($p < 0.001$). Lastly, regression analyses were done to test the predictive power of the various teacher behaviors on students' intrinsic motivation. Enthusiasm was found to be the strongest predictor for students' intrinsic motivation ($p < 0.01$). Autonomy support was also found to be a strong predictor of intrinsic motivation ($p < 0.05$); (Patrick et al., 2000).

As for the second study, participants were randomly assigned to receive a mini-lecture on biofeedback in either a high-enthusiasm or low-enthusiasm condition. The teacher used six nonverbal behaviors in conveying high- versus low-enthusiasm. These behaviors included varying the delivery of the text in relation to pace, volume, and intonation, expressing wide-open eyes, using gestures, large body movements, emotional facial expressions, and a lot of general energy and vitality. The low-enthusiasm treatment lacked all of these behaviors. The treatment was given to the participant and an additional student who served to reduce the focus put on the participant by the teacher. After completing a brief informational survey and reading an introduction on biofeedback, the first author entered and gave the mini-lecture in either a high- or low-enthusiasm. Both forms of the mini-lecture involved the same text and lasted approximately seven minutes. Following the lecture, the participant was asked to complete a questionnaire aimed at providing information that will help the authors know what was communicated well and what, if anything could be improved about the lecture. The questionnaire contained measures on perceived level of teacher enthusiasm (six items), self-perceived level of intrinsic motivation (three items), and a number of items intended to disguise the real purpose of the questionnaire. All items were based on a seven point Likert scale (Patrick et al., 2000).

Preliminary analyses to check for variation between gender showed no main effect. Using a one-way ANOVA, the authors found that the participants' perceptions of enthusiasm were consistent with the intended levels of enthusiasm ($p < 0.001$). The self-reported measure on intrinsic motivation was higher for participants experiencing the high-enthusiasm lecture than those experiencing the low-enthusiasm lecture ($p < 0.01$). These results served to supplement the first study and strengthen the generalizability of these findings. Additionally, while both studies involved college students, other studies that have shown enthusiastic teachers to be perceived favorable by students helps further strengthen the likelihood that these findings are generalizable to secondary science students (Alonso-Tapia & Pardo, 2006; Oldfather, 2002; Patrick et al., 2000).

While the findings from this study support the authors' hypothesis that teacher enthusiasm facilitates intrinsic motivation in students, there are several factors that may have also been influential in these positive findings. One potential influence is the initial levels of students' intrinsic motivation. There is a possibility that students' intrinsic motivation levels can influence teachers' enthusiasm. Also, with respect to the sample population, there was little explanation as to the recruitment method, the number of students that declined participation, or failed to complete the survey after agreeing. Participants were college level psychology students which for the sake of this paper's topic is not very applicable. However, the findings from the two studies combined create a strong belief in the value of enthusiasm (Patrick et al., 2000).

Research on the effects of enthusiasm on students' intrinsic motivation to learn is limited. However, the findings from these studies suggest a promising avenue for further research and a potential strategy for use with other age levels and subject areas. Additionally, similar trends from other studies have emerged, further supporting the use of enthusiasm as a strategy for intrinsically motivating students (Alonso-Tapia & Pardo, 2006; Oldfather, 2002; Patrick et al., 2000). There have been a number of broad and specific strategies identified and discussed in this chapter. Taken separately, there is certainly no single strategy that will serve as a panacea. However, when taken together these identified strategies will likely strengthen and support each other in creating a framework with which to scaffold and support the intrinsic motivation of secondary science students.

Summary

Chapter three was a summary and analysis of research addressing intrinsic motivation to learn in students from a variety of subject areas, grade levels, and nationalities. The research was reviewed and critiqued to determine viable teacher strategies and practices for positively impacting secondary students' intrinsic motivation to learn science. Findings from the research on autonomy support revealed that the use of clear and coherent lesson goals and expectations, along with the use of meaningful, relevant content, and the provision of choice are some of the sub-strategies that can be used to create a more autonomy supportive learning environment. Research on the use of cooperative and problem-based teaching models for positively affecting intrinsic motivation indicated a need for doing so within the context of a mastery-goal oriented and student-centered classroom. Research on goal orientations indicated that being friendly and showing concern and interest in students' success is one possible strategy for promoting mastery-goal orientations. Teaching incremental theory and using specific, task-related feedback were other potential strategies. The creation of a student-centered classroom is vital as the motivational characteristics and orientations of a diverse classroom of students will certainly be equally diverse.

One trend that emerged from the research was the potential beneficial effects of certain strategies when done within a mastery-goal oriented classroom. The positive effects of explicit teaching of learning strategies, provision of rationales for learning tasks, and use of social learning models on the intrinsic motivation of students would be strengthened and supported when done in combination with strategies that support mastery-goal orientations. Along similar lines, a readily applied strategy that will likely strengthen and support the success of other strategies is the use of enthusiasm in the classroom. Other research showed that the use of computer-based learning environments have some positive effects on the intrinsic motivation of secondary science students. However, the novelty of the treatment and the widely varying quality and content of the computer programs and applications must be considered when implementing this strategy. The following chapter provides an in-depth outline of the findings from this chapter. Findings addressed in chapter four will include research regarding autonomy support, social learning models, student-centered teaching, mastery-goal orientation, learning strategies, computer-based learning, and enthusiasm. Following this outline, chapter four addresses the implications of findings for the classroom, and provides some suggestions for areas for future research.

