HIGH SCHOOL STUDENT'S MOTIVATION TO ENGAGE
IN CONCEPTUAL CHANGE-LEARNING
IN SCIENCE

DISSERTATION

Presented in Partial Fulfillment of the Requirement for
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By

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ABSTRACT

This study investigated motivational factors that are related to engaging in conceptual change learning. While previous studies have recognized the resistance of students' scientific conception to change, few have investigated the role that non-cognitive factors might play when students are exposed to conceptual change instruction.

Three research questions were examined: (a) What instructional strategies did the teacher use to both promote students' learning for conceptual change and increase their motivation in learning science? (b) What are the patterns of students' motivation to engage in conceptual change learning? And (c) what individual profiles can be constructed from the four motivational factors (i.e., goals, values, self-efficacy, and control beliefs) and how are these profiles linked to engagement (i.e., behavioral and cognitive engagement) in conceptual change learning of science?

Eleven twelfth grade students (senior students) and the teacher in which conceptual change approach to teaching was used in daily activities
were selected. Data collection for this study included student's self-reported responses to the Motivated Strategies for Learning Questionnaire (MSLQ), classroom observation of students and the teacher, and structured interviews. Analysis of these data resulted in a motivational factor profile for each student and cross case analysis for entire group.

Results from this study indicate that each student has different motivation factors that are mostly influenced individual student to learn science. Among these motivation factors, task value and control beliefs were most important for students. The implication of these findings are that teachers need to encourage students to find learning for conceptual change a valuable task, and that students need to find applications for their new conceptions within their everyday lives. In addition, teachers need to encourage students to develop learning strategies for conceptual understanding. Furthermore, students' motivation to learn was also influenced by other factors that are not directly related to the four motivational factors assessed by the MSLQ such as the teacher's unique personality had a positive influenced on student learning. The overall conclusions drawn from this study are that conceptual change instruction requires the teacher to be aware of the importance of affective aspects and motivational factors of students learning.
Dedicated to
my late father Kahfi Kartawinata
(June 1917- December 29, 1995)
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CHAPTER 1

INTRODUCTION

Statement of the Problem

Understanding fundamental science concepts is considered a major goal for students learning science today. Conceptual understanding, according to National Science Education Standard (1996), is defined as:

...[an integration] of a complex structure of many types of knowledge, including the ideas of science, relationship between ideas, reasons for these relationships, ways to use the ideas to explain and predict other natural phenomena, and ways to apply them to many events (p. 23)

Thus, scientific understanding encompasses an ability to use conceptual knowledge of science, and it entails the ability to distinguish between what is and what is not a scientific idea.

Scientific understanding is also necessary for a scientifically literate society. To reach this goal, students need to learn science by engaging in learning activities that are interesting and meaningful to them. Likewise
teachers must be empowered to make instructional decisions about how students learn, and how resources are allocated during instruction. Thus, students and teachers must be partners who work together to achieve both of these learning goals (National Science Educational Standard, 1996).

The advantages of scientific understanding can be viewed from two perspectives: that of the individual and that of the society. From the individual student’s perspective, achievement of scientific understanding leads to: 1) a solid foundation for more advanced science learning, 2) personal satisfaction through more meaningful learning, 3) increased recognition from peers, teachers, and parents, and 4) a better chance for future career opportunities. Advantages to society for students who achieve scientific understanding lead to citizens who: (1) are scientifically and technologically literate, (2) can compete in the global workforce, (3) can provide input on policy issues regarding science, (4) can engage intelligently in public discourse, and (5) can increase economic productivity, as well as the productivity of the country through the application of this knowledge (National Science Education Standard, 1996).

In spite of the advantages of scientific understanding indicated above, students at all grade levels are not learning science concepts well. Evidence
from various sources (Anderson, 1987; Duit, 1993; Fensham, 1985; Yager & Hofstein, 1986) indicate that students are not learning enough science and do not understand important scientific concepts at a depth that would allow them to be considered scientifically literate. Anderson (1987) found that approximately 80% of The United States of America student population (K-12) failed to achieve an understanding of science concepts. Comparisons of science achievement between U.S. students and students in other countries also show that U.S. students perform significantly lower in science than their rivals (International Association for the Evaluation of Educational Achievement, 1988; National Science Foundation & the Department of Education, 1980).

The goal of this study is to bring together research on student motivation with research on conceptual change learning in science. A specific goal of this research is to investigate the relationships between motivation factors and students engagement in conceptual change learning in science. A brief overview of relevant research literature on conceptual change and student’s motivation to learn science is presented in this section. A more complete treatment of this literature can be found in Chapter Two.
Conceptual Change Learning in Science

In the United States, at least, understanding science is frequently linked to conceptual change learning. Research on student’s conceptual learning has been conducted for several decades. From this research, a model of student learning, the Conceptual Change Model, was proposed by Posner et al., (1982). This learning model is the focus of much attention and research in the science education community (Beeth, 1998; Beeth & Hewson, in press; Duit, 1993; Hewson, 1981, 1982; Hewson, Beeth, & Thorley, 1998; Pintrich, Marx, & Boyle, 1993; Strike & Posner, 1992). The authors of the Conceptual Change Model (hereafter referred to as the CCM) looked to an analogy between student’s conceptual learning in the classroom and the process of conceptual change in the science community. The CCM views student learning as a rational process analogous to the way in which many contemporary interpretations in history and philosophy of science picture change in the knowledge of scientific communities. Thus, scientific knowledge is constructed based on a learner current understanding of a phenomenon and the impacts of new information or new ways of thinking about existing information that bear on a concept.
Theoretical components of the CCM include the conditional status of a conception and the conceptual ecology (Posner et al., 1982). These core components of the model are useful to teachers in thinking about diagnosing student’s conceptual understanding. Hewson and Thorley (1989) describe the components as follow:

There are two major components to the model of conceptual change, the [status] conditions that need to be satisfied in order for a person to experience conceptual change and the person’s conceptual ecology that provides the context in which the conceptual change occurs and has meaning (p. 541).

The process of conceptual change can be described briefly as: learners must find reasons to become dissatisfied with an existing conception, and must then find a new conception intelligible, plausible and fruitful. The last three conditions characterize the status of a conception (Hewson, 1981, 1982). Each status condition is associated with one or more components of the conceptual ecology (Thorley, 1990).

Dissatisfaction with a current conception is the first condition required for the conceptual change process to proceed. This suggests that the less dissatisfied an individual is with his or her current understandings and ideas, the less likely he or she will be to consider changing his or her view. The second condition is that a new conception must be intelligible. To lead an
individual to consider a new concept as a better mean of explaining an experience than the current conception, he or she must first understand it. The third condition is that the new concept must be plausible. While a student might be able to understand a new concept, he or she may deem the new concept to be inconsistent with other ideas to merit further consideration. Finally, the new concept must appear fruitful; that is, it must have explanatory power and/or suggest new areas for investigation (Hewson, Beeth, & Thorley, 1998).

The second major component of the Conceptual Change Model, the conceptual ecology, refers to all of the knowledge that a person holds and recognizes as important. This knowledge consists of different kinds and focuses attention on interactions believed to exist within this knowledge base. The authors of the CCM identify the components of conceptual ecology as: 1) anomalies, 2) prototypical exemplars and images, 3) past experiences, 4) analogies and metaphors, 5) epistemological commitments, 6) metaphysical beliefs and concepts, and 7) other knowledge (Posner et al., 1982).

According to Hewson (1981), the degree to which an individual knows, accepts, and finds an idea useful is indicated by the status of that
idea for the individual. The conceptual ecology, on the other hand, relates to all the knowledge a person holds that influences the status of an idea. The process of learning, therefore, can be explained as the process of raising or lowering the status of a conception within the context of the learners' conceptual ecology. How a teacher might influence this process through instruction is a focus of this study.

Motivation and Conceptual Change

A number of criticisms have been directed at the Conceptual Change Model. Pintrich, Marx, and Boyle (1993) focus on one specific criticism: the CCM's lack of attention to affective aspects of learning, including motivational constructs that should lead to change in a conception. Pintrich, Marx, and Boyle argue that the CCM is a highly rational view of learning (being driven solely by logic and scientific thinking) with little or no reference to motivational constructs such as goals, value beliefs, or self-efficacy belief. In fact, given the CCM's reliance on rational mechanisms for learning (i.e., similar to changes within the scientific community) one might argue that there is one single de facto motivational construct in the model: disequilibrium. Indeed, Strike and Posner (1992) in a recent response to
Pintrich, Marx, and Boyle's criticism of the CCM indicated that affective factors are an important aspect of learning that should be investigated in relation to the CCM.

Despite the fact that the CCM has had considerable influence in science education research, science educators are still confronted with students who are unwilling to learn hard toward achieving conceptual understanding in science. Many students spend time and effort focusing on less important learning outcomes, such as memorizing science vocabulary or factual information, rather than trying to achieve scientific understanding (Anderson & Roth, 1989; Blumenfeld & Meece, 1988; Tobin & Gallagher, 1987). These students also rely on less appropriate learning strategies such as distorting scientific knowledge to fit their existing knowledge (Chinn & Brewer, 1998), mindlessly answering questions, copying answers from others, or not completing their work (Anderson & Roth, 1989; Blumenfeld & Meece, 1988). These findings alone are sufficient reasons for investigating the relationships among motivational factors and concept learning.

As described above, student learning can be explained as the process of raising and lowering the status of conceptions within the context of a
student's conceptual ecology. Pintrich, Marx, and Boyle (1993) and Boyle, Magnusson, and Young (1993) believe that student motivation is an important factor that can contribute to raising or lowering the status of a conception. For instance, accepting the fruitfulness of a new conception implies a role for value judgments about the applicability of a conception, such as how this conception might attain a desired end. Learning portrayed by the current CCM focuses only on student cognition without considering students' motivational beliefs about themselves as learners and their roles in the classroom community. This limited view of learning does not offer a complete picture of the process of conceptual change learning. Thus, the importance of considering student motivational beliefs in the process of student learning is essential if students are to engage in conceptual change learning. This is to say that personal, motivational, and social processes (Cobb, 1994; Driver, Asoko, Leach, Mortimer, & Scott, 1994; Kamii, 1982; Pintrich, Marx, & Boyle, 1993) influence the process of conceptual change.

Past research on conceptual change in science education claimed that problems of student motivation were largely attributable to the nature of traditional curriculum materials and instructional practices (Anderson, 1987; Dweck, 1986; Hesse & Anderson, 1988; Roth, 1985). These findings also
indicate that traditional curriculum materials and instructional practices do not provide opportunities for students to learn science content in meaningful or valuable ways. Consequently, some students do not perceive scientific understanding as attainable. In these cases, a student’s decision not to learn is a rational choice, since the curriculum materials and instruction do not motivate him or her to achieve a new scientific understanding as a better alternative to other existing conception (Anderson, 1987; Driver, 1987; Hesse & Anderson, 1988; Posner, 1982; Roth, Anderson, & Smith, 1987).

Some conceptual change researchers believe that students could attain a deeper understanding of science if curriculum materials and instruction gave them both the opportunity and support to achieve scientific understanding (Beeth, 1998; Beeth & Hewson, 1997). When students engage in activities that require a high degree of intellectual engagement, they not only increase their chance (expectancy) of achieving this goal but they also recognize the value of achieving this goal.

Research on student motivation, on the other hand, has found that student motivation involves a complex interplay of curriculum, instruction and student characteristics (Dweck & Elliot, 1983; Feather, 1982; McClelland, 1985; Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996).
Researchers of student motivation indicate that motivational problems result when students' decision-making processes are not entirely rational. For example, students' self-perceptions lead them to place low value on the goal of scientific understanding or to express a low expectancy of success in achieving this goal. Without making an effort to achieve scientific understanding, these students choose alternative methods of learning such as memorization. For that reason, researchers of motivation argue that students' beliefs about expected learning outcomes and characteristics of learning strategies, play an important role in the decisions students make about whether they will achieve scientific understanding. In spite of the conclusion that curriculum materials and instruction are crucial for student learning, researchers who study motivation have been primarily concerned with cognitive and affective aspects of student characteristics. Thus, research on motivation claims that to understand the problems of student motivation, educators need to examine why (i.e., goals) and how (i.e., strategies) students decide to learn while engaging in everyday classroom tasks (Brophy & Merrick, 1987; Lee, 1989). In science classrooms guided by principles of conceptual change, for instance, students who are motivated to learn should engage in classroom tasks with the goal of achieving scientific
understanding. They should also activate appropriate strategies associated with achieving this goal (Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996).

In light of the findings from these two research traditions, it can be argued that the CCM, in its current form, does not address motivation. An assumption of the CCM has been that if we get curriculum and instruction right, motivational problems will be solved. Scholars who study motivation, however, indicate that individual characteristics of students are important—the implication being that these factors interact with curricular and instructional factors so as to impact conceptual understanding. Unfortunately, until recently no one has studied this interaction. The study presented here investigated relationships among four motivation factors (i.e., goals, values, self-efficacy, and control beliefs) and engagement in conceptual change learning.

From the argument above, it can be assumed that motivation is crucial to the process of student learning viewed as conceptual change. In other words, if we want to understand how students come to engage in conceptual change learning, we need to understand which factors motivate students to learn for conceptual understanding. For this reason, research on the
relationship between student motivational constructs and learning for conceptual change in science is the main focus of this research.

**Objective and Research Questions**

The overall objective of this study is to link data from student motivational factor profiles to engagement in conceptual change learning in science. In addition, owing to the research context in which this study was conducted, the impacts of planned instruction on motivation will also be examined. The specific goals of this research are to:

(a) identify instruction strategies the teacher uses to both promote students’ learning for conceptual change and increase their motivation in learning science.

(b) identify patterns of students’ motivation to engage in conceptual change learning of science.

(c) identify profiles of individual students’ motivational factors (i.e., goals, values, self-efficacy, and control beliefs) in learning of science and determine how these profiles are linked to their engagement (i.e., behavioral and cognitive engagement) in conceptual change learning of science.

The specific research questions that are addressed through this study are:

1). What instructional strategies did the teacher use to both promote students' learning for conceptual change and increase their motivation in learning science?
2). What are the patterns of students' motivation to engage in conceptual change learning of science?

3). What individual profiles can be constructed from the four motivation factors (i.e., goals, values, self-efficacy, and control beliefs) for the eleven student participants in this study and how are these profiles linked to their engagement (i.e., behavioral and cognitive engagement) in conceptual change learning of science?

Overview of Research Design

This study is an in-depth investigation of motivation factors students perceive as important when learning science concepts. A senior high school (12th grade) classroom was selected for this study within which the teacher used a conceptual change approach to teaching. The site for this case study was a parochial high school in the greater Columbus metropolitan area. Participants in the study included eleven students and their teacher. The eleven students represented both genders (9 females and 2 males), and two ethnic backgrounds (10 Caucasians and 1 Hispanic).

Data on four motivational factors (i.e., goal, value, self-efficacy, and control beliefs) were collected using the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich et al., (1991). The MSLQ was administered to all eleven students one week prior to beginning classroom observation of instruction or interviewing students. The MSLQ is a self-report instrument and has been under development since 1986 when
NCRIPTL (National Center for Research to Improve Post-secondary Teaching and Learning) was founded. The MSLQ that was used in this study is the final version in which the Cronbach’s alphas are robust, ranging from .52 to .93 (Pintrich et. al., 1991). These statistics indicate that data obtained on the MSLQ have reasonable factor validity. MSLQ data assess students’ motivational orientations, and interpretation of these data suggests different learning strategies used by an individual student. The MSLQ contains two sections: the first section assesses four motivational factors (i.e., goals, values, self-efficacy, and control beliefs), and the second section assesses learning strategies. Because the purpose of this research is to identify motivational factors, only the first section of the MSLQ was used in this research.

In depth analysis of student scores on the four motivational factors (goals, values, self-efficacy, and control beliefs) were used to create motivational factor profiles for each student. In light of the above, the specific questions to be answered through this research are:

1. What instructional strategies did the teacher use to both promote students’ learning for conceptual change and increase their motivation in learning science?
The specific data sources that were used to address this question came from observation of instructions and interviews with students and their teacher. These data are used to support claims about student engagement in classroom activities.

2. What are the patterns of students' motivation to engage in conceptual change learning of science?

The data sources to address this question come from observation of instruction, field notes, and interviews of students and their teacher.

3. What individual profiles can be constructed from the four motivation factors (i.e., goals, values, self-efficacy, and control beliefs) for the eleven student participants in this study and how are these profiles linked to their engagement (i.e., behavioral and cognitive engagement) in conceptual change learning of science?

The data sources used to answer this question come from students' responses to the MSLQ, classroom observations, and interviews of students and teacher. The motivation section of the MSLQ developed by Pintrich et al., (1991) consists of 26 items that assess four motivational factors: goals, values, self-efficacy, and control beliefs were used as the self-report questionnaire instrument. Students' responses to MSLQ items were analyzed to gain data regarding each motivational construct (goals, values, self-efficacy, and control beliefs). Collectively, these data provided a motivational factors profile for each of the eleven students in the study.
Significance of the Study

Learning described as conceptual change is crucial to science education research today. However, in its current form, the CCM presents a highly rational view of learning with little or no reference to student motivational factors such as goals, values, self-efficacy, and control beliefs. These four factors are believed to enhance learning for conceptual change in science (Pintrich, Marx, & Boyle, 1993; Boyle, Magnusson, & Young, 1993). If the relationships between these factors and conceptual change learning can be understood, this finding would provide crucial insights regarding how students do or do not engage in learning presented as conceptual change. A further implication is that student understanding in science could be improved and enriched if the relationships between student motivational factors and conceptual change learning is understood.

Limitation of Study

Due to the specific goals of this study and the research design, findings from this study should be confined to the targeted students since the sample size is very small (eleven students and one teacher) and the selection of participants was purposeful. As a consequence, the findings can not be generalized to all students' grade levels, genders, and socio-cultural
backgrounds. However, more modest speculations on the applicability of
the findings from this study to other situations under similar conditions can
be expected (Patton, 1990). Finally, this study is a descriptive case study. A
major goal of this case study is to understand the relationship of student
motivational factors to conceptual change learning in a naturalistic
classroom situation and not to offer a causal explanation of this relationship.
CHAPTER 2

REVIEW OF LITERATURE

Introduction

A review of research on student motivation and student learning in science for conceptual change is presented here as a background for understanding this study. Two main sections are presented in this chapter. The first section analyzes theoretical foundation of motivation theory that concern: 1) motivation factors and motivational indices; 2) the Conceptual Change Model and learning for conceptual change; 3) student’s motivation to learn science and research on student’s motivation in learning science. The second section analyzes methodological literature related to this study. This section focuses on a discussion of the quality of student task engagement in learning science, and the measurement of student motivation.
Section I: Theoretical Foundations of Motivation Theory

Motivational factors

Pintrich, Marx, and Boyle (1993), and Wigfield, Eccles, and Rodriguez (1998) describe four factors that are crucial to motivation to learn. These individual student motivational factors include goals, values, self-efficacy, and control beliefs. Goals provide the student with the motivation to learn. According to Locke and Latham's (1990) theory concerning goals for learning, the two most important aspects of goals are goal choice and goal commitment. Goal choice refers to the actual goal an individual is trying to obtain and the level at which they are trying to attain that goal. Students have goal choice when they can select from a variety of levels of goals they want to pursue on a particular classroom task. Examples of goal choice include getting all questions right on an exam, getting enough correct answers to get a good grade or getting enough correct answers to pass a test. Goal commitment represents how strongly individuals are attached to a goal, how enthusiastic they are about the goal, or how determined they are to achieve a goal. Locke and Latham, (1999) noted that goal commitment is usually assessed by asking individuals to respond to the
following types of questions on a Likert scale: “How committed are you to attaining the goal?” “To what degree did you adopt the goal?” “It is hard to take this goal seriously”; “I don’t care if I achieve this goal or not”; “I am strongly committed to trying to achieve this goal” (Locke & Latham, 1990, p. 126).

Value is also a crucial factor in motivation to learn. Rokeach (1979) defines value as “core conceptions of the desirable within every individual and society” (p. 2). Value guides children’s cognition, motivation, and behavior by serving them general standards and beliefs necessary to avoid undesirable behaviors. Eccles and Wigfield (1995) describe four important models of task value: attainment value, intrinsic interest value, extrinsic utility value, and cost. Attainment value is the importance of doing well on a task. Intrinsic interest value is defined as the enjoyment people experience when doing a task or as their subjective interest in the content of a task. Extrinsic utility value is defined as the usefulness of the task for individuals in terms of their future goals, including career goals. Value is related more to the ends in a means-ends analysis of a task. For instance, a college student may not have much intrinsic interest in physics, but because he or she wants to be an engineer, this course may have a high utility value. Cost is another
component of task value. Cost value is defined as the perceived negative aspects of engaging in a task (Wigfield & Eccles, 1992). When individuals engage in one task, it means they cannot engage in another task at the same time. Accordingly, along with the choice of one specific task, there are costs associated with not selecting the alternatives.

Self-efficacy refers to “people’s judgements of their capabilities to organize and execute courses of action required to attain designated types of performances” (Bandura, 1986, p. 391). Bandura (1982) hypothesized that self-efficacy influence choice of activities, effort, and persistence. People holding low self-efficacy for accomplishing a task may avoid it while those who believe they are capable of doing a task are likely to participate. Especially when encountering difficulties, efficacious students work harder and persist longer than those with doubts.

Control beliefs are another motivational construct. Control beliefs refer to how much control a student has over his or her behavior or the outcome of a performance. Connell (1985) proposed three general control beliefs: internal control, external control, and unknown control. Students who believe that they have internal control over their own learning and performance, in contrast to students guided by external control or unknown
control, perform better in school (Connell, 1985).

In summary, student motivational factors like goals, values, self-efficacy, and control beliefs, are crucial constructs that are indicated by behaviors like effort, interest, persistence, and task engagement during classroom activities. Thus, observing these behaviors in classroom activities is an appropriate way to understand student motivation to learn.

Indices of motivation

Assessing motivation is important for researchers and practitioners who are concerned with understanding ways to optimize learning outcomes. Most professionals agree that inferring the presence of motivation is recognized in classroom activities as student task engagement (Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996). The quality of student task engagement is characterized by several indices. Pintrich and Schunk, (1996) describe four indices of motivation: 1) choice of task, 2) effort, 3) persistence, and 4) achievement. These indicators of motivated behavior in student learning will be documented during observation of classroom activities.

Lepper, Greene, and Nisbett (1973) conducted research on choice of tasks or interest with preschool children during free play. Children who
spent time drawing were assigned to one of three conditions: an expected-award group, an unexpected-award group, and a no-award group. In the expected-award group, young children were offered a good player certificate if they drew a picture. Students in the unexpected-award group were not offered the certificate but these students received the certificate after they drew a picture. Students in the no-award group were not offered the award, and did not receive it. After two weeks, these children were re-observed during free play when they choose a task to do. The result of the study showed that children who expected awards chose drawing for a significantly shorter time following the study than they had prior to it. However, the other two groups showed no significant change. This means that the expected-award condition decreased motivation as assessed by choosing to draw during free time.

Because students in higher grade have few if any choices, the choice of tasks as the indicator of student’s motivation is not a useful index of motivation in high school classrooms (Brophy, 1983).

Students motivated to learn are apt to expend effort to succeed even when learning is not easy. Corno and Mandinach (1983) state that when skill learning is involved, cognitive effort is an appropriate index of motivation.
Students who are motivated to learn are characterized by expending greater mental effort during instruction and employing cognitive strategies believed to be the best way to promote their learning. Included in these strategies are organizing and rehearsing information, monitoring level of understanding, and relating new material to prior knowledge (Peterson, Swing, Braveman, & Buss, 1982; Pintrich & DeGroot, 1990). It is important to note that the usefulness of effort as an index of motivation is constrained by ability in that as ability increases, more able students perform better with less effort.

Solomon's (1984) research found that a student's mental effort is related to self-efficacy. In his research, students judged self-efficacy for learning from TV or from written text, watched televised film or read the comparable text, judged the amount of mental effort necessary for their learning, and were tested on the content. The finding showed that students judged mental effort greater for text and showed higher achievement scores from text than those from TV. In this study, self-efficacy is positively correlated with mental effort and achievement and negatively correlated with TV.

Students who are motivated to learn ought to persist at the tasks, especially when they face personal restraints. Pintrich and Schunk (1996)
have shown that greater persistence leads to higher accomplishment. Persistence is an important factor for learning because worthwhile learning takes time before success may be readily forthcoming.

Persistence was used as a measure of motivation in research conducted by Zimmerman and Ringle (1981). They observed children who unsuccessfully solved a puzzle for either a long or short time while verbalizing statements of confidence or pessimism. These research findings show that children who observed the high-persistence model remained on task longer than children exposed to a low-persistence model. Children who observed the confident model also persisted longer than those who observed the pessimistic model did.

Another indication of motivation is student achievement. Students who choose to engage in a task, expend effort, and persist achieve at a higher level (Pintrich & Schrauben, 1992; Schunk, 1991). Many research studies have demonstrated positive relationships between achievement and the indices of motivation such as choice of tasks, effort, and persistence.
Learning in Science

The Conceptual Change Model

The Conceptual Change Model of learning has been described by Posner and his colleagues (Hewson & Hewson, 1984; Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1985, 1992). This model describes student learning as a rational process analogous to the way in which conceptual change is believed to occur within the scientific community. A conceptual change is defined as the occurrence of change in either the status of a conception or a component of the conceptual ecology (Hewson & Thorley 1989). Student learning, according to conceptual change model, occurs when a student actively constructs and transforms their own meanings, instead of passively acquiring and accumulating knowledge transmitted to them (e.g., Driver, Asoko, Leach, Mortimer, & Scott, 1994; Hewson, Beeth, & Thorley, 1998; Posner, Strike, Hewson, & Gertzog, 1982). Thus, student learning is not an accumulation of bits of information, but is an interactive, connective processes requiring changes of different kinds such as addition, linkage, rearrangement, and exchange of concepts (Beeth, 1998; Beeth & Hewson, 1997; Hewson, Beeth, & Thorley, 1998).
The conceptual change model has two components, the (conditional) status of a conception and the conceptual ecology. The status of a conception can be described as intelligible, plausible, or fruitful. Each status term is attached to one or more components of the conceptual ecology (Thorley, 1990).

The status of a conception, Hewson (1981) indicates that status describes the degree to which the student knows, accepts, and finds an idea useful. The status of a conception is described as intelligible, plausible, or fruitful depending on the degree of commitment the individual has to that conception.

Intelligibility of a new concept is a prerequisite to conceptual change. It means that a conception must be understood in the sense that the learner comprehends the meaning of the words that are used to describe it and that he or she can attach that meaning to some existing knowledge. Beeth (1993) offered an analogy for intelligibility—that it is analogous to the process of constructing a written sentence. In the process of writing a sentence, the writer must first understand the meaning of individual words and then have some sense of an agreed upon syntax necessary for constructing a sentence. For instance, “the car was green when it saw the horse” (Beeth, 1993. p. 11).
This sentence contains words which have relative unambiguous meanings but when taken together, they do have an agreed upon syntax. Because a reader is unable to understand how the color of a subject is related in any meaningful way to the object it "saw". In light of the example above, it is reasonable to assume that a conception must be intelligible before a person can do something psychologically with it since unintelligible conceptions can not be represented in one's thought (Hewson & Thorley, 1989).

A second condition that describes status is plausibility. Hewson, Beeth, and Thorley (1998) and Strike and Posner (1985) noted that plausibility has to do with the perception of truthfulness a conception has for learner. Plausibility comes from the question "does the learner believe that a conception they hold or are considering could be true based on his or her existing knowledge and beliefs about the world?" (Beeth, 1993). Plausible conceptions are linked to the reasons that someone has to believe that conception could be true in the real world because he or she believes it could be used to explain a particular phenomenon. Beeth (1998) and Strike and Posner (1985) indicate that components of the conceptual ecology are linked to the initial plausibility of a conception and lead to facilitating the process of conceptual change.
Fruitfulness is another status condition. Posner et al., (1982) explained fruitfulness as: the "[conception] should have the potential to be extended, to flourish in new areas of inquiry". Fruitful conceptions may be applied in a wide variety of situations. In addition, fruitful conceptions help to resolve previous anomalies, explaining past experiences, and presumably are generalizable to more phenomena larger than just one specific instance.

Finally, an intelligible idea becomes plausible if a person believes it to be true, finds it to be consistent with other ideas, and is able to reconcile it with other ideas that he or she has accepted. Furthermore, the idea can become fruitful if it solves otherwise insoluble problems (Beeth, 1998; Hewson, Beeth, & Thorley, 1998). Hewson (1981, 1982), and Hewson and Thorley (1989) noted that intelligibility, plausibility, and fruitfulness confer upon a conception its current status. Conceptions can be intelligible, intelligible and plausible, unintelligible and fruitful, or intelligible, plausible, and fruitful.

The conceptual ecology. The conceptual ecology relates to all of the knowledge that a person has and recognizes. Strike and Posner (1985) identified seven components of the conceptual ecology: anomalies, prototypical exemplars and images, past experience, analogies and
metaphor, epistemological commitments, metaphysical beliefs and concepts, other knowledge (see Figure 2.1). Beeth (1998) and Hewson, Beeth, and Thorley (1998) indicate that the conceptual ecology focuses attention on the interactions within this knowledge base, and identify the role that interactions among this knowledge play in supporting some ideas (raising their status), and discourage others (reducing their status). Although, the components of conceptual ecology are considered important in learning and knowledge development, students frequently do not identify components like epistemological component or metaphysical beliefs when speaking. However, these components have been inferred from classroom discourse (Beeth, 1993). Other components such as analogies, metaphors, exemplars, and images are easier to recognize in literal student conversations (Beeth, 1993; Strike & Posner, 1985).

All components of the conceptual ecology may contribute to determining the status of conception. If the individual experiences dissatisfaction with either the status of a conception or one of the ecological components underlying that conception, one of four possible outcomes must occur: (1) the new conception is rejected, (2) a new conception can be memorized, (3) a new conception can be captured by an existing conception,
or (4) a new conception can be exchanged for a previous conception if reconciliation is not possible (Hewson, 1981, p. 386).

Finally, the Conceptual Change Model is not incompatible with motivational issues. There are several “hooks” that integrate motivational factors with the CCM (Boyle, Magnusson, & Young, 1993; Pintrich, Marx, & Boyle, 1993). For instance, accepting the fruitfulness of a new conception, one of the conditions for conceptual change, implies a role for student’s value judgements by the learner about the conception as well as his or her goals, such as how this new information might help in attaining a desired end.

**Teaching and learning for conceptual change**

Teaching and learning activities cannot be separated from one another. These activities are necessarily interrelated (Beeth, Hewson, & Thorley, 1998) and have an ontological relationship (Hewson & Hewson, 1988). For instance, in a discussion about teaching, raising questions about learning cannot be avoided. In teaching for conceptual change, teachers have to facilitate students learning. Teachers need to know what students know, and plan the instruction that can accommodate their learning in meaningful ways for conceptual understanding (Beeth, 1998; Beeth & Hewson, in
press). Hewson and Hewson (1988) highlighted five key instructional strategies that accommodate student learning for conceptual understanding. These instructional strategies include:

a) be able to diagnose their students’ thoughts on the topic in hand, e.g., by using a pretest based on prior research, by posing a question which will elicit students’ responses, etc.

b) make provision for students to be able to clarify their own thoughts, through individual work or in group discussion, generally guided by well-planned questioning. In terms of the conceptual change model, students come to understand the basis on which their conception is plausible, and perhaps fruitful, to them.

c) ensure that there be a direct contrast between students’ views and the desired view, either by the teacher presenting the desired view or by it emerging from the class. In terms of the conceptual change model, students have to become dissatisfied with their existing ideas.

d) provide immediate opportunities for the desired view to be used in explaining a phenomenon. This might be achieved with carefully planned questioning, perhaps around a demonstration or after a laboratory session. This provides an opportunity for the students to see that the desired view is a plausible one.

e) provide immediate opportunities for students to apply their newly acquired understanding to different examples, both closely and more distantly related to the original example. This helps students see that their new conceptual is fruitful (Hewson & Hewson, 1988, pp. 607-608).

Thus, in conceptual change teaching teachers need to understand what students know, what students need to know and what instructional strategies
can accommodate learning for understanding. In this study, the criteria for conceptual change teaching proposed by Hewson and Hewson (1988) were used when selecting the teacher to observe.

As indicated above, student learning is related to teaching strategies. Two major aspects of learning for understanding are discussed in this section. First, the individual aspect of learning, and second the functional or social aspect of learning. Anderson and Roth (1989) describe individual learning to include that "students should develop knowledge of the world, as well as being scientifically accurate" (p. 274). The functional (social) aspect of learning includes that "students should develop knowledge that is useful for essential functions of describing, explaining, predicting, and controlling the world around us" (p. 274).

Related to individual aspects, Pines and West (1986) argue that student knowledge brought to the classroom should be linked to formal and scientific knowledge. If a student's prior knowledge is not in line with scientific knowledge, it means that he or she cannot link these two sources of knowledge. In this case, students need to infuse new, scientific knowledge with their incorrect prior knowledge or misconceptions through the conceptual change process. From the description above, it is suggested that
the most important issue in learning is the impact of a student's prior knowledge on future understanding.

In the process of conceptual change, students may restructure, modify or sometimes abandon previous knowledge (Hewson, Beeth, & Thorley, 1998; Hewson & Thorley, 1989; Strike & Posner, 1985). For that reason, the process of conceptual change sometimes is very hard for a large number of students. When it occurs however, it is crucial for them in terms of developing a more coherent, richer and deeper understanding of a science concept.

Research on Motivation in Learning Science

A review of research on student engagement in learning science is presented in this section. The discussion will focus on motivation to learn science and research on student motivation in science.

Motivation to Learn Science

Student motivation to learn science is defined by Lee and Brophy (1996) as "when students engage in science tasks with the goal of achieving a better understanding of science and activate strategies for doing so". This definition includes two main aspects: motivation to achieve a better understanding of science and the activation of strategies to learn science.
Porter and Brophy (1987) contend that understanding occurs when learners actively construct their own meanings, rather than passively acquiring knowledge that is transmitted to them. Thus, students construct an understanding of science when they are motivated to learn science. For that reason, the definition of student motivation to learn science integrates two different approaches to classroom research. These two approaches include student motivation to learn (Brophy, 1983, 1987) and learning for conceptual change in science (e.g., Beeth, 1998; Beeth & Hewson, 1997; Hewson, 1981; Hewson, Beeth & Thorley, 1998; Hewson & Thorley, 1989; Strike & Posner, 1985, 1992).

Motivation can affect both new learning and performance of previously learned skills, strategies, and behaviors. Motivation can influence what, when, and how students learn (Schunk, 1991). Students motivated to learn about a certain topic offered by a teacher are likely to get involved in activities they believe will help them to learn. In other words, students who are motivated to learn are characterized as actively engaging in classroom activities, mentally organizing and rehearsing the materials. For instance, students who are motivated are more likely to take notes, to check their level of understanding frequently, and to ask for help when they know that they
do not understand the material (Wigfield, Eccles & Rodriguez, 1998; Zimmerman & Martinez-Pons, 1992). Thus, students who are motivated to learn remain actively engaged in activities that should improve their learning. Brophy (1987) conceptualized a framework of student motivation to learn that infuses issues of motivation and learning process in the classroom setting. He argued that student motivation to learn could be distinguished from (a) general traits and (b) situation-specific traits. As a general trait “motivation to learn refers to an enduring disposition to value learning as a worthwhile and satisfying activity, and thus to strive for knowledge and mastery in learning situations” (p. 181). On the other hand, motivation to learn can be described as “a state of motivation to learn exists when task engagement is guided by the goal or orientation of acquiring the knowledge or mastering the skill that the task is designed to teach” (p. 182).

Student motivation in learning is identified by several aspects. Brophy (1987) hypothesized that most individuals who display motivation to learn as a general trait are likely to do so because they find learning to be intrinsically rewarding. Individuals who are motivated by a duty-bound sense of obligation could manifest learning. In specific situations, both types of individuals would display motivation to learn as a state similar to what
others have termed a mastery orientation (Dweck, 1986) or task engagement (Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996; Nicholls, 1984).

Research on motivation suggests that failures to understand classroom task is closely related to low quality task engagement (Corno & Mandinach, 1983; Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996). For instance, Anderson (1984) and Anderson et al., (1985) found that during seatwork assignments, first grade students, although they may be high achieving, rarely gave evidence of realizing the content-related purposes of an assignment. Instead, they perceived the purposes in terms of completing the assignment, as one student said “There! I didn’t understand it, but I got it done” (Anderson, 1984. p. 98).

Blumenfeld and Meece’s (1988) study of elementary school students in science noted that they were generally more concerned with procedures for completing or products assignments than with content per se. For example, when students were asked about their task engagement, they responded as follow: "So, I’ll know, if I want to be scientist" (p. 246).

Anderson et al., (1985) noted that in classroom work, a lot of students do not understand how to do classroom tasks. In their study it was found that while completing seatwork assignments, many lower achieving first grade
students did not have the strategies and skills necessary to complete classroom assignments in intended ways.

In summary, student motivation in learning is indicated in terms of a student’s choice of goals and use of strategies during task involvement. In particular, a state of motivation to learn shows when students get involved in a task with the goal of understanding the content and activates strategies for developing such understanding.

Research in student motivation in science

Student motivation to learn science is a complex phenomenon influenced by many factors including curriculum materials, teaching strategies and teachers, and individual student characteristics (Blumenfeld & Meece, 1988; Blumenfeld, Mergendoller, & Swarthout, 1987; Corno & Mandinach, 1983; Doyle, 1983; Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996). Lee and her colleagues have noted that engagement in science activities is a crucial indicator of student motivation. Task engagement in science learning relates to four factors representing cognitive as well as affective aspects of student engagement: (a) the student’s interpretation of classroom science tasks, (b) the student’s success or failure to progress in their scientific understanding, (c) student’s goal orientations
when learning science, and (d) student’s affective orientation (i.e., interests) toward science. Research related to interpretation of classroom tasks, goal orientation, and interests toward science is presented below.

Students’ interpretations of classroom science tasks. Peerson, Swing, Stark, and Waas (1984) conducted research on classroom learning and motivation related to student task interpretation. The study participants were high and low achieving students in elementary mathematics classrooms. Significant differences were found between high and low achieving students. The high achieving students tended to report the names of key concepts or describe the main concepts in a lesson. On the other hand, research conducted by Anderson et al., (1985) found no differences between high and low achievers in first grade students. These students seldom demonstrated evidence of understanding of content-related purposes for assignments. In addition, no student consistently explained assignments in terms of scientific context. In contrast, Blumenfeld and Meece (1988) found that even though students in elementary school science were mainly concerned with the products and procedures of learning science, most had some understandings of the content of the lesson when they were specifically asked.
Task difficulty is another aspect of student interpretation of classroom tasks. Task difficulty is the difficulty inherent in the task itself or as a difficulty experienced by individual students (Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996). Criteria such as Bloom’s taxonomy, Gagne’s learning hierarchy, or Doyle’s types of academic tasks have been used to evaluate task difficulty criteria. Findings from these studies noted that task difficulty experienced by students were crucial, even more crucial than object task difficulty (Anderson et. al., 1985; Lee, 1989; Lee & Andersos, 1993; Lee & Brophy, 1996; Peterson & Swing, 1982; Peterson, Swing, Stark, & Waas, 1984; Rohrkeper & Bershon, 1984).

Dweck and her colleagues distinguish the helplessness motivational pattern from the mastery-oriented pattern in achievement situation (Dienier & Dweck, 1978; Dweck, 1986; Dweck & Elliot, 1983; Elliot & Dweck, 1988). Children were identified as mastery oriented or as learned helplessness based on factors beyond their control. The learned helplessness model assumes that an individual searches for causal explanation of events such as school failure, personal problem with friends, and poor health that affect his or her behavior such as passivity, anxiety, and depression (Peterson et al., 1993). Dweck and her colleagues noted that in the face of difficulty,
helpless-oriented students avoided challenge and lacked persistence. However, mastery-oriented students looked for challenge and demonstrated high, effective persistence. This finding suggests that these two groups of students pursued different goals in similar instructional situations. Helpless students looked to gain competence or avoid negative judgements, while the mastery students sought to improve or develop their competence. Thus, interpretation of the nature of a classroom task by a student is related to his or her goals and strategies during specific task engagement, differentiating those students who are motivated to learn for conceptual understanding from those who are not.

**Students' goal orientations in learning science.** The relationship of goal orientation in learning science to student engagement in classroom learning has been reported by Blumenfeld and Meece (1988), Dweck (1986), Dweck and Elliot (1983), Eccles (1983), Elliot and Dweck (1988), Lee (1989), Lee and Anderson (1993), Lee and Brophy (1996), Maehr (1984), Meece and Blumenfeld (1987), Wentzel (1987, 1988). Goals can be identified in terms of a general orientation as well as situation specific (Brophy, 1987). Student goals change from one situation to another. Dweck and her colleagues (Dweck, 1985, 1986, Dweck & Elliot, 1983; Elliot &
Dweck, 1988) noted two types of general goals in achievement situations:
(a) learning goal and (b) performance goal. Learning goals are also labeled
as a mastery goal orientation. If a student adopts a mastery goal orientation,
then he or she should focus on learning, mastering the task, developing new
skills, improving his or her competence, trying to accomplish something
challenging, and trying to gain understanding or insight. Performance goals,
on the other hand, represent a focus on relative ability and how that ability
will be judged such as attempting to best another student's performance, and
seeking public recognition for this performance level (Ames, 1992).

Although general goals can be extensive, these goals are not
appropriate instruments for understanding specific goals in classroom
settings (Lee, 1989; Wegner & Vallacher, 1986). For instance, Wentzel
(1987) identified as many as 12 student goals in classroom settings. These
goals included: (1) successful student, (2) earn approval, (3) have fun, (4)
better than others, (5) get others to help, (6) responsibility, (7) make friends,
(8) be helpful, (9) learn new things, (10) understand things, (11) do your
best, and (12) things done on time. General goals also can not identify
specific aspects of classroom learning. For instance, learning as a goal has
different meanings to different students, like increasing vocabulary,
memorizing facts, understanding contents, or applying knowledge to the daily life. Thus, understanding of student goals in science learning is crucial in order to gain a better understanding of achievement across specific situation and over time.