CHAPTER FOUR: CONCLUSION

Introduction

As student-centered constructivist teaching practices receive more attention in the ongoing search for the best teaching practices, the historical path that has led up to the current era suggests that there will continue to be debate and dissenting opinions as to the most effective ways to teach America's youth. Considering the myriad philosophers, educators, and psychologists that have toiled over the complex and ambiguous details regarding teaching, learning, and schooling the world over, it comes as no surprise that we have yet to arrive at an overwhelming consensus. Nevertheless, as this debate continues, the importance of providing youth with a strong education in the physical and biological sciences continues to be of utmost importance in maintaining a safe, productive, and healthy society. Yet as mentioned in the first chapter, secondary students in the U.S. are not achieving the depth and quality of science education necessary for competing in today's global economy. Among the reasons for this paucity in secondary science achievement is a discontinuity between the motivations of students and the scientific knowledge and skills that are being taught in America's schools. The current discussion is intended to serve as a resource for the educational community on effective teaching strategies that help bridge the gap between secondary students' inner motivational resources and the science classroom. This chapter first includes a summary of the findings from chapter three then addresses the implications that these findings have on classroom practices. Lastly, the chapter addresses some suggestions for further research.

Summary of Findings

Among the studies reviewed, there are numerous conclusions that can be drawn. While many of the studies pertained directly to secondary science students in U.S. classrooms, many of the studies focused on subjects other than the secondary level, took place in schools outside of the U.S., or addressed motivation in content areas other than science. As such, the relevance and generalizability of these studies are limited. Nevertheless, there are certain conclusions that can be ascertained which help inform the field of research pertaining to secondary students' intrinsic motivation to learn science.

In setting out to employ teacher strategies and practices for the sake of increasing students' intrinsic motivation to learn, Lau and Roeser (2008) found that although students possess diverse motivational orientations, there tend to be some general patterns among student in the classroom.

Furthermore, several other studies found that effective strategies for intrinsically motivating some students did not necessarily work for other students (Alonso-Tapia & Pardo, 2006; Oldfather, 2002). These findings point out an obvious truth when striving to promote an intrinsically oriented classroom, namely that there is no one panacea. Nevertheless, there have been a number of studies that together build quite powerful argument for certain teacher practices.

In general, some of the most salient findings called for practices that support the autonomy of the students through the provision of choice (Ciani et al., 2008; Cordova & Lepper, 1996; Hanrahan, 1998), including students in the construction of classroom procedures and norms (Garcia & Pintrich, 1996), and having well organized, coherent lessons that are clearly connected to the goals, expectations and assessments in the classroom (Lodewyk et al., 2009; Seidel et al., 2005). In providing autonomy support for students, the deciding factor as to the effectiveness of those strategies and practices will inevitably be the perceptions of the students (Lavigne et al., 2007). Unfortunately, only one study in this section focused directly on secondary science students in U.S. schools. That being said, the other studies took place in a variety of countries and investigated the influence of autonomy support on students ranging from elementary through college level, most of which pertained to science.

From a slightly different perspective, the role of mastery goal orientation in promoting students' intrinsic motivation yielded several important findings. Teachers that held a mastery goal orientation were found to influence more mastery goal oriented behaviors in students, particularly help seeking (Butler & Shibaz, 2008). Teacher practices that aimed at increasing interest through novel situations, use of multiple instructional approaches, high levels of teacher involvement including friendly and approachable student-teacher interactions were found to be key components of classrooms that promoted a mastery goal orientation (Alonso-Tapia & Pardo, 2006; Patrick & Ryan, 2008; Song & Grabowski, 2006). One strong finding showed that the explicit teaching of an incremental theory of intelligence both increased intrinsic motivation and achievement in mid-level math students (Blackwell et al., 2007).

Assessment and evaluation practices were found to play a strong role in determining both the goal orientation structure of classrooms and the resulting intrinsic motivation of students. The heavy reliance on exams, tests, and grades were found to mediate the effects of mastery goal promoting teacher strategies (Stefanou & Parkes, 2003). While the previous study was based on elementary level students, other studies showed the strong influence that grades and tests can have on secondary students' approaches to learning (Shachar & Fischer, 2004; Tan et al., 2007). One additional finding related to assessment practices involved the types of feedback that students preferred. In another study, 6th grade students showed a preference for task-related written feedback over feedback in the form of grades and feedback that focused on the individual. This was further strengthened by another study showing a preference in elementary level females for process and product related verbal praise (Butler & Shibaz, 2008; Corpus & Lepper, 2007). The studies addressing assessment and evaluation practices have limited implications due to the focus on elementary level students in isolated populations, most of which did not study assessment in the context of science classrooms.