In sum, research on student motivation suggests that students possess multiple goals in academic learning situations. These goals are influenced by external factors, including the expectations of parents and teachers or student experiences during instruction.

**Students' interests toward science.** Student interest is usually proposed as an important aspect of student's motivation. Student interest influences attention, learning, thinking, and performance. It is usually assumed to be directed toward some specific activity or topic such as an interest in sports, science, music, dance, or computers (Krapp, Hidi, & Renninger, 1992; Schiefele, Krapp, & Winteler, 1992; Schiefele, 1991, 1996). Schiefele (1991, 1996) describes personal interest as a strong indicator of a deep level of learning. Personal interest include recall of main ideas, coherence of recall, responding to deeper comprehension questions, and representation of meaning that are crucial to a student's learning for understanding.
Student's interests toward science are generally used to determine affective orientations, including a liking for, an interest in, and an enjoyment of science. Theoretical and empirical evidence suggest that the relationship between affective orientations and task engagement might not be systematic (Brophy, 1983, 1987; Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996). Student motivation to learn is also focused on cognitive aspects of motivation, not just affective aspects (Brophy, 1983, 1987). Brophy (1987) states: "Whether or not they [students] find a particular task interesting or enjoyable, students who are motivated to learn strive to understand content or master skills" (p. 192). This implies that motivation to learn science is not directly related to attitudes or interests. For instance, students who like and enjoy science might not be motivated to learn science, however, students who do not like or enjoy science might be motivated to learn science.

Section II: Methodological Literature:

Quality of Student's Task Engagement in Learning

The quality of student task engagement in classroom activities is an appropriate tool for assessing student motivation during learning (Brophy, 1983; Brophy, Roshkemper, Rashid, & Goldberger, 1983; Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996). Practically, there are two approaches
that are commonly used to assess the quality of student engagement in classroom tasks: a student's behavioral responses, and a student's cognitive processes.

Brophy, Rorhkmper, Rashid, and Goldberger (1983), Carr and Evans (1981), Lee (1989), Lee and Anderson (1993), Lee and Brophy (1996), and Tobin (1986) measured student motivation in classroom settings by observing behavioral responses during task engagement. The most commonly measured behavior used in their research was time-on-task during class activities. Specific indicators of motivated behavior they observed included: involvement in classroom activities and the interaction of the student with instructional materials, peers, non-task stimuli, and interaction with the teacher. The procedures for collecting data involved time-sampling techniques—the observer attending to one student for a certain time period, recording characteristics of behaviors of interest on a coding sheet, and then moving to another student in an orderly manner.

Borg (1980) in his review of student motivational behavior indicated that the approach described above could be defended for several reasons: Methodologically, the measuring approaches are reliable. Data analysis is generally straightforward during individualized observation or interviews.
Theoretically, the observation measures of task engagement generally seems to be significantly related to motivated behavior and to more precise measures of student’s engagement in classroom tasks.

In spite of such advantages, many researchers question the validity of behavioral measurement methods. The main criticism is that behavioral observations only provide a gross, crude measure of task engagement. Critics of this method argue that cognitive processes are appropriate for assessing task engagement because, although students may appear to be involved in classroom tasks, the possibility of not being cognitively engaged in a task is hard to observe. Thus, the quality of cognitive processes can distinguish between students who are engaged in classroom tasks from those who are not (Anderson, 1981; Anderson, Brubaker, Alleman-Brooks, & Duffy, 1985; Blumenfeld & Meece, 1988; Corno & Mandinach, 1983; Doyle, 1979, 1983; Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996; Peterson & Swing, 1982; Peterson, Swing, Braveman, & Buss, 1982; Tobin, 1986; Wittrock, 1987).

Furthermore, Brophy (1987) specifically pointed out that “measures of student motivation to learn must reflect the quality of student engagement in academic activity” (p. 183). “Especially, it is the quality of students’
cognitive engagement in activity—the degree to which they approach the activity purposefully and respond to it thoughtfully” (Brophy & Merrick, 1987, p. 11). In addition, they explained that as goals and strategies are inseparable in academic tasks, the quality of students' cognitive engagement indicates conceptual change learning strategies during student's task engagement.

Based on a review of the relevant literature indicated above, the data collection methods for this study are a combination of observation, student interview and self-reports. This combination of data sources and collection methods provides a rich source of data regarding student's motivated behavior to learn for conceptual understanding.

**Measures of Student Motivation in Learning Science**

Throughout this study, student task engagement is used as the main indicator for assessing motivation to learn science. It is assumed that if a student is motivated to learn science he or she will exhibit a high quality of task engagement in order to learn a particular science concept. Lee (1989), Lee and Anderson (1993), and Lee and Brophy (1996) describe two specific indicators of learning for scientific understanding. First, students try to integrate their personal knowledge with scientific knowledge. In this case,
students are cognitively engaged in the process of gaining and understanding new science conceptions (intelligible and plausible). Second, students implement the scientific knowledge that they have for describing, explaining, predicting and controlling phenomena in the world around them (fruitful). In this case, students are behaviorally and cognitively engaged as they participate in classroom activities.

Students who are not motivated to learn science show a lower quality of task engagement in classroom activities. The indications of students who have low quality of task engagement in learning science are characterized by (1) engaging in classroom science tasks with alternative goals like memorizing vocabulary words or facts, merely completing assignments, or sometimes avoiding the work (Anderson & Roth, 1989; Blumenfeld & Meece, 1988; Tobin & Gallagher, 1987), and (2) choosing strategies that reduce the risk of failure and expenditure of effort like mindlessly answering questions, copying others’ answers, not realizing their conceptions, rote memorizing of facts, maintaining their misconceptions, or distorting scientific knowledge in order to fit to their misconceptions (Chinn & Brewer, 1998).
Other studies conducted by Anderson and Roth (1989), Anderman and Young (1994), Lee (1989), and Roth (1985) found that students who engage in a high quality of classroom task engagement show that they also use a higher quality of strategies for learning. For instance, while reading science textbooks, these students integrate personal knowledge with disciplinary knowledge, using disciplinary knowledge to explain real-world problems. Thus, these students exhibit goals of learning associated with scientific understanding, while others appear to have alternative goals, perhaps related to reading the text.

Finally, it can be summarized that student motivation in learning science can be measured by (1) the quality of student’s task engagement, as measured by behavioral and cognitive task engagement, (2) indicating his or her choice of goals, and (3) his or her choice of strategies during task engagement. High quality of task engagement is the indication of motivated behavior in learning for scientific understanding that is characterized by (1) integrating his or her personal knowledge with scientific knowledge and (2) applying scientific knowledge to describe, explain, predict and control the phenomena found in his or her immediate environment.
1. **Anomalies.** The characters of the specific failures of a given idea are an important part of the ecology, which selects its successor.

2. **Analogies and metaphors.** These can serve to suggest new ideas and to make them understandable.

3. **Exemplars and images.** Prototypical examples, thought experiments, imagined or artificially simulated objects, and processes all influence a person’s intuitive sense of what is reasonable.

4. **Past experiences.** Conceptions, which appear to contradict one’s past experiences, are unlikely to be accepted.

5. **Epistemological commitments.**
   a. **Explanatory ideals.** Most fields have some subject matter specific views concerning what counts as a successful explanation in the field.
   b. **General views about the character of knowledge.** Some standards for successful knowledge such as elegance, economy, parsimony, and not being excessively ad hoc seem subject matter neutral.

6. **Metaphysical beliefs and concepts.**
   a. **Metaphysical beliefs about science.** Beliefs concerning the extent of orderliness, symmetry, or non-randomness of the universe are often important in scientific work and can result in epistemological views which, in turn, can select or reject particular kinds of explanations. Beliefs about the relations between science and commonplace experiences are also important here.
   b. **Metaphysical concepts of science.** Particular specific conceptions often have a metaphysical quality in that they are beliefs about the

Figure 2.1: Component of conceptual ecology (Strike & Posner, 1985, pp.216-217)
ultimate nature of the universe and are immune from direct empirical refutation. A belief in absolute space or time is an example.

7. Other knowledge.

a. Knowledge in other fields. New ideas must be compatible with other things people believe to be true.

b. Competing conceptions. One condition for the selection of a new conception is that it should appear to have more promise that its competitors.
CHAPTER 3

METHODOLOGY

Introduction

This study is a descriptive case study that examined three research questions: 1) What instructional strategies did the teacher use to both promote students' learning for conceptual change and increase their motivation in learning science? 2) What are the patterns of students’ motivation to engage in conceptual change learning of science? 3) What individual profiles can be constructed from the four motivation factors (i.e., goals, values, self-efficacy, and control beliefs) for the eleven student participants in this study, and how are these profiles linked to their engagement (i.e., behavioral and cognitive engagement) in conceptual change learning of science? The sections of this chapter are arranged in the following order: school profile, data collection methods, and data analysis procedures.
School Profile

In this section, a profile of the school in which the study was conducted is presented. Information that characterizes the school was obtained from the school public relations office and the teacher. The section that follows includes descriptions of characteristics of the greater school community, and characteristics of the physics classroom selected for the study.

Characteristics of the School Community

This study was conducted in a private senior high school calculus-based physics class of a private four-year high school located in the greater Columbus, Ohio, metropolitan area. Data gathered by the school public relations office indicated that the total numbers of students for the 1997-1998 school year in all four grades was 890. Of these students, 85% were catholic and 15% were other religions. The student population consisted of 86% Caucasian, 7% African American, 2% Spanish-American, 2% Asian American, 1% Native-American, and 2% other. Students came to this school from nearby public, private, and suburban school districts. In general, most students came from middle class families. A majority of the parents of these students were college-educated business or professional people.
Sixty certificated professional teachers who have an average of thirteen years of teaching experience staff the school. Fifty percent hold advanced degrees. The school provides a number of special programs for college-bound students such as: accelerated programs in English, math, and science; advanced placement tests for college credit; tutoria service provided by National Honor Society students on campus; special programs in industrial technology; computer programming, work study, reading and learning skills, and vocational education in conjunction with local public schools; and the opportunity for all students to have their compositions or papers for any classes reviewed in the Writing Center and the Early English Composition Assessment Program (EECAP) sponsored in conjunction with a local university.

High school graduation requires a minimum of 22 credits including 4 credits of English, 3 credits of Mathematics, 1 credit of Health/Physical Education, 2 credits of Science (1 credit of Biology/1 credit of science elective), 3 credits of Social Studies (1 credit of world history or world geography, 1 credit of American history, 1/2 credit of government, 1 credit of senior elective), 1 credit of Visual or Performing Arts, 4 credits of Theology, and 4 credits of electives. As a part of these requirements, the
high school requires two yearlong courses in science. In addition to Biology, the courses could include a freshman science course, advanced biology, advanced chemistry, or calculus-based physics.

The graduating class of 1997 included 193 students with an average GPA of 3.026 (see Table 3.1). Of the students in this class 82% completed the ACT test, and 33% of the class completed the SAT test. Results of the ACT test showed that, for the students who took this test, the average was 22.1. This composite ACT average is above the average for students in the State of Ohio (21.3) and the National average of 20.9.

<table>
<thead>
<tr>
<th></th>
<th>Top Third</th>
<th>Middle Third</th>
<th>Lower Third</th>
<th>Total Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>64</td>
<td>64</td>
<td>65</td>
<td>193</td>
</tr>
<tr>
<td>GPA</td>
<td>3.835</td>
<td>3.004</td>
<td>2.212</td>
<td>3.026</td>
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<table>
<thead>
<tr>
<th></th>
<th>School Average</th>
<th>Ohio Average</th>
<th>National Average</th>
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<tr>
<td>ACT Composite:</td>
<td>22.1</td>
<td>21.3</td>
<td>20.9</td>
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<tr>
<td>SAT:</td>
<td></td>
<td></td>
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<tr>
<td>Verbal</td>
<td>546.40</td>
<td>535</td>
<td>505</td>
</tr>
<tr>
<td>Math</td>
<td>522.80</td>
<td>536</td>
<td>511</td>
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</tbody>
</table>

Table 3.1: Academic achievement for the class of 1997
Students who graduate from this school generally continue their education in college as indicated in the profile for students graduating in 1997 (see Table 3.2).

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>Students planning to further education</td>
<td>90%</td>
</tr>
<tr>
<td>Students planning to enter full-time job market</td>
<td>5%</td>
</tr>
<tr>
<td>Students planning to enter military</td>
<td>4%</td>
</tr>
<tr>
<td>Other/undecided</td>
<td>1%</td>
</tr>
</tbody>
</table>

Table 3.2: Future plans, graduating class of 1997

Of the total number of graduating students in 1997, 80% (154 senior students) planned to attend post secondary education. Of those planning to attend college, 79% selected 4-year colleges, 18% 2-year colleges, and 3% special schools for training (see Table 3.3).

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Students planning to attend 4-year colleges</td>
<td>79%</td>
</tr>
<tr>
<td>Students planning to attend 2-year colleges</td>
<td>18%</td>
</tr>
<tr>
<td>Students planning to attend special school for training</td>
<td>3%</td>
</tr>
</tbody>
</table>

Table 3.3: College-bound students plans.
Characteristics of Study Setting

The senior physics class selected for this study was taught using a conceptual change approach to teaching and learning. The criteria for selecting the classroom/teacher were based on Hewson and Hewson's (1988) description of instructional strategies that are consistent with teaching and learning for conceptual change (see pp. 32-33).

Two specific procedures were used to identify a teacher that met Hewson and Hewson's (1988) criteria: information from my adviser and direct observation of the teacher. Information regarding teachers who use conceptual change teaching strategies in science came primarily from my adviser who had been conducting collaborative research with these science teachers. Direct observation of the teaching-learning activities presented by this teacher was conducted to determine if the features of the instructional strategies that she used were consistent with the features outlined by Hewson and Hewson (1988). The decision to select a teacher for this research was made in light of how closely his or her instructional strategies matched to these criteria. Based on these criteria, Mrs. Karen Scott was selected for this study.
The study was conducted for nine week (42 days) during the 1997-1998 school year in the classroom of Mrs. Scott. She is an outstanding science teacher as indicated by her selection as a recipient of the 1998 Presidential Award for Excellence in Mathematics and Science Teaching. She is an experienced science teacher with more than thirteen years of classroom teaching experience. Her preferred methods of instruction parallel those described by Hewson and Hewson (1988) for implementing the conceptual change teaching model.

The class of eleven students, selected at the recommendation of Mrs. Scott, was a third period calculus-based physics class, two males and nine females. All students in this class agreed in writing to participate in the study as did their parent (a copy of the student/parent agreement form is included in Appendix A).

All of the study participants were seniors in high school, ranging in age from 17-18 years old. Ten of these students were from English speaking families and one was from a Spanish speaking family. Students in the class ranged in the class rank from 4 to 55 out of 179 students in the class of 1998 with cumulative grade point averages (GPA) ranging from 3.7664-4.1000 on a scale of 4.00. A GPA higher than 4.00 reflects bonus points for completion
of advanced courses such as Algebra III, Pre-calculus, Calculus, College Writing, Foreign Language IV-V, Latin IIIAP, Justice and Law, Advance Biology, Advanced Chemistry, and Calculus-Based Physics. Most of these students planned to continue their education after high school in a science or mathematics related field such as engineering, medicine or science teaching.

The curriculum covered during the period of this study was circular motion including various aspects of impetus and force. The topic of impetus includes general impetus, circular impetus, loss/recovery of original impetus, and impetus dissipation. The topics of force include the dominance principle, force compromise, centrifugal force, outward radial force, and centripetal force. According to the teacher, both of these physics topics were chosen to prepare these students for college-level physics.

Data Collection Methods

Two issues regarding the collection of data are discussed here. First, a general overview of data collection methods is given. Second, specific data collection procedures that were used to gain information related to each research question are described.
General Overview of Data Collection Methods

In this study the relationships between motivational factors and conceptual change learning are analyzed. To do this, various kinds of data were collected with the approval of the Human Subject Review Board (see Appendix B). The sources of data for this study included classroom observation, interviews (structured interviews), and a self-report questionnaire (MSLQ). A seven-point Forced Choice Likert Scale was used throughout the MSLQ. The scale ranges from (1) not at all true of me to (7) very true of me (see Appendix C).

Direct observation of teaching strategies and student’s behavioral engagement in learning science were conducted for nine weeks (42 days). These observations resulted in information about (1) the sequence of events that the teacher presented to students, the strategies she used, and the materials presented during science lesson (2) students’ responses to the teacher instruction, (3) instances when motivational behaviors were present. My participation in the classroom included helping the teacher to set up the class physically, ask questions of students, and taking part in some student activities (e.g., laboratory activities). The teacher’s directions related to participation of the researcher were honored, and these directions formed the
boundaries of my involvement in her classroom. Field notes were also collected during my participation in the classroom. Field notes focused on behavioral indices of motivation (i.e., effort and persistence), sequences of events that the teacher presented to students, strategies that the teacher uses and materials she offered including students’ responses to the teaching-learning process.

According to Bogdan and Biklen (1992) interviews “are used to gather descriptive data in the subjects’ own words so that the researcher can develop insights on how subjects interpret some piece of the world” (p. 96). In this study, interviews followed a structured format. Each interview was conducted individually and focused on: (1) obtaining additional information on motivational factors that was not elicited through the self-report questionnaire (i.e., student’s specific goals orientation of learning science), and (2) validating initial findings that resulted from self-reports and observations.

I interviewed students once a week during the study with each interview lasting between 15 minutes and half an hour. Because English is the second language for the researcher, I used a structured interview protocol (see Appendix E) where the students answered interview questions in
writing or on audiotape.

Videotape recordings were made in the classroom each day. The video camera was used to record classroom interactions (behavioral engagement) of students with other students and students with the teacher during science class. Sixteen of 120-minute videocassettes were collected during the study. These videocassettes were used to review daily classroom activities and to complement information recorded in daily field notes.

Relationships between Data and Research Questions

Specifically, data sources related to each research questions follow:

1. Instructional strategies and student motivation patterns to engage in learning science

The documentation of instructional strategies that the teacher used to encourage student learning and motivation, and the impacts of these strategies on student learn of science came from direct observation and student interviews. The observer kept descriptions of instructional events and science content and noted which teaching strategies seemed to be effective for inviting students to learn. Included in these strategies were students' reactions to the teacher, and what the impacts of these strategies were on students. After each observation, the observer completed the day's field notes and briefly summarized the selected participant's responses for
that day. Finally, data to answer the question about students' motivational patterns to engage in conceptual change learning mainly came from classroom observations, field notes, videotape recordings of daily classroom activities, students' self reports, and interviews of students and the teacher.

2. Student's motivational factors profiles

Data to answer the question about student motivational factors came from the response of the MSLQ from all eleven students in the study. On the MSLQ, students rated themselves on a seven point Likert scale from (1) not at all true of me to (7) very true of me. In scoring the MSLQ, scores were calculated by taking the mean of the items that make up the scale. For example, intrinsic goal orientation was evaluated by four items (e.g., items no. 1, 13, 18, and 20) and taking the average.

The score for each motivational factor (i.e., goals, values, self-efficacy, and control beliefs) was summed to create a profile for each student. The link between these profiles of student motivation and student's engagement (i.e., cognitive and behavioral engagement) in conceptual change learning of science are presented in Chapter Four.

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a) Goal orientation

Goal orientation refers to the student’s perception of the reasons why he or she is engaging in a learning task. On the MSLQ, goal orientation refers to general goals or orientations to the course as a whole. There are two goal orientations assessed through the student’s self-report questionnaire:

(1) Intrinsic goal orientation and (2) Extrinsic goal orientation.

Intrinsic goal orientation concerns the degree to which the student perceives himself or herself to participate in a task for reasons such as challenge, curiosity, and mastery (Pintrich et al., 1991). The specific MSLQ items that address intrinsic goal orientation are as follows:

Item (1) In a class like this, I prefer course material that really challenges me so I can learn new things.

Item (13) In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.

Item (18) The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.

Item (20) When I have the opportunity in this class, I choose course assignments that I can learn from even if they don’t guarantee a good grade.