Among the final studies, the most salient finding involved the notion of teacher enthusiasm as an influencing factor in the intrinsic motivational levels of students. Despite not focusing on secondary science students, and having a relatively small sample population of college age students, the strong positive results in both studies suggest that high enthusiasm in the classroom will positively impact the intrinsic motivation of students to learn the content being covered (Patrick et al., 2000). Among the remaining studies addressing studying strategies and computer-based learning, I am reluctant to draw any conclusions due to potential threats to internal validity (computer-based learning), or the lack of causality between the prospective strategy and students' intrinsic motivation (deep- and meta-cognitive studying strategies). That being said, both the explicit teaching of study strategies and the integration of computer-based learning are important teaching practices for purposes other than promoting intrinsic motivation and as such should not be discounted as vacuous teacher practices.

Classroom Implications

As students enter middle and high school, the need for independence and feelings of autonomy increase steadily, marking the transition between childhood and adulthood. By embracing teacher practices that convey support for student autonomy it is likely that students' intrinsic motivations will also be supported. Lavigne, Vallerand, and Miquellon (2007) and Garcia and Pintrich (1996) highlighted this relationship by showing that students who perceived their teacher to be supportive of their autonomy tended to also perceive classroom tasks to be of a higher value, to possess more of a mastery goal orientation, and in general possess higher levels of intrinsic motivation. Teacher practices for creating an autonomy supportive environment are quite open-ended and abundant. Indeed, the perceptions of the students ultimately determine the presence or absence of such support for autonomy, the teacher practices for supporting autonomy can theoretically be a diverse as the students with whom the practices are intended to support.

As Seidel, Rimmele, and Prenzel (2005) found in their study, there are certain teacher practices that are associated with autonomy support. Specifically, teacher practices that maintain transparency and clarity with respect to learning goals are highly conducive to positive student perceptions of autonomy support. Seidel et al. (2005) included the use of experiments in lessons, discussing the findings of those experiments with respect to lesson goals, summarizing and revisiting lesson goals over the course of the lesson, and responding to student questions as the major proponents of teacher practices that provide clear and coherent lesson goals, and therefore support student autonomy. Lodewyk, Winne, and Jamieson-Noel (2009) found that lessons that are relevant and meaningful to students in combination with ample resources and time for students to investigate and explore content are additional practices that support student autonomy. Taken together, it is implied that in order to support student autonomy and in turn support the intrinsic motivation of secondary science students, teachers must not only provide lessons that are relevant to students' lives, but provide clear explanations and well-structured phases with which students can engage in, investigate, and explore the content. As Lodewyk et al. (2009) pointed out these steps are effective only when students are provided enough time and adequate resources to discover and construct meaning themselves. In other words, clarity does not mean telling students what to know and how to know it, but rather, providing students with the resources, time, and intended outcomes. This approach provides students with clear expectations of what they need to do without removing the sense of accomplishment and discovery inherent in making connections individually and independently.

Another strategy that similarly supports the autonomy of students but also supports students' intrinsic motivation in other ways is the provision of student choice. This strategy can range from a narrow set of choices that have little or no impact on the nature of learning content or activities to a broad range of student choices that influence the design and structure of entire learning units. While it seems logical that including student choice in all aspects of the classroom experience would certainly support the intrinsic motivation of many if not all students, the valuable insight to be gained from the work done by Cordova and Lepper (1996), Hanrahan (1998), and Ciani, Summers, Easter, and Sheldon (2008) is that the provision of choice for the sake of supporting students' intrinsic motivation does not need to be all encompassing and require the restructuring of entire learning units due to preferential choices made by students. Instead, choice can be provided in ways that does not alter the nature of the instruction drastically while still effecting positive impacts on students' feelings of autonomy, competence, enjoyment, and self-efficacy.

The specific types of choices shown to be effective in supporting students' intrinsic motivation include types of materials to use in completing assignments, types of assessment to demonstrate understanding of particular learning goals, partners for engaging in cooperative learning, and choices relating to the path taken to arrive at the same instructional endpoint. In other words, once learning targets have been identified, a selection of assessments that would effectively demonstrate understanding would provide students with a choice that does not alter the nature of the learning content, but would simply offer students varied methods for showing their understanding and accomplishments. Similarly, having a selection of resources on hand in order to provide options for students to carry out learning tasks provides opportunities for students to make choices that will support their intrinsic motivation without leading to complicated and tangential distractions (Ciani et al., 1998; Cordova & Lepper, 1996; Hanrahan, 1998).

While Ciani et al. (2008) found that allowing students to choose their own groups is one potential strategy for supporting students' intrinsic motivation, the use of cooperative and other forms of social learning requires further considerations. There are a wide variety of ways to organize students into groups and oftentimes it may be in the best interest of the students and the teacher to organize students in particular ways to support the learning goals of the lesson. That being said, other aspects of social learning models that must be considered when striving to support the intrinsic motivation of all your students includes the timing within the greater context of the school year. For instance, Shachar and Fischer (2004) found that the presence of an upcoming high-stakes test regarding the subject matter being addressed in the study could have influenced the effect on students' perceptions toward the learning model. Of particular importance to consider when using this strategy for the sake of supporting intrinsic motivation are other influential factors that students are subject to outside of the classroom. In other words, while the provision of student choice is a more or less readily applied teacher strategy for promoting and supporting intrinsic motivation, the more complicated strategy of using social learning models for similar goals requires effort and attention paid to the goal orientations and social dynamics of the students.