Extrinsic goal orientation, on the other hand, complements intrinsic goal orientation and refers to the degree to which the student perceives himself or herself to participate in a task for reasons such as grades, rewards,
performance, evaluation by others, and completion of tasks (Pintrich et al., 1991). The MSLQ items that address extrinsic goal orientation include:

Item (6) getting a good grade in this class is the most satisfying thing for me right now

Item (9) the most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade

Item (11) if I can, I want to get better grades in this class than most of the other students

Item (25) I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.

b) Task value

Task value refers to the student’s evaluation of how interesting, how important, and how useful a task is (“what do I think of the task?”). The MSLQ items that address task value are:

Item (3) I think I will be able to use what I learn in this course in other courses

Item (8) it is important for me to learn the course material in this class

Item (14) I am very interested in the content area of this course

Item (19) I think the course material in this class is useful for me to learn

Item (22) I like the subject matter of this course

Item (23) understanding the subject matter of this course is very important to me.
c) Self-efficacy

Self-efficacy is an appraisal of one's ability to master a task. It includes judgements about one's ability to accomplish a task as well as one's confidence to perform that task (Pintrich et al., 1991). The items that address self-efficacy on the MSLQ are:

Item (4) I believe I will receive an excellent grade in this class

Item (5) I'm certain I can understand the most difficult material presented in the readings for this course

Item (10) I'm confident I can understand the basic concepts taught in this course

Item (12) I'm confident I can understand the most complex material presented by the instructor in this course

Item (16) I'm confident I can do excellent job on the assignments and tests in this course

Item (17) I expect to do well in this class

Item (24) I'm certain I can master the skills being taught in this class

Item (26) considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.

d) Control beliefs

Control beliefs of learning refer to students' beliefs that their efforts to learn will result in positive outcomes. If students believe that the efforts of study can make a difference in their learning, they should be more likely to
study more strategically and effectively (Pintrich et al., 1991). That is, if a student feels that he or she can control their academic performance, he or she is more likely to put forth what is needed strategically to affect the desired changes. Items that address student's control of learning beliefs from the self-report questionnaire are:

*Item (2)* if I study in appropriate ways, then I will be able to learn the material in this course

*Item (7)* it is my own fault if I don't learn the material in this course

*Item (15)* if I try hard enough, then I will understand the course material

*Item (21)* if I don't understand the course material, it is because I didn't try hard enough.

3). *Links between profiles of student motivational factors and student learning processes*

Data regarding how student motivational factor profiles are linked to student task engagement came from classroom observation and interviews. Observation was focused on observable behaviors of students during the learning process including task engagement, persistence, interest, and effort. Interviews focused on obtaining information about a student’s motivational factors that were not elicited through the self-report questionnaire (i.e., student specific goal orientations in learning science), student’s cognitive engagement in learning science, student’s interest and effort. The
instruments for recording observations and interviews developed by Lee (1989) were adapted for this study (see Appendix D).

Classroom observation and formal conversations with participants provided data about student's engagement in learning tasks. Classroom observations were focused on the students' level of engagement in the activities of each science lesson (i.e., classroom discussion, problem solving, and hands-on experiments). During classroom observations, the observer recorded information focused on one student each day. In addition, specific behaviors of other students were also recorded. To produce a complete data set across all student participants, an observation schedule was developed. Every student was observed three times during the study for a total of 150 minutes (see Figure 3.1).

In order to examine the quality of task engagement, two aspects of a student's engagement were noted: behavioral engagement and cognitive engagement. The indicators of behavioral engagement included: (a) on-or-off task behavior (persistence), (b) completion of assigned tasks, (c) completion of task, (d) reactions to teacher's instructional strategies, distraction from classmates, and (e) frequency of participation and during whole classroom activities.
<table>
<thead>
<tr>
<th>Students</th>
<th>The Days of Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISTI</td>
<td>6th 17th 28th</td>
</tr>
<tr>
<td>NOVY</td>
<td>7th 18th 29th</td>
</tr>
<tr>
<td>RINA</td>
<td>8th 19th 30th</td>
</tr>
<tr>
<td>DEWI</td>
<td>9th 20th 31st</td>
</tr>
<tr>
<td>RUDY</td>
<td>10th 21st 32nd</td>
</tr>
<tr>
<td>NUR</td>
<td>11th 22nd 33rd</td>
</tr>
<tr>
<td>ELLA</td>
<td>12th 23rd 34th</td>
</tr>
<tr>
<td>FANY</td>
<td>13th 24th 35th</td>
</tr>
<tr>
<td>RINI</td>
<td>14th 25th 36th</td>
</tr>
<tr>
<td>RIVA</td>
<td>15th 26th 37th</td>
</tr>
<tr>
<td>ASRJ</td>
<td>16th 27th 38th</td>
</tr>
</tbody>
</table>

Figure 3.1: Classroom Observation Schedule

Informal conversations during science activities and structured interviews were used to obtain data concerning student interpretation of the science tasks. Questions posed by the researcher revolved around the content objectives of the science lesson. For instance, the researcher asked student participants if they understood the content objectives (see Appendix E). The researcher provided no feedback to student participants even though their answers may have been inaccurate. Next, the researcher asked the student if they experienced difficulty with the science tasks, and continued by asking why they felt it was or was not difficult.
Structured interviews were conducted to obtain information related to students' attitudes and interests toward science. The interview focused on participants' general affective orientation toward science with questions such as likes or dislikes, interest and curiosity. Each question was followed by "why" questions (see Appendix E).

**Data Analysis Procedures**

Data analysis procedures are presented in this section. The data analysis procedures are intended to summarize information related to the research questions. The data analysis approaches used in this study included three general steps: (a) analysis based on the researcher's intuitive reasoning from a complete reading of the data, (b) analysis using a rating or frequency count, and (c) developing case studies. These three steps of data analysis took more than one cycle (i.e., revision) to produce the final case study presented in Chapter Four.

The first step in analyzing the data was based on the researcher's reading of the entire data set. This reading included data from students' responses to the MSLQ, classroom observations, and structured interviews. By reading the data thoroughly, the researcher became familiar with the general features of student motivation to engage in conceptual change.
learning in science.

The second step in the data analysis process was analysis of data using a rating or frequency count. In this step student motivational profiles based on MSLQ scores were calculated. Systematic analyses of MSLQ data were made using frequency counts in order to classify students based on their response to the four sub scales of the MSLQ.

In analyzing data related to student engagement in learning activities, three key aspects of engagement were the focus of analysis. These three key aspects included (a) self-initiated cognitive engagement, (b) cognitive engagement, and (c) behavioral engagement in science classroom activities. The followings are summary definitions taken from Lee (1989) and Lee and Anderson’s (1993) that describe three key aspects of students’ engagement in science learning activities. Self-initiated cognitive engagement is present when a student explains his or her thinking or expresses his or her ideas that are not solicited by the teacher but reveal cognition going beyond lesson content. Cognitive engagement is present when a student actively constructs his own knowledge as he tries to integrate personal knowledge with scientific knowledge. Behavioral engagement is present when a student is attentive and involved in class activities, like listening to the teacher or other
classmates during class discussion, not talking to others inappropriately, and following the teachers directions.

Based on these key aspects, categories of student involvement in classroom science tasks were developed. The following coding system was developed to identify patterns of student's involvement in conceptual change learning in science. The coding system, which incorporates the key issues (frequently, sometimes or seldom existence) of task engagement, included three categories:

Category 1: (a) frequent self-initiated cognitive engagement
           (b) frequent cognitive engagement
           (c) frequent behavioral engagement

Category 2: (a) some self-initiated cognitive engagement
           (b) frequent cognitive engagement
           (c) frequent behavioral engagement

Category 3: (a) little or no self-initiated cognitive engagement
           (b) some cognitive engagement
           (c) frequent behavioral engagement

The final step in the data analyses procedures was to develop the case studies. Development of the case studies specified links between student motivational factor profiles (motivation) and student engagement (i.e., behavioral and cognitive engagement) in conceptual change learning in science.

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CHAPTER 4

ANALYSIS OF DATA

Introduction

This chapter includes an analysis of data used to answer the research questions in the study. The research questions are related to: 1) instructional strategies the teacher used to both promote students’ learning for conceptual change and increase their motivation in learning science and 2) the patterns of students’ motivation to engage in conceptual change learning of science? To that end, the analysis of data collected during this study describes student motivational factor profiles and the links between these profiles and engagement in learning science for conceptual change.

Data analysis begins with an analysis of the teacher’s instruction and the impacts of that instruction on student learning with respect to question one: what instruction strategies did the teacher use to both promote students’ learning for conceptual change and increase their motivation in learning
science? The data selected to address this question are taken from summaries of field notes, structured interviews with students and the teacher (Mrs. Scott), and transcripts of discourse classroom activities. Following, a description of students’ motivational patterns to learn physics in Mrs. Scott’s class is presented by analyzing videotapes of classroom instruction, field notes, and student responses to the interview questions to support claims of research questions two: what are the patterns of the eleven students’ motivation to engage in conceptual change learning of science?

Second, an analysis of profiles constructed from the MSLQ’s four motivation factors (i.e., goals, values, self-efficacy, and control beliefs), and the links of these profiles to their engagement in the process of learning science for conceptual change are described. This analysis focused on student behavioral and cognitive engagement in learning science in order to address research question three: what individual profiles can be constructed from the MSLQ’s four motivation factors (i.e., goals, values, self-efficacy, and control beliefs) for the eleven student participants in this study and how are these profiles linked to their behavioral and cognitive engagement in conceptual change learning of science? Data selected to address this question are taken from student responses on the MSLQ, summaries of field
notes, structured interviews with students and the teacher (Mrs. Scott), and transcripts of discourse from classroom activities. Finally, a cross case analysis of all student profiles is presented.

**Description of Instruction**

The purpose of this section is to provide a description of data that can answer research question one: what instructional strategies did Mrs. Scott use to both promote students' learning for conceptual change and increase their motivation in learning science? This description begins with the sequence of instruction presented by Mrs. Scott and the students' responses (statements) to this instruction.

Mrs. Scott's instruction is generally consistent with the features of conceptual change teaching strategies outlined by Hewson and Hewson (1988). Based on my observation, her instruction generally followed a regular sequence of activities. She began instruction with bringing students to the learning situation by having them explore their intuitive understanding of significant conceptual ideas prior to presenting instruction that addressed further learning about a topic. Further Mrs. Scott, together with her students, developed ideas that were important to support the overall conceptions they were studying. During discussions, students were required to provide some
indications of the reasons underlying their ideas. Daily class activities were
dominated by classroom discussion, problem solving, and hands-on
experiment that allow students to express, comment and develop their ideas
for conceptual understanding. The following section is a description of
students’ responses to Mrs. Scott’s instructions that encouraged them to get
involved in the process of learning.

My goal of using conceptual change strategies is to gain insight of
what students’ current understanding on the concept is so that I know
what approach to take to my presentation of the concept. If I don’t
know what they are thinking, I won’t know to emphasize certain
aspects of the content.

By asking them to address their ideas about certain concepts, it makes
them aware of their current understanding. If their understanding
doesn’t coincide with the physicist’s [scientist’s] perspective, then a
conflict exists. From here they have to have situations that cause them
to feel comfortable in exchanging their current ideas with the
scientific ideas—so that in the end they adopt the correct idea. It is up
to me to provide situations that will help them to make change.

Further, Mrs. Scott explained her reasons for why it is important to
implement conceptual change teaching in her calculus-based physics class.

She explained that conceptual change instruction helps students learn for
understanding clearly in the following statement.

It is important for me to implement conceptual change teaching in my
class because I want the students to leave my class with the physicist’s
perspective. If I just lecture, then they will have a variety of ideas is
their own and what I have said. It is my feeling that once the test over,
they go back to their own original ideas and not adopt the scientific
perspective. I guess that through my own research (for my Masters)
and my continued research (from a monitoring and implementation standpoint—not written, though) I have seen students understanding greatly increase through the use of this strategy [conceptual change teaching strategy]. They talk about correct ideas for a much longer period of time—at least through the end of the year when I have to say goodbye! Seriously, whereas BEFORE they go through a conceptual change strategy, their talk about why things happen or what a particular concept is about is very much filled with misconceptions—
their current perspective.

AFTER conceptual change strategies are used they talk more from a physicist’s perspective. I begin the year with much emphasis on changing student’s ideas about speed, velocity, and acceleration. It is with velocity and acceleration that many misconceptions occur. Without them adopting a physicist’s perspective on these three ideas, the rest of mechanics won’t be analyzed properly. Same is true with the force section. Much conceptual change teaching and learning has to occur here to change the misconceptions about forces—especially what types of motion are produced by balanced versus unbalanced forces. These are the main topics.

Mrs. Scott’s success in implementing conceptual change instruction was evidenced by her students’ engagement both physically and mentally in learning activities and their ability to relate science concepts to everyday life. In daily classroom activities, Mrs. Scott applied a variety of teaching approaches that invited her students to learn for understanding. Among these approaches were helping each student learn by visiting his or her table, visualizing problems through videos, and creating a classroom environment conducive to learning (i.e. completing activities with physics-related toys, developing personal relationships with students, and relating physics
materials to daily or real life situations). Instruction in this class was meaningful to the students as indicated in the following statements.

Dewi: Mrs. Scott does a very good job of taking things in physics and explaining it in ways that we understand. She really knows how to relate to us and how to make physics fun and interesting.

Ella: Mrs. Scott is positive and energetic. She makes learning easy and fun. She encourages us to learn the information. When stuff gets hard, she does something fun to keep us positive by playing with toys or watching videos etc.

In another statement, Ella explains that she is taking this physics class because she likes Mrs. Scott’s teaching style.

Ella: Science has always been an interest of mine. I have taken a science class since 1st grade and enjoy them....I am taking physics because Mrs. Scott is teaching it and I enjoy her teaching style.

Mrs. Scott minimized factors that lead to trivial learning such as memorizing vocabulary and formulas. She encouraged students to think about what they already knew, why something happens, and how their ideas related to their daily lives. These instructional strategies engaged students mentally in learning for understanding.

Riva: Mrs. Scott is able to discuss both what happens and why this happens. She presents the formulas and other ideas in a simple manner. She also realizes why we have trouble with difficult ideas.
Rudy: I like Mrs. Scott's teaching because she makes you think about what you already know, and relates it to our lives. I learn a lot from her.

Isti: Mrs. Scott visually shows what she is talking about, which helps me to understand many of science concepts. She involves all of the class which makes me more interested in what we are learning. I like being involved in class discussions, because it helps me to remember things I have learned. Also, her obvious enthusiasm for teaching physics encourages me to learn as much as I can. The difficult ideas are taught exactly like the easy things are. So, I think this is encouraging because if she thinks I can learn it, then I am able to think I can, too.

Novy: Mrs. Scott's energy and creativity encourages me to learn and keep asking questions about physics concepts. No matter how difficult a concept is to grasp, Mrs. Scott will keep explaining it in as many way as she knows until you understand it. She will apply the concepts to many different actions and situations so it is easier to understand.

In daily teaching activities, Mrs. Scott frequently explained to the students that her teaching goal was to "help students learn to understand physics, not teach them physics". She highlighted this goal often because she believed that knowing how to learn physics was a crucial foundation for students to understand physics. Her daily teaching activities stressed central physics concepts. For instance, when presenting the topic of circular motion, Mrs. Scott began with the concept of motion and related it to daily, real life phenomena like a moving car, torque, and turning a door handle.
Teaching activities observed during this study included problem solving, student/teacher demonstrations, student presentations, hands-on experiments and the use of graphing calculators. In all of these activities, Mrs. Scott encouraged students to actively construct their own knowledge by implementing a variety of learning strategies, giving students opportunities to get involved in problem solving processes, and providing extensive supports for them. The teacher also reduced the demands of classroom tasks on students by clarifying the tasks or simplifying them into smaller steps. The following is Mrs. Scott’s statement concerning why it is important to implement a variety of teaching strategies in her instruction.

With regards to the implementation of certain teaching strategies, being involved with “The Private Universe” series at OSU made an extreme difference in the way I teach. That was just the beginning. After that, I took several of Dr. Beeth’s conceptual change teaching courses. That provided me the knowledge of what this is all about and why it is important. But the most major change came from my own research for my Masters thesis. It really wasn’t even what I was investigating (not my question for research), but how I interviewed these students before and after the lessons really showed me that this type of approach does make a difference. Since that time I have worked to improve this strategy. I have videotaped my lesson and just played them back for myself to analyze what students are saying before the lesson. Here is where I get the information from their talk and their writing.

I also believe in utilizing a variety of techniques. As you know, I am big on using the graphing calculator and associated equipment to explore relationship in variables from a math and science perspective. Yes, I will conduct the traditional labs, but I also like the creative labs of allowing the students the freedom to investigate a certain idea with
some given guidelines (like the circular-moving labs where they collected and analyzed data). This allows them freedom to make decisions.

One of the most important characteristics of Mrs. Scott's instruction is that she facilitates classroom dialogue by giving students a chance to discuss the problems. During this time students are encouraged to express and exchange their ideas. For instance, in daily class activities Mrs. Scott lets students brainstorm to stimulate questions that lead to the best answers and solutions for a problem. When doing so, she provides feedback to students that help them elaborate their conceptual understanding. The following student statements indicate how Mrs. Scott's instruction motivated some students to learn.

Rina: I think the best way she [Mrs. Scott] helps me learn and understand these new concepts are by her demonstration. She uses videos and toys and data collection tools to show us how things work. Mrs. Scott doesn't only tell us about new concepts, but she demonstrates them. She always asks "Why". Whenever we cover a new topic, Mrs. Scott does not only tell us about it but she makes us understand why it happens and she asks us why things happen. That way she can make sure we understand what we are learning and if we don't she doesn't stop helping us until we do. Another way Mrs. Scott helps me learn are by her enthusiasm. She gets so excited about things she is teaching that she makes me excited and I want to learn. Also she encourages us to learn the difficult ideas by never giving up on us until we understand. She will try anything to help us learn and understand any concepts we are having trouble with....She maximizes using all of
materials available to help us understand and she makes us think for ourselves.

Nur: Mrs. Scott uses a lot of examples or visual aids to help us learn new things. She also has us participate in these examples to help us visualize better what we are learning. She also has us figure out problems and experiments and have us start them on our own.

Ella: Mrs. Scott lets us come up with the answers ourselves and it is easier to understand things when we have worked through the problems ourselves—when we not only see how to do it and why but also why not.

From the statements above, it can be inferred that when facilitating classroom dialogue, students were encouraged to express and exchange their ideas. Discussions like these provided feedback to students so they could elaborate on their understanding. This teaching strategy motivated students to physically and mentally engage in the instructional activities. It is clear that Mrs. Scott tried to help students construct their own knowledge through active engagement, instead of presenting information directly to students in the form of lectures.

Patterns of Students’ Motivation to Learn

The purpose of this section is to provide data that can answer research question two: what are the patterns of students’ motivation to engage in conceptual change learning of science? The analysis of data presented here...
focuses on the description of motivational patterns of the eleven students in
the study. Three key aspects of student task engagement (self-initiated
cognitive engagement, cognitive engagement, and behavioral engagement)
were selected as the categories for determining patterns of student's
motivation to engage in learning science (Lee, 1989; Lee & Anderson, 1993;

In light of these three key aspects of student's task engagement, the
students participating in this study were grouped into three patterns. These
patterns included students who were (1) intrinsically motivated to learn, (2)
intrinsically motivated to learn, but not consistently engaged in learning each
day, and (3) extrinsically motivated to learn to fulfill a requirement (see
Table 4.2).

A detailed description of each pattern of task engagement is presented
in the following sections. The discussion focuses on issues of goals and
strategies during task engagement. Distinctive differences across patterns of
task engagement, including students' statements that support each
motivation pattern, are provided.
Table 4.1 is a summary of data related to student task engagement in learning science during the study (see Appendix H and I for the detail of frequency counts of these three key issues).

<table>
<thead>
<tr>
<th>Student</th>
<th>Self-initiated cognitive engagement</th>
<th>Cognitive engagement</th>
<th>Behavioral engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rudy</td>
<td>Frequently</td>
<td>Frequently</td>
<td>Frequently</td>
</tr>
<tr>
<td>Ella</td>
<td>Frequently</td>
<td>Frequently</td>
<td>Frequently</td>
</tr>
<tr>
<td>Novy</td>
<td>Frequently</td>
<td>Frequently</td>
<td>Frequently</td>
</tr>
<tr>
<td>Rini</td>
<td>Frequently</td>
<td>Frequently</td>
<td>Frequently</td>
</tr>
<tr>
<td>Asri</td>
<td>Frequently</td>
<td>Frequently</td>
<td>Frequently</td>
</tr>
<tr>
<td>Rina</td>
<td>Frequently</td>
<td>Frequently</td>
<td>Frequently</td>
</tr>
<tr>
<td>Isti</td>
<td>Sometimes</td>
<td>Frequently</td>
<td>Frequently</td>
</tr>
<tr>
<td>Fany</td>
<td>Sometimes</td>
<td>Frequently</td>
<td>Frequently</td>
</tr>
<tr>
<td>Riva</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Frequently</td>
</tr>
<tr>
<td>Nur</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Frequently</td>
</tr>
<tr>
<td>Demi</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Frequently</td>
</tr>
</tbody>
</table>

Table 4.1: Summary frequency of student initiated cognitive, cognitive, and behavioral engagement in classroom activities.

Note: Frequently = 16 or more occurrences over 42 lessons
Sometimes = 6-15 occurrences over 42 lessons
Seldom = less than 5 occurrences over 42 lessons
Intrinsically Motivated to Learn.

Six students (Rina, Asri, Novy, Rini, Ella, and Rudy) showed patterns of motivation in this category. This group of students demonstrated self-initiated cognitive engagement in most activities such as classroom discussions, problem solving and hands-on experiments, without solicitation by the teacher. They got involved in learning primarily because they wanted to learn. For instance, the following statement from one student belonging to this group illustrates why she wanted to learn physics.