Perhaps the aforementioned strategy would be more appropriate when applied as a sub-strategy within a larger framework of strategies that aim to create a more student-centered classroom environment, one that is built around goals of mastery, collaboration, and risk-taking. Given the diverse array of motivational orientations and characteristics that are present in any given classroom, strategies that support a student-centered classroom learning environment are likely to add to the success of other teaching strategies aimed at promoting intrinsic motivation in secondary science students. Lau and Roeser (2008), as well as Skinner and Belmont (1993) elucidated on the importance of getting to know your students and identifying the motivational orientations, ability levels, and other student characteristics in order to inform subsequent instructional decisions. That being said, there were not any conclusive, concrete strategies that emerged from these studies for the direct purpose of intrinsically motivating students. However, Oldfather (2002) conveyed how a classroom that is responsive to diverse cultures and perspectives helps support students during periods of amotivation or disinterest. Therefore, creating a student-centered classroom, however that process may unfold, not only leads to increased knowledge of individual students and their motivational resources, but also helps create an environment that supports students during the multifaceted and emotionally complex setting of schooling.

Recognizing the ways in which student disinterest and lack of motivation arise in the classroom can help provide insight into strategies that will in turn help counteract those negative feelings. Considering that secondary science classrooms are mandated to address particular standards and learning targets, it is inevitable that students will at times lack interest in engaging in certain key content. Furthermore, as Lodewyk et al. (2009) and Alonso-Tapia and Pardo (2006) suggested, providing lessons that are relevant and meaningful is important for promoting intrinsic motivation in students. However, it is reasonable to assume that many lessons may initially be perceived by students to be uninteresting or irrelevant. For this reason, the provision of rationales is one such strategy for facilitating relevance of instructional content for students. Jang (2008) emphasized the use of non-controlling, autonomy supportive language when providing rationales for lessons. While the context of this study was not directly related to secondary science students it is reasonable to assume that presenting rationales in such a way would be tantamount if not more effective than providing rationales in other more controlling or directive manners. Another equally important idea worth considering is the larger rationale that classes and specific content are commonly connected with. Nieswandt and Shanahan (2008) elucidated on this notion in the context of a secondary science class designed for students not intending on pursuing careers or higher education in science. Rationales that are attached to classes and various topics related to any given class may influence the ways in which students internalize and engage in the content, therefore influencing subsequent teacher efforts to support student engagement and intrinsic motivation. In this sense, it is worthwhile and advised to consider outside or external influences that students may bring into the classroom when both creating and providing rationales for lessons and classroom activities.

Another set of teacher strategies that are effective for promoting intrinsic motivation in secondary science students stems from the research addressing goal orientations. The specific strategy of teaching incremental theory has been identified and supported by the work of Blackwell, Trzesniewski, and Dweck (2007). This strategy involves explicitly teaching about the how the brain works with respect to learning, emphasizing the unfixed abilities of humans and the importance of effort in learning. This is one of the more concrete strategies identified in this body of research. Other strategies identified by Song and Grabowski (2006) involve evaluation practices, and framing of tasks that promote mastery and learning over performance and competition. Additionally, findings supported the use of language that was autonomy supportive and avoided a centralized source of authority in order to promote independent thinking and responsibility for learning and classroom tasks.

Alonso-Tapia and Pardo (2006), as well as Patrick and Ryan (2008) identified several other strategies effective in promoting a mastery goal orientation. Both studies highlighted the importance of using multiple approaches for explaining and illustrating content. However, Patrick and Ryan (2008) emphasized positive teacher-student interactions in promoting mastery goal orientations while Alonso-Tapia and Pardo (2006) emphasized more focus on creating curiosity through novel situations, showing connections between learning and assessment, as well as taking steps to promote student participation in the classroom. At this point, embracing teacher strategies that aim to spark curiosity, providing clear rationales for lessons, connecting assessments to the classroom learning activities and maintaining positive teacher-student relationships are best teacher practices that will greatly contribute in promoting mastery goal orientations and intrinsic motivation in secondary science students. Although not necessarily a strategy, Butler and Shibaz (2008) shed some light on the importance of teachers themselves possessing a mastery goal orientation in order to promote in students behaviors similar goals. This notion is also important in order to maintain positive and transparent relationships between teacher and students.

Deeply interconnected with the body of research focused on goal orientation is the work done by Stefanou and Parkes (2003), Butler and Nisan (1986), as well as Corpus and Lepper (2007). These authors addressed assessment and evaluation practices and found that student feedback was particularly effective in promoting intrinsic motivation when focused on the task at hand, providing relevant information about the process or product in order to provide next steps for improvement, or to identify successful aspects of a given piece of work. Maintaining positive and supportive teacher-student relationships, while providing feedback relating to the work rather than the person responsible for the work, will help support both a positive learning environment, as well as positive and high student expectations (Patrick & Ryan, 2008).