Asri: I also do the work in physics because I need to. I need to do it so that I can understand the material. I can’t understand the math or [physics] concepts if I don’t. If I don’t do the work, the class would be pointless.

Further, she explained that her involvement in learning physics was because she enjoyed the subject and it related to her everyday life.

Asri: I study physics because it explains our everyday life. It explains why things in the world are the way they are. I study it because I enjoy it and because I understand it. I like physics because it is logical thinking, and that’s how my brain functions!

Personal interest toward science is an important feature for students in this category. Other students placed in this category explained that their motivation to learn science was intrinsic as well. All students in this category became involved in classroom activities because the activities
themselves were enjoyable and this motivated them to learn for conceptual understanding.

This group of students was also characterized by expanding their thinking beyond the content of the material being taught. Consistently they applied their knowledge to daily life and tried to integrate their personal knowledge with the physics concepts they were taught. In other words, they actively constructed their own knowledge based on experiences in Mrs. Scott's classroom and their existing knowledge as indicated the following statement:

Ella: It seems to me that everything has physics in it and I can't do anything anymore without thinking about the physics behind it. Science makes the world go round, or at least helps us explain it. All this stuff was around a long time ago, but as we progress, so does science and technology. Now we try to understand and explain why things behave as they do.

During classroom activities, students in this category generally dominated conversations. Their frequency of involvement in asking questions, giving ideas, and volunteering for hands-on experiments exceed that of their peers (see Appendix H). Furthermore, these students indicated their involvement in learning strategies that occurred outside of class time in study parties, group discussions, or after class discussion with the teacher. Thus, their attempts to construct knowledge by relating and integrating their
knowledge with experience from real life are features of their engagement in learning.

**Intrinsically Motivated to Learn, not Consistently Engaged.**

The second category describes a group of students who demonstrated self-initiated cognitive engagement in a number of class activities, but not all. This group of students (Isti and Fany) was sometimes difficult to distinguish from the previous group. Their inconsistency in engagement during some tasks became the distinguishing feature. They were generally successful in integrating their personal knowledge with scientific knowledge, and they applied this knowledge to explain phenomena found in everyday life. However, in some instances they did not actively participate in class activities and exhibited behavior such as drawing pictures, engaging in social conversation with other students, or laying their head on the table. For instance, Fany, one of students belongs to this group said: "...only when it is fun do I like to study physics".

Another feature of students belonging to this category is that while they did demonstrate cognitive engagement in classroom activities, their ideas were limited only to the content or material being taught. Questions that they asked generally revolved around definitions or clarifications of an
assigned problem. A difference between this group and the first is that this group of students sometimes did not demonstrate any ideas or thinking beyond the immediate content of what was taught. Generally, they only became involved in classroom activities if the content presented was unclear to them.

**Extrinsically Motivated to Learn to Fulfill Requirement.**

The third category includes those students who were motivated only to fulfill a science requirement. Three students (Nur, Dewi, and Riva) were identified as belonging to this group. Comments from these students were mostly limited to the material being taught and the teacher actively solicited their thinking and ideas by calling on them during class. While they did become involved in class activities, their involvement in asking questions, giving ideas, and voluntarily answering questions was not as frequent as students in the first or second categories (see Appendix H).

The most important feature of this group of students is that they got involved in class activities because the course was needed to complete a school requirement. For instance, the following is a statement from one of students belong to this group:

**Dewi:** I study physics because it is a required course to take in order to graduate here at [the school]. If it wasn’t required, I probably would not be taking it.
The following table summarizes student motivation patterns to learn physics that shows these patterns of students’ motivation in relation to the three categories of student engagement.

<table>
<thead>
<tr>
<th>Motivation Patterns</th>
<th>Student</th>
<th>Key aspects of student’s engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Self-initiated cognitive engagement</td>
</tr>
<tr>
<td>Intrinsically motivated to learn</td>
<td>Rina</td>
<td>frequently</td>
</tr>
<tr>
<td></td>
<td>Asri</td>
<td>frequently</td>
</tr>
<tr>
<td></td>
<td>Novy</td>
<td>frequently</td>
</tr>
<tr>
<td></td>
<td>Rini</td>
<td>frequently</td>
</tr>
<tr>
<td></td>
<td>Ella</td>
<td>frequently</td>
</tr>
<tr>
<td></td>
<td>Rudy</td>
<td>frequently</td>
</tr>
<tr>
<td>Intrinsically motivated to learn, but not engaged consistently each day</td>
<td>Iyi</td>
<td>sometimes</td>
</tr>
<tr>
<td></td>
<td>Fany</td>
<td>sometimes</td>
</tr>
<tr>
<td>Extrinsically motivated to learn to fulfill requirement</td>
<td>Nur</td>
<td>seldom</td>
</tr>
<tr>
<td></td>
<td>Dewi</td>
<td>seldom</td>
</tr>
<tr>
<td></td>
<td>Riva</td>
<td>seldom</td>
</tr>
</tbody>
</table>

Table 4.2: Summary of student motivation patterns to learn physics
Student Motivational Factor Profiles

The purpose of this section is to provide data that can answer research question three: what individual profiles can be constructed from the MSLQ's four motivation factors (i.e., goals, values, self-efficacy, and control beliefs) for the eleven student participants in this study, and how are these profiles linked to their engagement (i.e., behavioral and cognitive engagement) in conceptual change learning of science? This question is answered by analyzing responses to the four MSLQ subscales for each student and comparing individual profile to the class as a whole. Each profile provides a picture of the kinds of motivation factors believed to influence that student when learning for conceptual change.

As described in chapter three, the Motivated Strategies for Learning Questionnaire (MSLQ) is a self-report instrument designed to assess four motivational factors: goal orientation, task values, self-efficacy, and control beliefs. Goal orientation refers to the student's perception of the reasons why he or she is engaged in learning a task. On the MSLQ, goal orientation refers to a general goal or orientation to the course as a whole. Two kinds of goal orientation were assessed: Intrinsic and extrinsic goal orientation. Intrinsic goal orientation is concerned with the degree to which a student perceives
himself to participate in a task for reasons such as challenge, curiosity, and mastery. Having an intrinsic goal orientation towards an academic task indicates that participation in a task is a goal all to itself, rather than participation being a means to achieving this goal.

Extrinsic goal orientation complements intrinsic goal orientation and is concerned with the degree to which a student perceives himself or herself to be participating in a task for reasons such as grades, rewards, competition with others or positive evaluation/reinforcement by others. When one is high in extrinsic goal orientation, engaging in a learning task is the means to an end (Pintrich et al., 1991). Pintrich also indicates that a student who scores high in extrinsic goal orientation is concerned with issues that are not directly related to participating in the task itself (e.g., grades, rewards, comparing one’s performance to that of others).

Task value refers to a student’s evaluation of how interesting, how important, and how useful a task is to them. It is related to the question “What do I think of this task?” According to Pintrich et al., (1991), a high task value score should lead to more involvement in learning. Task value, based on response to MSLQ items refers to a student’s perception of the course material in terms of interest, importance, and utility.
Finally, Pintrich et al., (1991) described self-efficacy and control beliefs as motivational factors. Self-efficacy is a self-appraisal of one’s ability to master a task. It includes judgments about the ability to accomplish a task as well as confidence in one’s skills to perform a task. Control beliefs are related to a student’s control over his or her learning. Taken together these factors indicate a student’s beliefs that his or her efforts to learn will result in positive outcomes such as conceptual understanding. Pintrich also suggests that if a student believes that his or her efforts do make a difference in learning, he or she should be more likely to study more strategically and effectively. So, if the student can control academic performance, he or she is more likely to put forth what is needed to effect the desired changes.

Motivational Factor Profile of the Class

The MSLQ was administered to all student participants one week prior to the beginning of classroom observations and interviewing. In administering the MSLQ, the student participants were asked to work individually to rate themselves on the four motivational factors. Completing the MSLQ required approximately 30 minutes.

In scoring the MSLQ, the mean of the items that make up a scale were calculated for the individual and the class as a whole (Pintrich et al., 1991).
Pintrich et al. (1991) indicate that, in general, a higher score such as a 4, 5, 6, or 7 is better than a score below 4. Thus, if a student's score is 4 or above, the student is motivated to learn.

Pintrich et al. (1991) also described the interpretation of individual scores in relation to the class average for the MSLQ. If a student's score falls in the bottom 25% of the class, this means that most of the students in the class are more motivated than this student. If a student's score falls in the middle 50%, then this student is similar to most students in the class. If a student's score is in the top 25%, the student is more motivated than other students in the class are. The distribution of student motivation scores for participants in this study (see Appendix F) resulted in three students in the bottom 25% (Dewi, Nur, and Riva), five students in the middle 50% (Isti, Novy, Rina, Fany, and Astri), and three students in the top 25% (Rudy, Ella, and Rini).

Table 4.3 shows that the overall MSLQ composite motivation score for the eleven students in this study is 5.6 (standard error of 0.16). Individual student motivation scores ranged from 4.6 (Nur) to 6.3 (Rini and Rudy). The range between the lowest and the highest scores is not widely different (1.7). This means that based on the MSLQ data, all of the students participating in
this study are not significantly different in terms of their overall motivation
to learn science. Because the lowest student motivation score average is 4.6,
it can be concluded that all of students in the class are motivated to learn
science (i.e., calculus-based physics). According to Pintrich et al., (1991), it
can be inferred that these students have high motivation to learn. This claim
supported by Mrs. Scott’s statement that all of these students were highly

<table>
<thead>
<tr>
<th>Class</th>
<th>ISTI</th>
<th>NOVY</th>
<th>RINA</th>
<th>DEWI</th>
<th>RUDY</th>
<th>NUR</th>
<th>ELLA</th>
<th>FANY</th>
<th>RINI</th>
<th>RIVA</th>
<th>ASRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>5.3</td>
<td>5.9</td>
<td>5.3</td>
<td>5.2</td>
<td>6.3</td>
<td>4.6</td>
<td>6.1</td>
<td>5.8</td>
<td>6.3</td>
<td>4.8</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Table 4.3: Overall student motivation score average based on the MSLQ

motivated to succeed and very much wanted to succeed. This may be related
to their choice to take this calculus-based physics class as their program
requirement for graduation. In other words, students who are highly
motivated to learn science may choose more rigorous science-related courses
(i.e., calculus-based physics class). The following is Mrs. Scott’s statement

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about how her motivated students were to learn physics.

The third period calculus-based physics class is quite unique. Great mix of students. Some had Freshman Science Inquiry, so they were used to me and my style (which had changed since they were freshman). These students were highly motivated to succeed and were gifted with great personalities that just "clicked". They were all not best friends, but they were pals--no enemies, They were very personable and very much want to succeed.

The overall composites for the four sub-scale scores ranged from 5.2 to 5.8--goal orientation (5.2), task value (5.8), self-efficacy (5.6), and control beliefs (5.8). Of the four motivational constructs, task value and control beliefs were the most important factors for these students to learn science indicated by the scores on these constructs (see Figure 4.1). This means that students are motivated to learn science because they value the instructional tasks offered by the teacher as being applicable to their real lives, and they believe that they can control their learning outcomes by actively engaging in learning activities and developing appropriate learning strategies for conceptual understanding (the complete data set on individual student motivational factor scores is included in Appendix F).
Figure 4.1. Overall motivational factor scores
Analysis of Motivational Factor Profile for Each Student

Each student's scores on the motivational profile varied from the class average. Following is a description of the motivational factor profile for each student and a description of that student's engagement in learning science.

ISTI

ISTI has a mean total motivation score of 5.3. ISTI's average on individual motivation factors is: 5.2 for goal orientation, 5.3 for task value, 4.5 for self-efficacy, and 6.3 for control beliefs. ISTI's motivation to learn science consists of 24% goal orientation, 25% task value, 21% self-efficacy, and 30% control beliefs. Control beliefs comprise the largest portion of ISTI's motivational profile (see Figure 4.2).

Compared to the overall mean for the class, ISTI's score is slightly below that of the class (5.3 for ISTI compared to 5.6 for the class). ISTI's motivation is located in the middle 50% of the scale of the class. This means that her motivation is similar to most students in the class (Pintrich et al., 1991).

ISTI's task value and self-efficacy scores are slightly below those of the class. However, her control belief score is above that of the class.
(see Figure 4.3). This indicates that she believes her efforts to learn will result in positive outcomes. Her control beliefs score (6.3) is also above that of the class. In the following statement, Isti explained what she does when she encounters difficulty in learning a physics concept.

The first thing I do is asking a friend who understands the material. I seem to understand things better when a group of us get together and work out things we don't understand as a group effort. Next, I would ask Mrs. Scott if I really don't understand difficult concepts or materials.

In her explanation, Isti indicated several strategies such as discussing with her friends and asking the teacher. The researcher probed Isti's response by asking what she does outside of class to help her learn physics better. Isti responded with comments about a study party, doing homework, and asking for extra explanation from the teacher as some of the strategies she undertook to learn physics.

The following statement reflects Isti's efforts outside of class in order to help her learn physics better.

The day before the physics final exam, me and four other people had a study party! I also do the homework assigned and I study for the tests. If I am having problems understanding, Mrs. Scott is there for some extra explaining before or after school.

Another statement that supports Isti's beliefs that her success in learning physics is due to her efforts as follows:

99
Figure 4.2: Isti’s motivational factor percentage

Figure 4.3: Isti’s motivational factor scores compared to those of the class.
When I am discouraged with some new physics ideas, I try to focus my thought to the problems. I imagine and relate them to my everyday life. Mrs. Scott will try hard to explain them and she will help me understand and encourage me. I am not giving up until I understand. Also, my motivations are myself and always trying to do the best I can do, and the fact this class is a required course for me to graduate. I am also motivated to get an “A” this semester, so I don’t have to take the final exam.

From her statements, Isti indicates that she can control her academic performance by putting forth what is needed strategically to affect the desired outcomes—understanding physics concepts and getting an “A”. In daily class activities, she cognitively and behaviorally engaged in classroom activities. She generally spent most of her time asking questions, sharing her ideas, and working to solve problems given by the teacher, although the questions she asked generally were limited to the clarification of the content presented. Isti rarely was involved in social conversation with her classmates during class time. Only twice did I find that she was not actively engaged in classroom activities. In these instances she spent most of the time drawing on the book cover because she already “knew and understood the concepts” from a previous lessons. In other words, Isti is motivated to learn science because she believes that her efforts will lead to success in Mrs. Scott’s class. From all of description above, it can be concluded that Isti is intrinsically motivated to learn science although she is not constantly
engaged each day.

NOVY

Novy has a mean total motivation score of 5.9. For the four sub-scale factors Novy’s average is: 6.4 for goal orientation, 6.3 for task value, 5.0 for self-efficacy, and 6.0 for control beliefs. Novy’s total motivation to learn science consists of 27% goal orientation, 27% task value, 21% self-efficacy, and 25% control beliefs. Goal orientation, task value, and control beliefs are equivalent portions of Novy’s overall score (see Figure 4.4). This means that goals, task values, and control beliefs are equally important factors for her when learning science. On the other hand, self-efficacy comprises the smallest portion of Novy’s motivation factor.

Compared to the overall class score, Novy’s motivation score is slightly higher than that of the class (5.9 for Novy compared to 5.6 for the class). However, her self-efficacy score is below that of the class average (see Figure 4.5). Based on the MSLQ data, this means that Novy is less sure of her ability to master a task compared to her classmates. Her uncertainty includes a lack of confidence in her ability to accomplish a task as well as a lack of confidence in her skills to perform that task.
Figure 4.4: Novy's motivational factor percentage

Figure 4.5: Novy's motivational factor scores compared to those of the class.
According to Pintrich et al., (1991), Novy's motivation factor profile is located in the middle 50% of the scale for the class. Her scores on goals, task value, and control beliefs (6.4 for goals, 6.3 for task value, and 6.0 for control beliefs) all are higher than those are for the class. This is interpreted to mean that Novy is concerned with the degree to which she perceives herself to be participating in a task for reasons of a goal all to itself as well as a mean to achieving this goal. The following statements are Novy's reasons indicate for learning physics. She learns physics because she plans to continue her education in college and is taking this course to prepare a foundation that she will take to college.

I study physics because it is in the college preparation curriculum here at [the school] and I am required to take 3 sciences. Since I wanted to take calculus, I was required to take calculus-based physics if I wanted to take physics at all. Also, I would get an "incomplete" on my grade card if I dropped the class and my parents would be quite upset.

Novy's high score in task value indicates that she also perceives the physics course materials to be an important part of her daily life, and this may lead her to become more involved in learning. Novy perceives that all aspects of physics are important and topics such as torque, rotation, and kinematics do apply to her daily life.

I can't think of one specific physics topic that's more important than another. All of the topics are very important. Every aspect is
important to me because it all affects me: torque, rotation, kinematics, etc. I picture my own situations in life and relate physics concepts to those in my life. So, physics is very important, because without it, we would not be here. Physics is involved in every aspect of our life.

Novy also believes that her effort to learn will result in positive outcomes as indicated by her high score on control beliefs. In daily class activities, Novy is one of the most active students asking questions for clarification, giving her ideas, getting involved in class problem solving, and discussing science topics with her classmates. Twice she was the first student to volunteer for a physics demonstration and a hands-on experiment.

Based on her profile, Novy is behaviorally and cognitively engaged in learning. She is intrinsically motivated to learn science. Planning to continue her education at college, she believes that science affects her daily life and that her efforts are leading to positive outcomes. She also recognizes the stake her parents have in her learning well in high school. Thus, she is concerned with doing well in the future as well as in her current physics class. In other words, Novy's motivation to learn science is dominated by the motivation factors of goals, task value, and control beliefs--factors that are important reinforcements for her as she participates in learning science.
RINA

Rina’s mean of total motivation score is 5.3. Rina’s average for individual motivation factors are: 4.2 for goal orientation, 6.8 for task value, 4.4 for self-efficacy, and 5.8 for control beliefs. Rina’s total motivation to learn science consists of 20% goal orientation, 32% task value, 21% self-efficacy, and 27% control beliefs (see Figure 4.6). Task values comprise an extremely large portion of Rina’s motivation score.

Compared to the overall mean of the class, Rina’s score is slightly below the average (5.3 for Rina compared to 5.6 for the class). From the four sub-scale factors, her task value score is far beyond that of the class (see Figure 4.7). Based on this data, task value seems to contribute most to her motivation to learn science. On the other hand, goal orientation is less of a priority for her as indicated by a mean of 4.2, well below that of class (5.2) and below that of her other motivational factors. In general, Rina’s motivation to learn science is high, although her overall score is below that of the class mean. Rina’s motivation factor profile is located in the middle 50% of the scale of the class. This means that Rina’s motivation is similar to most students in the class (Pintrich et al., 1991).
Her task value score of 6.8, a score that is far above that of the class, can be explained by the fact that Rina strongly perceives science course materials as interesting, important, and useful to her. For example, it can be inferred from Rina’s response below that she found science to be each of these in her daily life.

I suppose that physics and science in general is a means of discovering things, of understanding how world, and the things in it, work. Science has showed me things like how the body works and why plants grow. Physics has thought me about gravity and acceleration and how a bike wheels turns around or a door open when we turn the handle. All the little things that happen in the world around me, things I take granted, can be explained by science. Science helps me to understand all the things that happen in the world. This world is constantly changing and science makes new advances all the time. Science for me is a mean of helping me understand things that already exist but new discoveries are constantly being made and science is a big part of that too. New species are discovered here on earth. New stars are found out in the space. Science is an ongoing thing that must change as the world changes.

Rina connects everyday phenomena with the science she is learning. This may fertilize her curiosity and lead her to more involvement in conceptual change learning activities such as getting involved in classroom discussion, problem solving, hands-on experiments, and other learning inquiries. She is motivated to learn science because she understands the value of science in her life.
Figure 4.6: Rina's motivational factor percentage

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<tr>
<th>Goal</th>
<th>Task value</th>
<th>Self-efficacy</th>
<th>Control beliefs</th>
<th>Mean</th>
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<td>Rina's</td>
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<td>6.8</td>
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<tr>
<td>Class</td>
<td>5.2</td>
<td>5.8</td>
<td>5.8</td>
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Figure 4.7: Rina’s motivational factor scores compared to those of the class.
Rina continues her explanation of how science is useable, interesting, and important to her in the following.

Since I have begun studying physics, I apply my new physics perspective to more and more things that is happening around me in my everyday life. I see things and I put things in terms of physics and it has helped me see just how great the effect of physics in everything that happens in the world around me. I am motivated to do well in this course by my interest in the subject and my will to understand what is happening in the world and why it happens.

In the statement above she perceives that science is a tool for understanding and appreciating how the world around her functions. Further, Rina explains why learning science is so interesting to her—because science is a key for understanding the world. Also, she believes that science can be a tool to explain the past and the future and a way to understand that the environment and technology are constantly changing.

I study science for many reasons. One of most important to me is because I like it. Another reason is because to keep up with world and the way the environment and the technology are constantly changing. I study science, I believe that science is a tool to discover things and therefore the key to the future. It is hard to explain, but science helps me understand things of the past and the present, but it will also help to uncover and explain things in the future. Physics is also important to me because I can use what I learn in that class to help me with calculus since it is the same material and I use physics concepts to understand more complex calculus ideas and ideas in calculus to understand physics.
All of these factors may lead her to become more involved in conceptual change learning as indicated below.

I try to find examples of the concept in every day things or I talk to my friends about it and see if they have better understanding they can share with me or I look in [physics book] because it is easy to read or I do example problems. A lot of the time I ask Mrs. Scott for help in understanding it. Just about all the ideas of physics are hard to understand because they are new to me and I have to completely change my perspective on things.

For Rina, getting a good grade, rewards, positive evaluation by other students, and competition with peers are not her concerns. She learns physics for conceptual understanding. In the following she indicates the grade she expects to receive for this physics class.

I am hoping to receive a high "B" at least for this class [physics class]. If I could get an "A" I would have it but I understand that the course material is a lot harder than some other courses I took. I will try my best to do well in this course and no matter what grade I get I knew I tried hard. With courses like this I don't think the grade is so important as learning and understanding the material.

She also recognizes that many science concepts are interrelated in the following.

I do work in physics class because I have to do work to fully understand. The concepts, and especially the math involved with physics, are sometimes very complicated for me and hard for me to understand. I have to read from [physics textbook] and do the problems and experiment with the data collection devices to understand the concepts. If I didn't do my work I would fall behind and often one concept leads to another, so that I have to understand one to understand the other.
Rina is a quiet student in the class and rarely participates in social conversations, even when a student sitting next to her tried to engage her. In group activities, like hands-on experiments, she works with her group mates, Nur and Fany. Rina always set up the equipment for the group and the group worked together quietly to complete the task.

In summary, Rina is intrinsically motivated to learn science. She is concerned with how interesting, important, and useful science is in her life. She understands that life cannot be divorced from science. She recognizes that science is a tool for understanding phenomena found in the world around her. For these reasons, Rina works hard in science class to develop her conceptual understanding of physics.

**DEWI**

Dewi has a mean motivation score of 5.2. Dewi’s average on individual motivational factors are: 5.2 for goal orientation, 5.7 for task value, 4.6 for self-efficacy, and 5.3 for control beliefs. Dewi’s total motivation to learn science consists of 25% goal orientation, 28% task value, 22% self-efficacy, and 25% control beliefs (see Figure 4.8).

Compared to the class mean, Dewi’s score is below that of the class (5.2 for Dewi compared to 5.6 for the class). Three of four sub-scales factor
Figure 4.8: Dewi's motivational factor percentage

![Pie chart showing motivational factors]

Figure 4.9: Dewi's motivational factor scores compared to those of the class.

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<th>Goal</th>
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<tr>
<td>Class</td>
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for Dewi: task values, self-efficacy, and control beliefs, are also slightly below those of the class (see Figure 4.9). However, her goal orientation score is exactly the same as that of the class.

According to Pintrich et al., (1991), Dewi’s motivation factor profile is interpreted to mean that her motivation is located in the bottom 25% of the class. Dewi’s lack of intrinsic motivation to learn science is captured in her statement of why she studies physics.

I study physics because it is a required course to take in order to graduate here at [the school]. If it wasn’t required, I probably would not be taking it. I have no [intrinsic] motivation to do it [physics], it just occurs, if I had to pick up one thing, it would be to get a good grade.

She gets involved in learning physics because the course is a graduation requirement. The most important thing for Dewi is to fulfill this school graduation requirement. She would not have taken this physics course if it were not needed for graduation.

During daily class activities, Dewi frequently asked her friends to get involved in social conversation. Sometimes she distracted other students sitting close to her. She was seldom cognitively involved in classroom activities such as contributing ideas, helping to solve problems, or asking questions for clarification. She realizes that physics experiments are not easy
for her and that she sometimes had a hard time understanding the purposes for an experiment, including relating previous concepts to the current ones.

For me personally, I have a little more difficult time than most of my classmates. I know how to do the experiments but sometimes I have trouble understanding the purpose of the project or sometimes I have trouble seeing how things that we have done before tie into the project that we are currently doing.

She explains the most difficult part of the hands-on physics experiments as:

The most difficult part of the experiment is the actual experiment; figuring out ways to do the project successfully and coming up with new ideas.

From the analysis of data above, Dewi indicated the difficulties she experienced when figuring out ways to complete a project successfully. This might be related to why she rarely expressed her ideas in daily class activities. In summary, based on her profile, Dewi is motivated to learn science to fulfill a program requirement. Of course, passing and receiving a good grade in this course was an important goal for her, although she is not actually motivated to learn science.

RUDY

Rudy has a mean total motivation score of 6.3. Rudy’s average on individual motivation factors are: 5.9 for goal orientation, 6.7 for task value,
7.0 for self-efficacy, and 5.5 for control beliefs. Rudy’s total motivation to
learn science consists of 24% goal orientation, 27% task value, 27% self-
efficacy, and 22% control beliefs. Self-efficacy and task value comprise the
largest portion of Rudy’s motivation scores (see Figure 4.10). Compared to
the overall mean for the class, Rudy’s motivation score is at the top for this
class (see figure 4.11). This means that Rudy is more motivated than any
other students in this class. From the four motivational factors, his self-
efficacy score is also the highest score in the class (7.0) followed by his task
value score, the second high score for the class (6.7).

His self-efficacy score of 7.0 means that Rudy strongly believes in his
ability to master science tasks. He is confident in his own ability in be
successful when learning science and his ability to accomplish a task well.
The following statement typified his beliefs about his ability to be successful
when learning in science.

So far, I never really get discouraged trying to learn new ideas
in physics. I never faced difficulty in solving physics problems, my
grade is always an “A”. Once, when I was missed 3 days of class, at
first, I was confused, but I caught on towards the end of the
experiment. I just relax and try to understand it, because I know that I
will understand it eventually. I think once we knew how we were
going to gather the information, the actual gathering was pretty easy.
Figure 4.10: Rudy’s motivational factor percentage

Figure 4.11: Rudy’s motivational factor scores compared to those of the class.

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<th>Goal</th>
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<th>Self-efficacy</th>
<th>Control beliefs</th>
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Rudy perceives that everything he does in science will end with a positive outcome, including a good grade. He believes that all of his success in learning physics is because of his ability. He never faced any serious difficulties in understanding the physics concepts presented by Mrs. Scott.

Rudy's task value score was 6.7, a score that is also far above that of the class (see Figure 4.11). This can be explained by the fact that Rudy strongly perceives science course material as interesting, important, and useable. For instance, during a class discussion about a science fiction film entitled "Back to the future" he became actively engaged in the discussion. Once he came to the conclusion that "science and technology are ways of life for modern people". Furthermore, he explained that one of the disadvantages of science and technology to human beings is that "people become lazy and depend on technology". He was always interested in discussing science and technology related topics. Rudy's perception of science course materials as interesting, important, and useable may lead him to become more involved in the conceptual change learning activities presented by Mrs. Scott. It also can be inferred from Rudy's response below that he found the material for this course to be interesting, important, and useable in his daily life.
I like all of physics topics, but I like the kinetic motion pretty well. It is pretty important for me because we deal with this every day, it is a part of our everyday lives. I like to learn new ideas in science/physics. You know, my motivation come from myself, trying to constantly better myself and obtains more knowledge.

In daily class activities, Rudy was cognitively and behaviorally engaged in daily class activities. He was consistently involved in the assigned activities. He frequently raised his hand to answer questions proposed by the teacher, asked her for clarification, and freely contributed his ideas. The teacher and other students readily accepted his ideas. When doing written work such as quizzes or tests, he generally finished before other students in the class. According to Mrs. Scott, Rudy was the best student in her calculus-based physics class and he is also one of the top ten academically in the senior class.

Rudy is intrinsically motivated to learn science. He believes strongly that his ability will lead to successful learning. His judgments about his own ability to accomplish a task, as well as his confidence in his skills to perform in that task, are important reasons why he is motivated to learn.

NUR

Nur has a mean total motivation score of 4.6. Nur's average on individual motivation factors is: 5.1 for goal orientation, 4.7 for task value,
4.0 for self-efficacy, and 4.5 for control beliefs. Nur's total motivation to learn science consists of 27% goal orientation, 26% task value, 22% self-efficacy, and 25% control beliefs. Goal orientation comprises the largest portion of Nur's motivation score followed by task value and then control beliefs (see Figure 4.12). Compared to the overall class mean, Nur's motivation score is the lowest. All of Nur's motivational factors scores are below those of her classmates (see Figure 4.13). Her motivation to learn science is the lowest in the class.

Nur's motivation factor profile places her in the bottom 25% of the class. Her lack of intrinsic motivation in physics is captured in her statement:

I study physics because it is a required course, but I really don't like physics. Only when the topics is fun I like to study [physics].

From the statement above, it is clear that Nur takes physics not because she likes it, but because she needs the course to graduate. Although, Nur doesn't like physics, she tries to do her best to receive a good grade. This is clearly indicated in the following statement.

The important thing for me [to learn physics] right now is to get a good grade. I expect to get somewhere between a "B" and an "A". Because I really try hard but not everything comes easy to me right away.
Figure 4.12: Nur’s motivational factor percentage

![Pie chart showing motivational factors]

- Goal: 27%
- Control beliefs: 25%
- Task value: 26%
- Self-efficacy: 22%

Figure 4.13: Nur’s motivational factor scores compared to those of the class

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<td>5.8</td>
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The teacher and Nur’s classmates play important roles in helping her learn what she can. Mrs. Scott’s teaching and Nur’s classmates lend her valuable supports that encourage her to try to learn physics.

[In learning physics] I get discouraged a lot but I get encouraged to stick with it by my friends because they understand me, and what we are learning. Also, Mrs. Scott makes physics fun, so even though I don’t understand and have difficulty with it, I can relate some type of ideas with it.

In most daily class activities, Nur spent time quietly. This might be related to her language and cultural background since Nur is the only student in the class from a Spanish speaking background. Mrs. Scott frequently assisted her in-group activities and Nur permanently worked with two other students, Rina and Fany. Differences in language and culture might have affected her comprehension, and this may have contributed to the motivation score she received on the MSLQ.

ELLA

Ella has a mean total motivation score of 6.1. Ella’s average on individual motivation factors is: 4.9 for goal orientation, 6.3 for task value, 6.8 for self-efficacy, and 6.2 for control beliefs. Ella’s total motivation to learn science consists of 20% goal orientation, 26% task value, 28% self-efficacy, and 26% control beliefs. Self-efficacy comprises the largest portion
of Ella's motivation score (see Figure 4.14).

Compared to overall mean for the class, Ella's motivation score was second from the top. From the four motivational factors, her self-efficacy score mean was far beyond that of the class (6.8 for Ella compared to 5.6 for the class). Her other two motivational factor scores, task values and control beliefs, were also above those of the class (see Figure 4.15). However, her goal orientation score was slightly below that of the class mean.

Ella's motivation factor profile placed in the top 25% of the class. Her self-efficacy score of 6.8 indicates that Ella strongly believes in her ability to master science tasks. Her strong appraisal of her own abilities to successfully learn science, including judgments about her ability to accomplish a task as well as her confidence in her skills to perform that task, is reflected by this score.

The following statement indicates that she believes in her ability for successfully learning science. She usually understands physics materials offered by the teacher, so, she is not discouraged when learning physics.

Up to now, I don't become discouraged because I usually understand things well. When I do I get extra help etc. I talk to my friends and Mrs. Scott about what I can do to improve myself.
Figure 4.14: Ella's motivational factor percentage

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<th>Task Value</th>
<th>Self-efficacy</th>
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Figure 4.15: Ella's motivational factor scores compared to those of the class
Further, Ella explains that she does little studying outside of class because she believes that classroom activities give her enough opportunity to learn the physics concepts offered by the teacher. Instead, she likes to discuss physics-related topics with her friends outside of class.

When I'm driving with my friend, we talk about going around banked curves and how an object in motion stays in motion—but I don't do much outside of class besides a little studying for test and homework.

Ella's high score on task values and control beliefs, indicate that she perceives science course materials as important and usable. Because these are important and usable to her, she is involved in more daily science class activities than others. For instance, during a discussion of "gravitation," she promptly reacted and volunteered her idea to the teacher's probing questions about gravitation-related factors. She explained that mass is directly related to gravity—"the greater mass, the greater gravitation will be". Further, she gave the example that "planet Jupiter has a greater mass, so it must have a greater gravity". Ella's statement below indicates that she appreciates physics and links it to important parts of her life.

It seems to me that everything has physics in it—and I can't do anything anymore without thinking about the physics behind it. Physics as part of science makes the world goes around, or at least helps us explain it. All of this stuff was around a long time ago, but as we progress, so does science and technology. Now we try to understand and explain why things behave the way they do.
Learning how and why things act the way they do makes me view the world differently. Instead of thinking that something is phenomenal, I know it’s just simple physics but it can be applied to real life. So, why physics has always been an interest of mine. I have taken a science class since the first grade and enjoying them. Also, physics help us explain many things that happen in society and in the world today—Motions, sound, almost everything. We could still survive without knowing about physics, but it’s interesting to see why things behave the way they do. It also helps us do things mathematically—roller coasters etc.

From the statement above, it can be inferred that Ella understands how knowledge of physics is important for human life. She believes that learning science can help her to understand and describe how many things happen in the world around her. This may lead her to more involvement in the conceptual change learning activities presented by Mrs. Scott.

Curiosity and mastery are also important concerns for Ella when she learns physics. This is indicated by her participation in daily physics tasks. She is one of the few students who frequently raised her hand to answer questions offered by the teacher, asked for clarification, or freely gave her ideas during problem solutions. The teacher and other students generally accepted her ideas.

Thus, based on her profile, Ella is intrinsically motivated to learn science. She believes that her ability is supported by her perception of how important and usable science is in her daily life, and that this contributes
her success in learning science. Curiosity and mastery of the science materials offered seem to be important goals for her. This may invite her to become actively involved in daily activities. She is not concerned with her grade because she believes that her ability will lead her to obtain a good grade.

**Fany**

Fany has a mean total motivation score of 5.8. Fany’s average on individual motivation factors is 5.6 for goal orientation, 5.7 for task value, 6.4 for self-efficacy, and 5.3 for control beliefs. Fany’s total motivation to learn science consists of 24% goal orientation, 25% task value, 28% self-efficacy, and 23% control beliefs. Self-efficacy comprises the largest portion of Fany’s motivation scores (see Figure 4.16).

Compared to the overall mean of the class, Fany’s motivation score mean was slightly above that of the class (5.8 for Fany compared to 5.6 for the class). From the four motivational constructs, her self-efficacy and goal orientations were slightly above those of the class as well. However, her control beliefs and task values were slightly below the average score (see Figure 4.17). In general, Fanny’s motivation to learn science based on her response to the MSLQ, was high. Her motivation factor profile is interpreted
Figure 4.16: Fany's motivational factor percentage

Figure 4.17: Fany's motivational factor scores compared to those of the class

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to mean that her motivation is located in the middle 50% of the scale of the class (Pintrich et al., 1991). This means that Fany's motivation is similar to most students in the class.

Fany's high scores on self-efficacy and goal orientation indicate that she perceived her ability in these areas to be important to her success in learning science. One of her main goals in this course was to fulfill a requirement for graduation, although she didn't have any plans to go into a science field in college. Fany believes that physics knowledge is necessary to help advance her knowledge, regardless of whether or not she plans to pursue a science field in college.

Right now, I study physics to fulfill my required credits in order to graduate. But if I didn't need the credits I would still take a science class to further my knowledge. I don't plan to go into the science field, but I think it is necessary to be as well educated as possible. This means studying all academic areas regardless of whether or not you plan to pursue that field in college. To me studying physics is just to help advance my knowledge.

Fany perceives that science is interesting and important in her daily life and could be a tool for understanding phenomena found in the environment. This can be inferred from her statement below in which she indicates how important and useable physics knowledge is to her daily life.

Physics is important in certain areas of life. If you are curious about why your car skids, you can look at physics to find out why. Physics can make you more aware of gravity or forces or friction. It helps to
make us more aware of what exactly is going on in our environment and it allows us to adjust to changes in our environment.

Mrs. Scott’s teaching has affected Fany’s learning of physics. Fany feels that the way Mrs. Scott presents examples and notes, and her thorough explanations, help her learn physics ideas. This was indicated by Fany in the following:

Mrs. Scott is one of the best science teachers I have ever had! She is such a good teacher because she does examples in front of the class and she explains things thoroughly. She makes sure we know what we are doing by giving us good notes and examples.

In daily class activities, Fany spent most of her time copying everything Mrs. Scott wrote on the board, although she sometimes asked questions for clarification as well. Mrs. Scott frequently came to Fany’s desk to help her focusing attention on the materials being offered and to make sure that she understood these materials.

From the description above it can be summarized that Fany was intrinsically motivated to learn science although she didn’t get involved consistently each day. She believed that science is important and useable to understand phenomena found in the world around us. In addition, Fany perceived that people need to know science knowledge because it allows us to adjust to changes in our environment.

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Rini has a mean total motivation score of 6.3. Rini’s average on individual motivation factors are: 6.3 for goal orientation, 6.5 for task value, 6.1 for self-efficacy, and 6.3 for control beliefs. Rini’s total motivation to learn science consists of 25% goal orientation, 26% task value, 24% self-efficacy, and 25% control beliefs. All of Rini’s motivational factors are nearly equal in terms of percentage (see Figure 4.18). This means that all four motivational factors are important considerations for her to learn science.

Compared to the overall mean of the class, Rini’s motivation score was one of the tops in this class (see Figure 4.19). According to Pintrich et al., (1991), Rini’s motivation factor profile places in the top 25% of the scale of the class.

Rini’s task value score of 6.5 can be interpreted to mean that she perceives science course material as important. For example, it can be inferred from Rini’s response below just how important physics is to her.

Topics in physics have been the most important for me. Learning about torque and inertia/angular velocity has been the most important and most interesting so far. It’s important to know some of these things for everyday life. This can help you figure out some problems in life (torque applied to open a door; where to place a doorknob, etc.) and explain why things happen. So, it applies to my everyday life.
because almost everything I do has a physics concept or idea behind it. I am sure physics is important to those who deal with it on everyday basis, but to some I don’t think so. Maybe this is because they don’t care or they don’t understand.

From her response, it is clear that topics in physics are interesting to her because a lot of them are useable for figuring out and explaining why things happen in her everyday life. She also indicates that nearly everything she does in her daily life can not be separated from some concepts or ideas in physics.

The importance of the science to Rini may lead her to get involved in conceptual change learning activities. She is a student who always participated actively in daily activities and frequently answered questions offered by the teacher. For instance, in brainstorming activities of the topic of “work and energy”, she was the first student who offered a definition of “work” as “an applied force on an object that moves a certain distance in the direction of the force”. Ideas generated by Rini frequently became the source for further class discussion. Rini’s active involvement in learning is also supported by her response about what she does to learn physics better.

Reviewing my notes has really helped me to understand the physics concepts more. Also doing the projects such as combining calculus and physics, has advanced my understanding. In case, I particularly encounter difficult ideas in physics, I always either ask my classmates to explain the concepts to me, or I ask Mrs. Scott to help me more
fully understand the ideas. Like other students, sometimes I do get
discouraged, but I know I have to keep going. My classmates
courage me, as well as Mrs. Scott, to stick with it and think
through it.

Rini perceives that reviewing notes, doing projects, discussing with
classmates, and asking the teacher questions of clarification helped her
understand physics ideas more fully. She believes that all of her efforts
dealing with learning physics may lead her to a better understanding of
physics concepts and that this will affect her future career. Rini plans to
continue her education in science, as clearly indicated in her statement
concerning why she studies physics.

I study physics because it is required for graduation. Along with this
being one of required class I must take, I might go into a future career
dealing with science. To satisfy my father and the fact that I want to
pass this course with a good grade (an “A”), motivates me.

The role of teacher is also crucial to Rini’s learning of science. Rini
found that the way a teacher teaches, such as bringing everyday situations to
the physics concepts, and the availability of physics-related toys, make
physics class fun for her. These factors motivated Rini to get involved in
Mrs. Scott’s physics class.

Mrs. Scott’s explanations and experiments really help to clarify
ideas we have learned. Her toys and other paraphernalia show me
everyday situations combined with physics concepts. She also keeps
pushing us to try to explain things for ourselves and think through
problems. Plus, she makes class fun for us so it’s not so boring.
Figure 4.18: Rini’s motivational factor percentage

Figure 4.19: Rini’s motivational factor scores compared to those of the class

<table>
<thead>
<tr>
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<th>Goal value</th>
<th>Task value</th>
<th>Self-efficacy</th>
<th>Control beliefs</th>
<th>Mean</th>
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<tbody>
<tr>
<td>Rini</td>
<td>6.3</td>
<td>6.5</td>
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<tr>
<td>Class</td>
<td>5.2</td>
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In summary, Rini is intrinsically motivated to learn science. Her future career plan dealing with science encourages her to stay involved actively in conceptual change learning in this class. In addition, Rini’s efforts are critical part of her learning that she believes result in positive outcomes such as conceptual understanding and a good grade.