Additional strategies identified in this body of research involve more tenuous findings that would benefit from further research. However, as Patrick, Hisley, Kempler, and College (2000) found, teacher enthusiasm is a strategy that had particularly pronounced effects on student motivation. Despite the salient results of these studies, the context was far removed from the setting of most secondary science classrooms. That being said, along the same lines a Butler and Shibaz (2008), in order to promote mastery goal orientations or enthusiasm in your students, it is reasonable to conclude that an honest portrayal of such characteristics will unlikely negatively impact students' intrinsic motivation and will more likely positively contribute to such efforts. Lastly, studies done by Nolen and Haladyna (1990), as well as Young (2005) tenuously promote the explicit teaching of metacognitive study strategies such as elaborating, monitoring, and organizing information to help support the intrinsic motivation of students. Granted it is unclear if intrinsic motivation in students lead to the valuing and use of metacognitive study strategies or if knowledge and use of such skills leads to higher levels of intrinsic motivation. That being said, a relationship certainly exists and given that both partners in this relationship have been shown to be highly conducive to deeper learning and success in school, teaching metacognitive study strategies is a worthwhile effort and one that may in turn help support the intrinsic motivation of students in the classroom.

Research conducted with respect to the use of computer-based learning environments found positive outcomes for the intrinsic motivation of primary and secondary level science students. Both Wang and Reeves (2006) and Liu (2006) reported positive effects on students' levels of intrinsic motivation as a result of computer enhanced learning. However, given the limitless variations in computer-based learning programs and the gaps in computer access among schools in America, it is difficult to generalize any conclusive results for the purpose of intrinsically motivating all secondary science students. As will be discussed in the following section, the use of computers for promoting intrinsic motivation is one area that would benefit from further research into the differential effects of the various styles and approaches to computer-based learning.

Suggested Areas of Future Research

While the wealth of research continues to grow, many relationships have yet to be addressed in the context of secondary science classrooms. Therefore, one direction for future research is to investigate many of the already studied strategies and their effects in students studying mid-level and high school science. In particular, the effects of assessment practices commonly used in science classrooms on the goal orientations and students' subsequent motivational levels warrants much needed research. Additionally, while autonomy supportive practices have been widely studied, the effects of specific autonomy supportive teacher practices on secondary science students in the U.S. have gone largely unaddressed. Also, goal orientations as they relate to students' in-school and out-of-school experiences is an area promising valuable insight into how teachers can increase the perceived task value and utility of learning science for all students.

One aspect that has received a lot of attention is the use of collaborative learning models in science classrooms. Indeed the heavy use of laboratory exercises and inquiry-based learning makes collaborative learning an integral component of many science classrooms. However, there were little or no studies investigating the differential effects of group work in the presence of explicit instruction on necessary social and communication skills versus group work that is simply implemented without any attention to student preparation for cooperative group work. Indeed, one major criticism of many of the studies related to the implementation of a cooperative or problem-based learning unit was the lack of any prerequisite opportunities to develop and strengthen the necessary skills for conducting effective group work. In most of the cases addressed, the effectiveness of the treatments was ultimately dependent on the social skills and communication skills that the participants accrued prior to the treatment conditions.

Lastly, additional qualitative research on the use of specific teacher practices aimed at increasing students' intrinsic motivation would certainly be beneficial to the educational community. What is needed in my opinion is qualitative research that focuses on diverse student populations and the effects of student-centered, democratic teaching practices on the perceived autonomy and competence of students in secondary science classrooms. If one of the current goals is to prepare a citizenry that is knowledgeable in scientific concepts and ways of thinking, then teacher practices that aim to foster independent, self-determined students should be of utmost priority.

Conclusion

Chapter one elucidated upon the reasoning and rationalization for a review and analysis of literature regarding teaching strategies that support the intrinsic motivation of secondary science students. This section examined the goals of science education in America's middle and high schools, as well as the traditional manner in which such an education has been conducted. With the rapid advancements in scientific knowledge, we have witnessed a similarly growing challenge in effectively passing on the vital information and skills of science and technology in a way that serves individual students, as well as the larger society in which we live. As witnessed over the past several decades, science achievement in secondary students has steadily decreased, warranting a closer look into the methods and strategies that are favored for teaching science. While chapter one pointed out several possible avenues which may offer insight into this profound and complex relationship, the notion of intrinsic motivation to learn in secondary students promises to hold particularly valuable insight into ways to effectively teach science.

Chapter two examined the historical background of intrinsic motivation and the evolutionary pathway that science education has followed. Historically speaking, the role of the individual has only recently gained attention in the context of learning and schooling. Although debates between the role of the individual in learning and best teaching practices have continued for well over a century, only in the last several decades has the concept of intrinsic motivation emerged and gained favor over the longstanding practices of Skinner and other behaviorists. The use of rewards and other externally motivating strategies has long been a favorite practice for teaching students in America's schools. However, as the cognitive and emotional aspects of learning have gained attention, approaches to teaching that ignore such aspects have become disfavored. In its stead, a growing body of research has emerged addressing various teaching strategies and their effectiveness in supporting the intrinsic motivation of students to learn.