Riva has a mean total motivation score of 4.8. Riva’s average on individual motivation factors is: 3.9 for goal orientation, 3.2 for task value, 6.5 for self-efficacy, and 5.5 for control beliefs. Riva’s total motivation to learn science consists of 26% goal orientation, 17% task value, 34% self-efficacy, and 29% control beliefs (see Figure 4.20). Self-efficacy comprises the largest portion of Riva’s motivation score.

Compared to the overall class, Riva’s motivation score is far below that of the class (4.8 for Riva compared to 5.6 for the class). Of the four motivational factors, three of them (goals, task value, and control beliefs) are quite far below those of the class (see Figure 4.21). According to Pintrich et al., (1991), a motivation factor profile like Riva’s can be interpreted to mean that his motivation is in the bottom 25% of the class.
Figure 4.20: Riva's motivational factor percentage

Figure 4.21: Riva's motivational factor scores compared to those of the class
Riva's lack of intrinsic motivation to learn science is indicated in his statement of how important physics is for him. He indicated that physics is not very important for him because he doesn't have any plans to pursue an occupation in a physics-related career.

There are no [physics] topics that are more important than others we learn about. All of them are the same for me. I am not too interested in physics because I do not plan to pursue a field or occupation concerning physics, the topics covered are not very important. Learning physics is a new experience for me. I have never taken a physics course before, so nearly all of the materials are new to me. Although, the materials are not so interesting to me, I aim to get good grades in this class more than anything else.

However, getting a good grade is a major concern for Riva as indicated in his response to why he studies for this course. He believes that learning in high school can be an important foundation for success in his future education.

I study physics because I am forced to study it. If I don't, I will not understand the materials and do poorly on tests. If I do poorly on tests, I will receive poor grades, possibly low enough to cause me to fail the physics course in which I am enrolled. I try to earn a good grade [an "A"] and to understand material as well. If I want to do well in college and beyond, I feel that I should do well in high school.

Although, Riva doesn't really like physics, he does put forth the efforts necessary to learn the concepts Mrs. Scott taught. The personal relationship he has with Mrs. Scott is an important reason that motivates
Riva to put forth his best effort. The following statement indicates how important this personal relationship with the teacher is to Riva.

Mrs. Scott's enthusiasm helps me to stick in her course. She helps me to learn. Her high standards for her students also encourage me. She demands the best we can give. We develop such personal relationships with her that we hate to let her down.

In class, Riva seldom was involved in the activities. But, once he offered an idea to the class or answered a question, it was readily accepted by his peers and teacher. The following is his response as to why he rarely expressed his ideas in class.

I try to come upon a correct answer before I contribute a response to the class. Most students would agree that it is rather pointless to answer a question, which you do not know the answer to. Before I choose to speak, I decide how logical my response is and whether it is correct or not. Ideas, which are different from numeric solutions, are different. I try to give ideas which might help further the lesson. If I do not quite understand the lesson, I most likely will not contribute an idea because it will not further the lesson.

From the statement above it can be inferred that although he doesn't actively get involved in classroom discussions, this does not mean that Riva was not involved cognitively. He does offer his idea when he believes that his ideas will further the conversation. Thus, Riva's low score on the MSLQ does not accurately depict his level of effort in the class.
ASRI

Asri has a motivation score of 6.0. Asri’s average on individual motivation factors are: 4.8 for goal orientation, 6.3 for task value, 6.0 for self-efficacy, and 7.0 for control beliefs. Asri’s total motivation to learn science consists of 20% goal orientation, 26% task value, 25% self-efficacy, and 29% control beliefs (see Figure 4.22).

Compared to the overall class score, Asri’s score is above that of the class (6.0 for Asri compared to 5.6 for the class). Her scores on the four individual motivation factors, control beliefs, self-efficacy, and task value are also above those of the class (see Figure 4.23). Her score on control belief is far beyond that of the class, the highest in the class (7.0) and comprises the largest portion of Asri’s total motivation score. This means those control beliefs are crucial for her when learning science.

Her control belief score of 7.0 means that Asri strongly believes that she can control her learning. She believes that her efforts to learn will result in positive outcomes such as understanding the concepts presented and obtaining a good grade. For example, the following statement is Asri’s response to what she has done to learn physics.

This is the first time I have taken physics class. I really didn’t know anything about physics before I took the class. Because the class is
interesting, it greatly affects my grade and I would like to go into engineering and I will need it. I mostly do the work to get a good grade, but I also do the work because I need to. I need to do it, so that I can understand the materials. I can’t understand the math or concepts if I don’t do the work, then the class would be pointless. Also, I often ask a lot of questions. I not only ask Mrs. Scott, but also I ask other classmates what they think about it.

At home, I have watched a lot of Olympic winter games. When I watch them I try to pick out all the things I have learned about. I tell people at home and therefore practice the material even more. Once, I get stuck or discouraged, I encourage myself because I know that if I put my mind to it and pray to God that eventually I will get it.

From the statement above, it can be inferred that Asri learns physics not only because she plans to go into engineering and expects to get a good grade, but she also likes to learn physics. She clearly states that she learns physics because she is thinking about her future education. In classroom activities she actively asked questions of clarification and offered her ideas to the teacher or class.

Asri has learned to apply her understanding of physics in different ways. She applies her understanding of the physics concepts from class to her experiences outside of school. For example, she tried to pick out some of the physics concepts she learned while watching the Olympic winter games on television.

Asri strongly believes that God also helps her with any problems she faces. Her beliefs in the greatness of God are indicated in her statement.
Figure 4.22: Asri's motivational factor percentage

Figure 4.23: Asri's motivational factor scores compared to those of the class
about the grade she expects to receive in physics at the next grading period.

I expect to get an “A”. It may not be a high “A”, but I think I have
done well enough and worked hard enough to earn an “A”. The class
is difficult, but with God, anything is possible.

Mrs. Scott’s instruction also plays a crucial role in Asri’s learning.

Demonstrations, hands-on experiments, problem solving practice, and
relating the materials to real daily life, make class interesting to her, as she
indicates below:

Mrs. Scott does a lot of demonstrations and hands-on activities. To
learn physics well I think this is important because [physics] is
complex. Lecturing would make the class uninteresting. Also, she has
us practice problems a lot. Practice makes perfect! She [Mrs. Scott]
makes the material interesting and poses real life questions about what
we are studying. Her teaching has led me to look at things differently
even outside of the classroom.

The statement above indicates that Mrs. Scott’s implementation of a
variety of class activities, allowing students multiple opportunities to get
involved in problem solving, and her extensive supports for students create a
teaching and learning environment that is important for students, especially
for Asri.

In summary, based on her profile, Asri is intrinsically motivated to
learn science. Planning to continue her education in engineering, getting a
good grade, and working hard in and out of class are the crucial factors for
her to learn physics. In addition, her belief that God’s assistance in her daily life is a valuable support for her to do her best when learning science.

Cross Case Analysis of Students’ Motivational Factor Profiles

In the analysis presented so far, the profiles for each student have been described and analyzed. These profiles provide a picture of the kinds of motivational factors believed to contribute to a particular student’s learning for conceptual understanding. However, the need for a cross case analysis of this data emerged as the individual student profiles were identified.

The cross case analysis of all students was implemented by grouping data across the eleven students. The descriptions that follow illustrate common characteristics across all students, and identify distinctive elements for individuals.

From the cross case analysis, five trends not directly related to MSLQ factors were identified as the reasons students mentioned for engaging in Mrs. Scon’s calculus-based physics class. These trends include (1) the teacher’s personality, (2) preparation for future career/college, (3) personal interest in science, (4) the content of the course was important for daily life, and (5) the course is required for graduation.
In light of the data analyzed above, a detailed account of these five trends is presented in this section. The presentation includes statements from students and the teacher that support these trends.

Trend 1: The teacher's personality

All students mentioned the personality of the teacher as a reason for taking Mrs. Scott's physics course. She has a warm personality and is supportive to students as they learn. This personal relationship was successfully developed in Mrs. Scott's class as indicated by her statement about the love and care she had for her students.

Mrs. Scott: I love my subject matter and love to teach, but most of all I love them. This may sound silly, but I could have all the knowledge in the world and really get caught up in teaching physics, but if I don't have a sincere love for the students I teach it will all mean literally nothing. They want to know that the person who is there teacher cares for them as both a student and a person.

She treated all of her students as individuals who have the same right to learn for understanding. For instance, she always checked with her student to ensure that they understood concepts from previous instruction before she presented new ones. In doing so, she asked questions such as “Do you have any questions [of your homework]?,” checked students' homework/projects, helped students solve the problems they faced in learning physics, In
addition, she was always available to work with students who needed more explanation after class.

Mrs. Scott’s personality was a powerful external motivator for students to remain cognitively and behaviorally engaged while learning physics concepts. This claim is supported by the fact that all of the students in the class indicate that Mrs. Scott had personality motivated them to learn physics. The following statements are examples of how Mrs. Scott’s students felt about their personal relationships with her.

Riva: Mrs. Scott’s enthusiasm helps me to stick in her course. She helps me to learn. Her high standards for her students also encourage me. She demands the best we can give. We develop such personal relationship with her that we hate to let her down.

Rina: I try very hard to understand everything taught by Mrs. Scott because I know how much it means to her that we do understand and how much it troubles her when we don’t.

Navy: Mrs. Scott’s energy and creativity encourages me to learn and keep asking questions about physics concepts. No matter how difficult a concept is to grasp, Mrs. Scott will keep explaining it in as many ways as she knows until you understand it. She will apply the concepts to many different actions and situations so it is easier to understand.

The students also recognized Mrs. Scott as one of the best science teachers at the school. She was always ready to motivate students to get involved in daily activities of her physics class. In addition, her energetic
and enthusiastic teaching methods influenced students to learn physics as indicated by the following statements.

Fany: Mrs. Scott is one of the best science teachers I have ever had! She is such a good teacher because she does examples in front of the class and she explains things thoroughly. She makes sure we know what we are doing by giving us good notes and examples.

Novy: Mrs. Scott is very energetic and always is eager to teach. It is easy to learn the material she presents to us because she applies much of what we learn to everyday life and everyday occurrences. I love coming into exciting class where she is always energetic and ready to teach everyday. Physics is one of the few classes I can stay awake in. Now, no matter where I am or what I am doing, I always think of the physicists’ perspective of every action, thanks to Mrs. Scott.

From all of the statements above, it can be inferred that Mrs. Scott treats each of her students with love, while at the same time she expects a high level of academic performance. Her energy, enthusiasm, and willingness to assist students are readily apparent in all of students’ comments about her personality. The following is Mrs. Scott’s perspective on why she needs to teach this way in the classroom.

I also think there has to be creative in the classroom. Creativity, willingness to take risks and to go beyond the normal. My enthusiasm must spread throughout and it is up to me to touch each student with that enthusiasm and love.
These factors are important reasons why the students in this class get involved and stick with learning physics, even though many students would agree that physics is not an easy course.

Trend 2: Preparation for future career

As described earlier, most students attending this school plan to further their education beyond high school. Generally, they plan to continue their education in science or mathematics-related fields and pursue science-related careers. As a group, they believe that taking calculus-based physics will provide a valuable foundation for future learning. In other words, they understand that if they want to do well in college, they should learn well in Mrs. Scott's course. This claim is clearly described in the following students' statements.

Isti: I study physics to help increase my knowledge for future learning experiences. I also study science to help myself in the college courses I will be taking.

Novy: I study physics because it is in the college preparation curriculum here at [the school] and I am required to take 3 sciences. Since I wanted to take calculus, I was required to take calculus-based-physics if I wanted to take physics at all.

Rina: I didn't have to take physics or anything, but I took it because I thought it would be fun and interesting and because I believe that shouldn't slack off senior year and not take math because if you don't when you get to college you will be in trouble because the math won't be fresh in your mind and that goes for science too. That is why I took calculus and physics this year.
Rini: Along with this being one of required classes I must take, I might go into a future career dealing with science.

Riva: I study physics... to earn good grades and to understand the material as well. College is a major motivating factor. If I want to do well in college and beyond, I feel that I should do well in high school.

The statement above, confirms that these students are highly motivated to learn. Their concerns with being successful in college motivate them to work hard in their high school physics class. In doing so, they engage cognitively in the learning activities Mrs. Scott presents. Among these activities were classroom discussions, problem solving, and outside of school study parties that increased their understanding. For instance, in one classroom discussion about "living in space," Mrs. Scott asked her students to analyze the application of physics concepts to support human life in space. Mrs. Scott expected her students to apply their physics knowledge to generate logical ideas to address the problem offered. Furthermore, to increase student's conceptual understandings of physics, Mrs. Scott solved this problem in class, by encouraging all of her students to get involved in the thinking process. Daily classroom activities were student centered, in that the teacher and students together became active in learning.
physics for conceptual understanding. Thus, the myth that physics is a hard course, for Mrs. Scott’s students is refuted by their commitment to do their best in order to reach future career goals.

**Trend 3: Personal interest toward science**

Personal interest toward science also plays an important role for students to get involved in this physics course. As Schiefele (1996) describes, personal interest is a strong indicator of a deep level of learning. Personal interest including recall of main ideas, coherence of recall, responding to deeper comprehension questions, and representation of meaning are crucial to students’ learning for understanding. The following student statements indicate their motivation to learn physics by getting involved in daily classroom activities.

**Rina:** I study physics for many reasons. One of the most important to me is because I like it. I motivated to do well in this course by my interest in the subject and my will to understand what is happening in the world and why it happens.

**Ella:** Science has always been an interest of mine. I have taken a science class since 1st grade and I enjoy them.

**Rina:** Since I have begun studying physics, I apply my new physics perspective to more and more things that are happening around me, in my everyday life. I see things, I took for granted before in new light. I put things in terms of physics and it has helped me see just how great the effect of physics is in everything that happens in the world around me. I believe that science is a tool to discover things and therefore the big things to the future. It is
hard to explain, but science helps me understand thing of the past and the present, but it will also help to uncover and explain things in the future.

Asri: I study it (physics) because I enjoy it and because I understand it. I like science because it is logical thinking, and that is how my brain function!

From the statements above, it is clear that these students' personal interests toward science invite their curiosity to learn, and motivate them to get involved actively in learning. In fact, they enjoy class activities such as doing individual or group projects, presentations, discussions, hands-on experiments, and problem solving that helps them learn for conceptual understanding. Thus, students' personal interests toward science are a necessary reason for them to get involved in the lessons Mrs. Scott presented.

Trend 4: The content was important for daily life.

The importance of physics knowledge for daily life also attracted these students to the course. Generally, they recognized that modern life could not be separated from involvement with science and technology. Nearly all of Mrs. Scott's students argued that they were involved in learning physics because of its usefulness in their daily lives. Many indicated that almost everything that happens in the world could be related
to science. Thus, having knowledge about science can help them to understand phenomena found in the real world. The following statements indicate how important physics is for these students.

Isti: Learning science is an important part of knowing and why things work the way they do in the world around us. We all encounter some type of physics concept at least once everyday. It is important to know how these things work.

Novy: Physics to me means just about every aspect of my life, cars, planes, walking, everyone’s action and all objects. It is very important, because without it, we would not be here. Physics is involved in every aspect of our life. Outside of class, I am constantly remind of physics, everywhere I go for example when I drive home I apply a torque to my steering wheel to turn the car.

Dewi: [Physics] deals with everyday life. It can help you figure out some problems in life (torque) and explain why things happen.

Fany: Physics is important in certain areas of life. If you are curious about why your car skids, you can look at physics to find out why. Physics can make us more aware of gravity or forces or friction. It helps to make us more aware of what exactly is going on in our environment and it allows us to adjust to change in our environment.

Rini: It [physics] applies to my everyday life, because almost everything I do has a physics concept or idea behind it.

Asri: I study science because it explains our everyday life. It explains why thing in our world are the way they are.

From the statements above, it can be inferred that the usefulness of scientific knowledge helps these students to understand phenomena found in
the world around them. It is important for them to acquire science
knowledge because it facilitates their understanding of daily activities. Thus,
the usefulness of scientific knowledge is one of the reasons why students
take Mrs. Scott’s calculus-based physics class.

**Trend 5: Course required for graduation**

As mentioned in the previous section, physics is one of the elective
courses to take for graduation from this school, especially for students
planning careers in science. This claim is clearly supported in the following
students’ statements.

**Isti:**  My motivations are myself and always trying to do the best I
can do, and the fact this class [physics class] is a required
course for me to graduate.

**Dewi:** I study physics because it is a required course to take in order
to graduate here at [the school]. If it wasn’t required, I probably
would not be taking it.

**Nur:** I study physics because it is a required course [to graduate], but
I really don’t like science.

**Ella:** It is a required to have certain number of science credits to
graduate also. I am taking physics because Mrs. Scott is
teaching it and I enjoy her teaching style.

**Fany:** Right now, I study physics to fulfill my required credit in order
to graduate.

**Rini:** Along with this [physics class] being one of the required class I
must take [to graduate], I might go into a future career dealing
with science.
From all of these students’ statements above, it can be summarized that several credits in science courses are necessary for students who plan to major in science. This graduation requirement is an important reason why students take calculus-based physics. It doesn’t matter if they like physics or not. In fact, Mrs. Scott’s calculus-based physics class was their choice because of her conceptual change curriculum, her warm personality, and her supportive teaching style that helped them learn in meaningful ways.
CHAPTER 5

CONCLUSIONS AND IMPLICATIONS

Introduction

Questions answered through this study were: 1) What instructional strategies did the teacher use to both promote student’s learning for conceptual change and increase their motivation in learning science? 2) What are the patterns of student’s motivation to engage in conceptual change learning of science? and 3) what individual profiles can be constructed from four motivation factors (i.e., goals, values, self-efficacy, and control beliefs), and how are these profiles linked to engagement (i.e., cognitive and behavioral engagement) in conceptual change learning of science?

This chapter contains four major sections: 1) conclusions drawn from the analysis of data, 2) implication of the findings from this research for science teachers and the Conceptual Change Model (CCM), and implications for other schools/classrooms, 3) limitations of the study, and 4) recommendations for future research. Conclusions drawn from this study are
presented within the conceptual framework set out for this research in Chapter One.

**Conclusions of the Study**

The Conceptual Change Model is widely accepted and has had considerable influence in science education research. However, science educators are still confronted with students who are unwilling to work hard toward achieving scientific understanding through conceptual change. Many students spend time and effort focusing on less important learning outcomes such as memorizing science vocabulary or factual information, rather than trying to achieve conceptual understanding. In addition, they also rely on inadequate explanations for science concepts by distorting scientific knowledge to fit their existing knowledge, mindlessly answering questions, or copying answers from their texts or peers. This raises a concern among science educators about how student motivation is linked to learning science when the teacher teaches for conceptual understanding.

In spite of the acceptance and influence of the CCM in science education, a number of criticisms have been directed at the model. One specific criticism of the CCM is that it lacks attention to affective aspects of learning, including motivational constructs (Pintrich, Marx & Boyle, 1993). This is most likely due to the fact that the CCM presents a highly rational
view of learning (being driven solely by logic and scientific thinking) with little or no reference to motivational constructs such as goals, value beliefs, or self-efficacy beliefs. This study attempted to bring together research on these motivational constructs with research on conceptual change learning in science. A specific goal of this research was to investigate the relationships between motivation factors and students' engagement in conceptual change learning in science.

The present study was conducted in a senior high school science classroom (i.e., 12th grade calculus-based physics) where the teacher implemented principles of conceptual change instruction through her instruction. The overall results, as measured by the MSLQ, show that all of the students in the class were motivated to learn science. According to Pintrich et al., (1991), MSLQ scores of 4 or higher are interpreted as high in motivation to learn and each student in the study scored above 4 on a scale of 7. Sub scores on four factors contributing to the overall score (i.e., goals, values, self-efficacy, and control beliefs) were also obtained from the MSLQ instrument. Individual differences on these sub scales portrayed different motivation profiles that were used to infer what influenced an individual student to learn science for conceptual understanding. In addition to these four factors, students' motivation to learn science for conceptual
understanding was also influenced by other factors not directly related to the four sub scales assessed by the MSLQ. Obtained through student interviews, these factors included: (a) the teacher’s unique personality had a positive influence on student learning, (b) preparation for a career or college was a strong motivational factor for these students, (c) personal interests to learn science were important, (d) the content of the course was perceived to be important/useful in students’ daily lives, and (e) the course was required for graduation.

In regard to the first research question: what instructional strategies did the teacher use to both promote student’s learning for conceptual change and increase their motivation in learning science? Data presented in Chapter Four supports the conclusion that the instruction strategies used by Mrs. Scott in teaching science, exemplified in her stated teaching goal “to help students understand physics, not to teach them physics”, did influence how students in this classroom perceived their roles in learning. Her use of conceptual change teaching strategies such as diagnosing students’ thoughts on a topic, making provisions for student to be able to clarify their own thoughts through individual work or in group discussion, relating science concepts to everyday life, and creating a classroom environment conducive for students to learn are consistent with principles of conceptual change
instruction outlined by Hewson and Hewson (1988) with one notable exception (see p. 33). These instructional strategies were combined with Mrs. Scott’s ability to develop a personal relationship with each student. While she was successful in implementing conceptual change instruction in her daily teaching activities, Mrs. Scott also possessed a great personality, as perceived by her students, and was highly dedicated to helping her students understand science concepts well.