In searching for effective strategies for intrinsically motivating secondary science students, chapter three examined and analyzed a variety of literature addressing the effects of various teaching strategies and practices on the intrinsic motivational levels of students. The literature was organized into several categories including: Autonomy support, student choice, social learning models, student-centered teaching, rationales, goal orientations, evaluation practices, learning strategies, computer-based learning, and teacher enthusiasm. Each of these categories was in turn synthesized to identify key teacher strategies that are most effective in promoting and supporting the intrinsic motivations of secondary students for learning science, the primary question asked in this paper.

Research reviewed in the sections pertaining to autonomy support and the provision of student choice revealed that teacher practices that are associated with autonomy support are effective in promoting the intrinsic motivation of secondary science students. The practices identified in the research varied and included allowing students to make instructionally irrelevant choices during lessons and activities that are purposeful and meaningful to their lives, as well as providing clarity and coherence among the classroom lessons, goals, and expectations. All of these practices require that students have adequate resources and time with which to engage in the content, explore the content autonomously, and discover meaning for them. In this way, students' competence, autonomy, relatedness, and in turn their intrinsic motivation will benefit tremendously.

The section regarding learning in a social context revealed that while teaching models including cooperative learning and problem-based learning are highly promising as strategies for intrinsically motivating secondary science students, the influence that other prerequisite conditions, such as students' pre-existing social and communicative skills, is unclear and must be considered when incorporating such collaborative forms of learning. Furthermore, the research specifically addressed jigsaw methods and group investigation methods, two of a wide variety of different approaches to cooperative and problem-based learning. In other words, further research would serve well to elucidate on the differential effects of other models of social learning with respect to students' intrinsic motivation. Research from the student-centered teaching section revealed that increased support during periods of amotivation or disinterest, increased risk-taking, and more collaborative classroom learning environments are some of the potential benefits of creating and maintaining a classroom that is culturally relevant and informed by the individual motivational and personal characteristics of all students in the classroom.

Research from a number of sections, including rationales and evaluation practices, support findings from the goal orientations section which showed that the promotion of a mastery goal oriented classroom is highly effective in promoting the intrinsic motivation of secondary science students. Explaining the purpose behind lessons and activities in a way that is autonomy supportive and non-controlling is one such strategy that emerged from the research. Additionally, providing feedback to students that directly pertains to the task rather than the individual is also a strategy for supporting goal orientations that are focused on learning and mastery rather than performance and competition. Other promising strategies that emerged from this body of research include promoting curiosity through novel situations, as well as utilizing a variety of approaches and styles in the classroom. All of these strategies will certainly benefit if the practicing teacher is mastery-oriented themselves and maintains positive expectations and relationships with the students. In other words, all of these strategies framed around promoting a mastery-goal oriented classroom hinge on a passionate dedication to learning and to the growth-ability of the brain in learning. Explicit teaching of incremental theory is one way to introduce this concept and promote the mastery-goal orientation and intrinsic motivation of students in the class.

Some strategies that are less conclusive yet still worthy of mention include the explicit teaching of metacognitive study strategies and the use of computer-based learning. Based on the research reviewed in these sections, study strategies such as elaboration, organization, and rehearsal are indeed associated with higher levels of intrinsic motivation. As such, it is implied that explicit instruction and use of metacognitive study strategies would provide students with the skills and competence necessary to pursue learning that is intrinsically motivated. Furthermore, the use of computer-based learning environments is one strategy for providing a more varied approach to learning, as well as a way for providing choice, supporting autonomy, and potentially creating more relevance. However, the wide variety of programs available warrant further research in order to identify some of the key elements of effective computer-based learning environments that are most conducive to supporting students' intrinsic motivation.

In the final section of chapter three, teacher enthusiasm was found to be highly influential in promoting the intrinsic motivation of students. This strategy involves using inflection in your voice, using hands and gestures to help convey ideas and words, and using facial expressions to emphasize certain information. Although this or any other single strategy identified in this chapter is by no means a panacea, certain key strategies including the use of enthusiasm serves to benefit the effectiveness and success of other strategies for intrinsically motivating secondary science students. In other words, many of the aforementioned strategies would only be strengthened when carried out with enthusiastic teaching and instruction as opposed to monotonous and mundane instruction.

Schools in America have historically been interested in the success and prosperity of society as a whole. As demands for a scientifically literate citizenry continue to grow and as the interest and achievement in science of America's youth continues to decline, the role of intrinsic motivation and the individual's interests, desires, and needs becomes more apparent. In order to effectively teach in today's increasingly diverse classrooms, it is vital that teachers address the entire student. There is no one strategy that will result in an entire classroom of intrinsically motivated students. However, through embracing the strategies identified in this paper, teachers can begin creating a classroom environment that will allow students' diverse intrinsic motivations to be nurtured and supported in a variety of ways. In particular, teacher strategies that support student autonomy and promote mastery goal orientations will lead to increased opportunities for students to investigate, discover, and make sense of science content in personally relevant and meaningful ways. This will lead to increased engagement and deeper learning of science content. Furthermore, if students' intrinsic motivations are supported in the secondary science classroom, the lessons that students take away will be more meaningful and will prepare students to be effective and active participants in a science laden global economy.

REFERENCES

Alonso-Tapia, J. & Pardo, A. (2006). Assessment of learning environment motivational quality from the point of view of secondary and high school learners. *Learning and Instruction*. *16*(2006), 295-309.

Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology*. *84*(3), 261-271.

Beck, R. C. (1990). *Motivation: Theories and principles* (3^{rd} Ed). Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Bernard, L. C., Mills, M., Swenson, L. & Walsh, P. R., (2006) An evolutionary theory of human motivation. *Genetic, Social, and General Psychology Monographs,* 2005, *131*(2), 129–184 Retrieved March 10, 2009 from http://www.drmillslmu.com/publications/ Bernard-Mills-Swenson-Walsh.pdf

Blackwell, L. S., Trzesniewski, K. H. & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development. 78*(1), 246-263.

Blyth, A. (1981). From individuality to character: The herbartian sociology applied to education. *British Journal of Educational Studies. 29*(1), 69-79.

Braund, M. & Reiss, M. (2006). Towards a more authentic science curriculum: The contribution of out-of-school learning. *International Journal of Science Education*. *28*(12), 1373-1388.

Butler, R. & Nisan, M. (1986). Effects of no feedback, task-related comments, and grades on intrinsic motivation and performance. *Journal of Educational Psychology*. *78*(3), 210-216.

Butler, R. & Shibaz, L. (2008). Achievement goals for teaching as predictors of students' perceptions of instructional practices and students' help seeking and cheating. *Learning and Instruction. 18*(2008), 453-467.

Ciani, K., Summers, J., Easter, M. & Sheldon, K. (2008). Collaborative learning and positive experiences: Does letting students choose their own groups matter? *Educational Psychology*. *28*(6), 627-641.

Cohen, E. (1994). *Designing groupwork: Strategies for the heterogeneous classroom.* New York: Teachers College Press

Cordova, D. & Lepper, M. (1996). Intrinsic motivation and the process of learning: Benefical effects of contextualization, personalization, and choice. *Journal of Educational Psychology*. *88*(4), 715-730.

Corpus, J. & Lepper, M. (2007). The effects of person versus performance praise on children's motivation: gender and age as moderating factors. *Educational Psychology*. *27*(4), 487-508.

Deci, E. L. & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Publishing.

Duschl, R. (1990) *Restructuring science education: The importance of theories and their development.* New York: Teachers College Press.

Dweck, C. (2000). *Self-theories: Their role in motivation, personality, and development.* Philadelphia: Psychology Press.

Garcia, T. & Pintrich, P. (1996). The effects of autonomy on motivation and performance in the college classroom. *Contemporary Educational Psychology. 21*(1996), 477-486.

Gardels, N. (Interviewer) & Baltimore, D. (Interviewee). (2002). *Scientists in the age of terror and knowledge-based economies.* [Interview commentary]. Retrieved from New Perspectives Quarterly Web site: http://www.digitalnpq.org/global_services /nobel%20laureates/03-18-03.html

Gibboney, R. (2006). Intelligence by design: Thorndike versus Dewey. *Phi Delta Kappan. 88*(2), 170-172.

Glass, B. (1970). *The timely and the timeless.* New York: Basic Books.

Hanrahan, M. (1998). The effect of learning environment factors on students' motivation and learning. *International Journal of Science Education*. *20*(6), 737-53.

Hanze, M. & Berger, R. (2007). Cooperative learning, motivational effects, and student characteristics: An experimental study comparing cooperative learning and direct instruction in 12th grade physics classes. *Learning and Instruction*. *17*(1), 29-41.

Hidi, S. & Harackiewicz, J. (2000). Motivating the academically unmotivated: A critical issue for the 21st century. *Review of Educational Research. 70*(2), 151-179.

Huerta, G (2009). *Educational foundations: Diverse histories, diverse perspectives.* Boston: Houghton Mifflin Company.

Jang, H. (2008). Supporting students' motivation, engagement, and learning during an uninteresting activity. *Journal of Education Psychology*. *100*(4), 798-811.

Lau, S. & Roeser, R. (2008). Cognitive abilities and motivational processes in science achievement and engagement: A person-centered analysis. *Learning and Individual Differences*. *18*(2008), 497-504.

Lavigne, G., Vallerand, R. & Miquelon, P. (2007). A motivational model of persistence in science education: A self-determination theory approach. *European Journal of Psychology of Education*. *22*(3), 351-369.

Liu, M. (2006). The effect of a hypermedia learning environment on middle school students' motivation, attitude, and science knowledge. *Computers in the Schools*. *22*(3-4), 159-171.

Lodewyk, K. R., Winne, P. H. & Jamieson-Noel, D. L. (2009). Implications of task structure on self-regulated learning and achievement. *Education Psychology*. *29*(1), 1-25.

Lynch, J. (2009, May 18). Some bad news before I go… Message posted to http://scienceblogs.com/strangerfruit/2009/05/some_bad_news_before_i_go.php#more

Morling, B. & Kitayama, S. (2008). Culture and motivation. In J. Shah, & W. L. Gardner (Eds.), *Handbook of motivation sciences*. New York: Guilford.

Nemiroff, G. (1992). *Reconstructing education: Toward a pedagogy of critical humanism.* New York: Bergin & Garvey.

Nieswandt, M. & Shanahan, M. (2008). "I just want the credit!" Perceived instrumentality as the main characteristic of boys' motivation in a grade 11 science course. *Research in Science Education*. *38*(1), 3-29.

Nieto, S. (2007). *Affirming diversity.* New York: Longman.

Nolen, S. & Haladyna, T. (1990). Motivation and studying in high school science. *Journal of Research in Science Teaching*. *27*(2), 115-126.

Obama, B. (Speaker). (2009). *44th Presidential Inauguration* [Speech transcript]. Retrieved from CNN Politics.com Web site: http://www.cnn.com/2009/POLITICS/01/20/obama.politics/ index.html

Office of Superintendent of Public Instruction. *Washington state report card* [data file]. Retrieved from http://reportcard.ospi.k12.wa.us

Oldfather, P. (2002). When students do not feel motivated for literacy learning: How a responsive classroom culture helps. *National Reading Research Center: Research Reading Report. 8*, 1-21.

Patrick, B., Hisley, J., Kempler, T. & College G. (2000). What's everybody so excited about? The effects of teacher enthusiasm on student intrinsic motivation and vitality. *Journal of Experimental Education. 68*(3), 217-237.

Patrick, H. & Ryan, A. (2008). What do students think about when evaluating their classroom's mastery goal structure? An examination of young adolescents' explanation. *The Journal of Experimental Education. 77*(2), 99-123.

Pintrich, P., Marx, R. & Boyle, R. (1993). The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research. 63*(2), 167-199.

Randler, C. & Bogner, F. (2007). Pupils' interest before, during, and after a curriculum dealing with ecological topics and its relationship with achievement. *Educational Research and Evaluation*. *13*(5), 463-478.

Reese, W. (2005). *America's public schools: From the common school to "no child left behind."* Baltimore: John Hopkins University Press.

Reeve, J. (2006). Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit. *The Elementary School Journal. 106*(3), 225-236.

Ryan, R. M. & Deci, E. L. (2000). When rewards compete with nature: The undermining of intrinsic motivation and self-regulation. In C. Sansone & J. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: The search for optimal motivation and performance* (13-54). San Diego: Academic Press.

Seidel, T., Rimmele, R. & Prenzel, M. (2005). Clarity and coherence of lesson goals as a scaffold for student learning. *Learning and Instruction*. *15*(2005), 539-556.

Shachar, H. & Fischer, S. (2004). Cooperative learning and the achievement of motivation and perceptions of students in 11th grade chemistry classes. *Learning and Instruction*. *14*(2004), 69-87.

Skinner, B. F. (1972). *Beyond freedom and dignity.* New York: Bantam Books.

Skinner, E. & Belmont, M. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of Educational Psychology. 85*(4), 571-581.

Song, H-D. & Grabowski, B. (2006). Stimulating intrinsic motivation for problem solving using goal-oriented contexts and peer group composition. *Educational Technology Research & Development. 54*(5), 445-466.

Spring, J. (2005). *The American school: 1642-2004*. New York: McGraw-Hill Publishing.

Stefanou, C. & Parkes, J. (2003). Effects of classroom assessment on student motivation in fifth-grade science. *The Journal of Educational Research. 96*(3), 152-162.

Stipek, D. (2002). *Motivation to Learn: Integrating theory and practice.* Boston: Allyn & Bacon.

Stuart-Hamilton, I. (1999). *Key ideas in psychology*. Philadelphia: Jessica Kingsley.

Sungur, S. & Tekkaya, C. (2006). Effects of problem-based learning and traditional instruction on self-regulated learning. *The Journal of Educational Research*. *99*(5), 307-317.

Tan, I., Lee, C. & Sharan, S. (2007). Group investigation effects on achievement, motivation, and perceptions of students in Singapore. *The Journal of Education Research*. *100*(3), 142-154.

U.S. Department of Education, National Center for Education Statistics. (2007a). Highlights from PISA 2006: Performance of U.S. 15-year-old students in Science and Mathematics Literacy in an international context (NCES 2008-016). Washington, DC: U.S. Government Printing Office.

U.S. Department of Education, National Center for Education Statistics. (2007b). *The condition of education 2007* (NCES 2007-064). Washington, DC: Government Printing Office.

Vansteenkiste, M., Lens, W. & Deci, E. (2006). Intrinsic versus extrinsic goal contents in self-determination theory: Another look at the quality of academic motivation. *Educational Psychologist. 41*(1), 19-31.

Wang, S. & Reeves, T. (2006). The effects of a web-based learning environment on student motivation in a high school earth science course. *Educational Technology Research and Development*. *54*(6), 597-621.

White, R. (1959). Motivation reconsidered: The concept of competence. *Psychological Review. 66*(5), 297-333.

Wilber, D. (2008). iLife: Understanding and connecting to the digital literacies of adolescents. In K. Hinchman & H. Sheridan-Thomas (Eds.). *Best practices in adolescent literacy instruction.* New York: The Guilford Press.

Wilson, B. L. & Corbett, H. D. (2001). *Listening to urban kids: School reform and the teachers they want.* Albany, New York: State University of New York Press.

Young, M. (2005). The motivational effects of the classroom environment in facilitating self-regulated learning. *Journal of Marketing Education*. *27*(1), 25-40.