In her students’ eyes, Mrs. Scott was an energetic and creative science teacher. The conceptual change instruction employed by Mrs. Scott and her personal attention to the students positively affected their motivation to engage in conceptual change learning. They learned not only to express their thoughts on science contents but they also developed scientific understanding and considered the applications of those ideas to their daily lives. Thus, the conceptual change instruction used by Mrs. Scott, her personality, and her dedication to teaching motivated students to engage in learning for understanding. This suggests that science teachers need to create a teaching-learning climate that accommodates learning in ways that are considerate of these affective variables. Therefore, a major finding of this research is that motivation to engage in conceptual change learning in science is influenced by the teacher’s personality and instructional strategies,
as well as a student's individual goals. Students in Mrs. Scott's classroom engaged in conceptual change learning for all of these reasons.

In reference to the second research question: what are the patterns of student's motivation to engage in conceptual change learning of science? Data presented in Chapter Four support the conclusion that while all of the students in this study are highly motivated to learn, most are intrinsically motivated to learn science. Three patterns of motivation to engage in conceptual change learning in science were identified in Chapter Four. These patterns included intrinsically motivated to learn, intrinsically motivated to learn but not consistently engaged in learning each day, and extrinsically motivated to learn to fulfill an academic requirement. Those students intrinsically motivated to learn, and intrinsically motivated to learn out not consistently engaged in learning each day are motivated to learn science because they find learning science personally interesting and enjoyable. These students (Rina, Asri, Novy, Rini, Ella, Rudy, Istri, and Fany) learn mainly to understand science concepts and they elaborate science concepts by actively constructing their own knowledge as they integrate their existing ideas with scientific ideas. They also apply these ideas to understand and explain phenomena found in their everyday lives. Students extrinsically motivated to learn to fulfill an academic requirement
(Nur, Dewi, and Riva) learn science mainly to fulfill a graduation requirement. Understanding science concepts is a major goal for the students belonging to this category, although it is not the first priority. Thus, the overall conclusion for this pattern of student motivation is that students' learning goals play an important role in motivating them to engage in conceptual change learning. This goal played a crucial part in the decisions these students made about whether they would achieve scientific understanding. This conclusion is supported by Lee's (1989) findings that students who are motivated to learn engage in classroom tasks with the goal of achieving scientific understanding, and they activate strategies associated with achieving this goal.

In light of the final research question: what individual profiles can be constructed from four motivation factors (i.e., goals, values, self efficacy, and control beliefs) for the eleven student participants in this study and how are these profiles linked to their engagement (i.e., cognitive and behavioral engagement) in conceptual change learning of science? Data presented in Chapter Four support the conclusion that each of the students had a unique motivational factor profile, that is, each student had a MSLQ profile that was different from all other students. Furthermore, scores on task values and control beliefs sub scales indicate that these factors were most important to
most students. This suggests that students are motivated to learn science because they value the instructional tasks offered by the teacher as being applicable to their real lives. In addition, the students believe that they can control learning outcomes by actively engaging in learning activities. The implications of these findings are that teachers need to encourage students to connect science concepts taught in the classroom with students’ everyday lives and to encourage students developing appropriate learning strategies for conceptual understanding.

Together, teacher’s instructional strategies and students’ motivational factors contribute to their engagement in learning for understanding. Instructional strategies that were implemented based on conceptual change teaching and student’s motivational factors are crucial to student engagement in learning. This finding suggests that both research traditions, student’s motivation and conceptual change approaches to learning science, have important implications for those who wish to improve science teaching and learning. The teacher should consider that interaction with individual students in ways that help students become motivated to engage in learning within the social contexts of the classroom are an important factor. In other words, it is crucial to bring together issues of student motivation and conceptual change learning as suggested by Boyle, Magnusson, and Young.
(1993), Pintrich, Marx, and Boyle (1993), and Strike and Posner (1992). In summary, student motivation is a crucial factor that should be considered in order to maximize student engagement in learning for conceptual change.

From the cross case analysis of all students’ motivational factor profiles, the teacher’s personality was found to be the most significant factor in motivating students. All students participating in this study mentioned their teacher’s personality as the most important factor for them to get involved in the learning activities she presented. They agreed that Mrs. Scott’s sincere regard for them as individuals was a powerful extrinsic motivator for them to learn for understanding. This finding suggests that developing student-teacher interactions within the social context of the classroom is a crucial factor in teaching and learning processes associated with conceptual change.

The significant of positive relationship between teacher and students is clearly found in statements made by Dewi, Riva, and Nur. As previously described Dewi, Riva, and Nur were students who do not really like science and placed a low value on the goal of scientific understanding. Their lack of interest and motivation to learn science is clearly described in Chapter Four (see pp. 111, 118, and 134). However, Mrs. Scott’s success in developing a positive personal relationship with these students helped them develop
learning strategies for conceptual understanding. Their lack of interest toward science was reduced when their efforts were directed to satisfy their teacher, "we don’t want to let her (Mrs. Scott) down" (Riva’s statement). This suggests that in teaching and learning for conceptual change teachers need to interact with students in ways that promote greater engagement with each other and with the science content to be learned.

Implications for Science Teachers and CCM

The following discussion covers implication of the study for science teachers interested in improving the quality of student engagement in conceptual change learning. Teachers’ roles in the teaching and learning process used here are a significant factor in raising student motivation to learn in meaningful ways, especially for students who do not hold understanding as a primary goal, have negative attitudes toward science, and put low quality of task engagement. Students who are intrinsically motivated to learn and who place a high value on the goal of scientific understanding are successful without extensive support from the teacher. In this study, these students demonstrated a high quality of cognitive engagement in learning science independently. However, for students like Riva, Nur, and Dewi (about 25% of the class population) who have low quality of task engagement, a lower value in the goal of scientific understanding, and
negative attitudes toward science, require extensive teacher support
necessary to energize their efforts to engage in learning for understanding.

Implications for Other Schools/Classrooms

Science teachers in public schools are generally faced with a variety
of problems in terms of student learning. Class size (mostly between 20 to
30 students), diversity among students with different needs, short class
session, and ill-prepared and overloaded teachers may be more extensive
than in this study. In addition, teaching instruction may not be tied to real
life. All of these problems are reasons to try to motivate students who lack
motivation to learn, especially for students who possess low value in the
goal of scientific understanding and who have negative attitudes toward
science. These students have a low expectancy of success in science class.

Instructional strategies based on conceptual change teaching and
extensive teacher support to students can be effective in helping students
learn in meaningful ways. The effectiveness of these two factors (conceptual
change teaching and teacher support) is clearly described in the cases of
Riva, Dewi, and Nur.

A further implication of this study for science teachers is that they
need to help students increase their motivation to learn by reducing factors
that are identified here as barriers to student motivation in the social contexts
of classrooms. From the analysis of data presented in Chapter Four at least two factors related to students' motivation constrain their engagement in conceptual change learning. These constraints include lack of value in the goal of scientific understanding and lack of interest in learning science.

To reduce these constraints, science teachers need to help students realize that scientific understanding is a valuable goal, as the first priority of learning science, and to develop positive attitude toward science.

a. Help students to realize the value of scientific understanding in learning.

Scientific understanding is a goal for a scientifically literate society and encompasses the ability to use conceptual knowledge of science. Understanding entails the ability to distinguish between what is and what is not a scientific idea. Applying fundamental science concepts is required in modern society and is a major goal of school science education today. To reach this goal, students need to learn science by engaging in learning activities that motivate them to learn for understanding.

The importance of scientific understanding to daily life was recognized by most of the students in this study. However, some students did not put it as the priority of their personal goal (see cases of Riva, Dewi and Nur). In learning science they were more concerned with getting a good grade or fulfilling a course requirement. Lack of intrinsic motivation to learn
in meaningful ways seemed to be the major problem for these students because they had low value in the goal of understanding.

Relating course materials and teaching strategies to real daily life can help students realize the value of scientific understanding. One way to accomplish this might be by inviting parents to the school and letting them tell stories about their daily experience of taking care of plants in the garden, and repairing a doorknob. Science teachers have to place students in the process of learning science by giving them chances to explore the application of science and technology in their real lives first hand. This brings students to the conception that in a scientific society, daily life can not be separated from science and technology. As students experience the value of scientific understanding for everyday, science teachers can guide them to internalize science concepts as an end in itself.

0. Help students to develop positive attitude toward science.

As described before, one of the teacher's responsibilities is to help students learn in meaningful ways. A lot of students do not really like science. Some develop negative feeling, loosing interest in course materials and daily class activities. Consequently, they begin to perceive that science is hard. These negative attitudes toward science are negative factors when it comes to student motivation and constrain learning for understanding.
To reduce negative attitudes toward science, instructional strategies should promote students' awareness of their affective orientations in learning science. Science teachers should provide well planned learning strategies that accommodate every individual student's needs. They should provide extensive support for individual students, especially students who have limited background knowledge in science and limited motivation to learn science for understanding. Science teachers need to pay more attention to individual students' needs and communicate with them about their attitudes towards learning. In helping students reduce negative attitudes toward science, science teachers will need to determine the best ways to implement instructional strategies that develop quality social environments in science classrooms. Thus, in implementing CCM, teachers need to consider affective aspects of students' learning including motivational constructs that can lead to change in students' concepts.

Limitation of the Study

The limitations of this study resulted from the small sample of students studied. Case studies like this one require extended periods of observation and data collection in order to establish a complete picture of the characteristics of student motivation in the process of student learning for conceptual change. Every effort was made during the study to identify
motivation factors and engagements in conceptual change learning with the greatest probability of addressing the research questions. Because this study is the first attempt to identify links between student motivational factors and engagement in learning science, the results of this study are just a starting point for developing further studies in student motivation to learn science.

Finally, the results of this study are not intended to be generalized to all applications of conceptual change instruction or to create a new model of CCM. In addition, all of descriptions related to CCM and student motivation factors to learn science presented here are not intended to be used as a set of lessons that would guarantee similar results in other settings. What can be summarized from this study is that motivational factors to learn for conceptual change in science involve complex interactions among all aspects of teaching and learning. These complex interactions need to be understood as research in student motivation to learn in conceptual change continues.

Recommendations for Future Research

This study is the first attempt to identify the relationships between students’ motivational factors and engagement in conceptual change learning. The descriptions here portray how specific motivational factors interact for individual students when learning science. To understand the
uniqueness of student motivation factors in learning science requires further
research, with the findings from this study as a starting point.

Many questions related to student motivation in conceptual change
learning are valuable for future research such as “what should science
teachers do to support the highly motivated students? What happens if these
students don’t have a strong teacher? Would their motivation become less
strong?” “How would motivation factor profiles look if student participants
were more heterogeneous in achievements, ethnic and cultural backgrounds,
with other teachers?” And “how are student motivation factors related to the
status of students’ conceptions (intelligibility, plausibility, and
fruitfulness)?”

Answers to these questions are crucial if science educators are to
understand more about the links between student motivational factors and
students learning for conceptual change.

Finally, the overall conclusions drawn from this research are that
conceptual change instruction requires the teacher to be aware of the
importance of affective aspects, including motivational factors, on students
learning. Teachers have to decide how to conduct instruction within positive
social environments so that they can facilitate learning for every individual
student in meaningful ways. Understanding the complexity of these
relationships among factors that influence students' learning in science a worthwhile goal if we are to better serve students in the future.
Appendix A

Initial requests and letters
Dr. Michael Beeth,

I agree to participate in the doctoral research study to be conducted by you and Lily Barla. However, you must describe the research to any groups of students you wish to work with and get their permission and that of their parent(s) before conducting this study. I understand that this study does not require me to change any of my teaching plans and that your involvement in interviewing students will occur outside of their scheduled science class, during their study period, before or after school.

I would like to receive a copy of any research articles that result from this study.

Sincerely,

[Signature]

Karen Scott
Science Teacher

Jul 5, 1998
Dr. Michael Beeth,

I have spoken with Mrs. Karen Scott regarding your request to conduct educational research in her classroom at DeSales High School. I authorize you and Lily Berlin to conduct this research with the following conditions:

1) You must obtain the written permission of the parent(s) or guardian of any student asked to participate in the research.

2) You must coordinate all research activities through Karen Scott.

3) You ensure the anonymity of all students in any written documents that come from this study.

Sincerely,

Patrick Rossetti, Principal
DeSales High School
Hello, my name is Michael Beeth and this is Lily Barfia. We teach teachers, like Mrs. Scott, about science and science education at The Ohio State University in Columbus.

We are here today to tell you about a research study we would like to conduct at St. Francis DeSales High School and to ask if you would consider participating in this study.

First let us tell you about the study. We are interested in how what you already know affects the ways in which you learn new ideas in science. We study this because we are interested in improving ways to help students understand more of the science they learn. We will do this by asking each of you to complete a survey regarding four motivational factors in science, listening to what you and your teacher talk about as you participate in the science classes she has planned for you, and looking at the answers you give on written assignments. Based on the results from the survey, we will select eight students to interview from time to time throughout the study. Students whose responses to the survey represent the widest possible variation on each of the four motivational factors will be selected for the interviews. During these interviews we may ask these eight students to clarify something they said during a class discussion or wrote on an assignment, and you can ask us to clarify our questions as well. It would be good for us if you could always give some reasons for why you understand an idea or why you do not, as well as why you believe an idea is or is not a good one. I understand that giving reasons for your ideas is a regular part of what Mrs. Scott asks you to do, is that so?

[Response from students]

Well then this project shouldn't ask any more of you than you already do as students in Mrs. Scott's science classes.

Just to let you know some more about the project:

You will not be asked to complete any extra assignments because you agree to participate in this study. Mrs. Scott is still your teacher, and she will decide which assignments you are to complete and what grades you will receive on these assignments and as a final grade for the course.

We will be present in your science class for up to nine weeks. We will participate in your discussions about science, and audio and videotape record the conversations and activities that occur during class. We use these recordings because they provide a record of what happened during class and we can review many times. We will also look at the written assignments you produce for Mrs. Scott. We want you to know that at any time you can withdraw from this study by telling any adult at St. Francis DeSales, if you so choose.
To participate in this study we need to get your permission, and the permission of your parent or guardian, before we can begin. This letter and the form attached to it [distribute Parent Letter and Student Agreement Form] contain the same information about this study that I have just described.

Do you have any questions about the study or your involvement in it?

[Response from students]

Our telephone numbers and e-mail addresses are listed at the bottom of the letter if anyone would like to ask questions before signing the Student Agreement Form. It is important that both you and your parent or guardian sign this form. We ask that you return the form to school as soon as possible.

Are there any questions?

[Response from students]
Dear Parent/Guardian:

We are writing to request your permission, and that of your child, to participate in a study of “Conceptual Change Teaching and Learning.” A teacher at DeSales High School, Mrs. Karen Scott, is familiar with and does use teaching strategies associated with conceptual change in her science classes. In brief, conceptual change is a theory of learning that elicits the current scientific understandings that students have and uses that information as the basis for helping them develop more in-depth scientific understandings. Mrs. Scott currently uses strategies that are thought to support conceptual change learning in her science teaching. We are interested to know if these teaching strategies have any effects on motivation to learn science. Dr. Michael Beeth, an Assistant Professor at The Ohio State University, and Lily Baria, a doctoral student in science education, are the researchers who will be conducting this study. Similar studies of students’ scientific conceptions have typically focused on assessing students’ understanding of science concepts after instruction. This study is an attempt to understand if and how the motivational factors we have identified influence the learning of new science concepts.

The study we have in mind will involve your child and their teacher throughout nine weeks of the academic year. All students will be asked to complete a survey to determine which motivational factors they have towards science and science learning. We will be present in the classroom to observe all science lessons taught by Mrs. Scott, to interact with the students, and to audio and videotape record discussions that occur during class. We will collect and analyze samples of the written assignments produced by your child throughout the study, and we will audio and video record their science class during the period of this study. Your child may also be selected to participate in three or four interviews conducted during the school day. Students will be selected for interviews based on the responses they provide on the survey. We are interested to interview those students whose responses represent the widest possible variation on each of four motivational factors. If selected, your child would be interviewed by Lily Baria at times that are mutually agreed upon (e.g., during a scheduled study period). Information collected during this study will not be made available to the administration at DeSales High School, used to evaluate the performance of your child by us or shared with the teacher for the purpose of assigning grades. Your child will not be involved in any activities related to this study that require additional time outside the regular school day or any additional assignments not planned by the teacher. All science topics and assignments collected during this study will be part of the instruction planned by Mrs. Scott.

Students participating in this study will not be identified by name in any written or oral reports of the study. In addition, the name and location of the school will be altered to ensure anonymity and your child may withdraw from participation in the study, without penalty, by contacting any adult at St. Francis DeSales High School.

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We explained the purpose of this study to your child in Mrs. Scott's class and described what their participation in the study might require. If you are willing to grant permission, and if your child is willing to participate, please sign the Participant Agreement Form attached to this letter and return it to Mrs. Scott as soon as possible. It is necessary that both you and your child sign the form in the spaces indicated. Keep this letter for your records. If you have any questions about this study, feel free to contact Dr. Michael Beeth or Lily Barlia at the phone number or e-mail address below.

Sincerely,

Michael E. Beeth, Ph.D.
333 Arps Hall
1943 N. High Street
Columbus, OH 43210
614/292-5377
beeth.1@postbox.acs.ohio-state.edu

Lily Barlia, ABD
School of Teaching & Learning
577 Riverview Dr., Apt. 102
Columbus, OH 43202
614/447-9982
barlia.2@postbox.acs.ohio-state.edu
Lily Barila, a doctoral student, and I, a faculty member at The Ohio State University, are interested in studying how students learn science. We invite you to participate in a research study that will attempt to determine how you think about the science that Mrs. Scott has planned for your science class. In order for us to conduct this study, we would like to be in the classroom to observe instruction and interact with you, your classmates, and Mrs. Scott during your regular science class. We will be talking to you during the class and collecting audio and videotape recordings of your class as you participate in the lessons. Mrs. Scott has planned for you. Some students may also be asked to participate in individual interviews about how they are learning science. We will not give you extra assignments or be involved in determining your grade for the class. Our involvement in your science class will last for up to nine weeks.

We would very much appreciate your agreement to participate in this study. If you agree to be in the study, please sign your name on the left line below and ask your parent or guardian to sign on the right. You may stop your participation in the study at any time by telling Mrs. Scott or any other adult person at St. Francis DeSales High School.

Please sign your name in the space below and have your parent or guardian sign if you agree to participate in the study. This form should be returned to Mrs. Scott by the end of the week. If you have any questions about this study, please contact Michael Beeth or Lily Barila at the phone number or e-mail address below.

Student’s Signature

Parent’s Signature

Information for parents:

This study is approved by the administration at DeSales and Mrs. Scott. No student will be identified in any publication arising from this study. The study will occur throughout the academic year. No student will be evaluated by us for the purpose of assigning grades and we will not influence grades given by Mrs. Scott. A copy of the results of the study will be made available to DeSales High School. Authorization (signatures) from you and your child are both necessary.

Respectfully,

Michael E. Beeth, Ph.D.
333 Arps Hall
1945 N. High Street
Columbus, OH 43210
614/292-5377
beeth.1@postbox.xcs.ohio-state.edu

Lily Barila, ABD
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barila.2@postbox.xcs.ohio-state.edu

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Appendix B

Human subject approval
Research involving Human Subjects

ACTION OF THE INSTITUTIONAL REVIEW BOARD

With regard to the employment of human subjects in the proposed research protocol:

9830010 STUDENTS MOTIVATIONAL FACTOR PROFILES AND THEIR ENGAGEMENT IN CONCEPTUAL CHANGE LEARNING IN SCIENCE. Michael E. Bech, Lily Barlia, School of Teaching and Learning

THE BEHAVIORAL AND SOCIAL SCIENCES HUMAN SUBJECTS IRB HAS TAKEN THE FOLLOWING ACTION:

X APPROVED*  ___ DISAPPROVED

___ APPROVED WITH CONDITIONS  ___ WAIVER OF WRITTEN CONSENT GRANTED

* Conditions stated by the IRB have been met by the investigator and, therefore, the protocol is APPROVED.

It is the responsibility of the principal investigator to retain a copy of each signed consent form for at least three (3) years beyond the termination of the subject's participation in the proposed activity. Should the principal investigator leave the University, signed consent forms are to be transferred to the Human Subjects IRB for the required retention period. This application has been approved for the period of one year. You are reminded that you must promptly report any problems to the IRB, and that no procedural changes may be made without prior review and approval. You are also reminded that the identity of the research participants must be kept confidential.

Date: January 23, 1998

Signed: ____________________________
(Chairperson)

HS-0255 (Rev. 3/94)

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SURVEY QUESTIONS ABOUT MOTIVATION
(Pintrich et al., 1991)

I would like to ask for your participation in the study. As part of the study, you will be asked to fill out several questionnaires related to your motivation in this class (science class). YOUR PARTICIPATION IS VOLUNTARY AND NOT RELATED IN ANY WAY TO YOUR GRADE IN THIS CLASS. All your responses are strictly confidential and only the researcher will see your individual responses.

The attached questionnaire asks you about your motivation for work in this class (science class). THERE ARE NO RIGHT OR WRONG ANSWERS TO THIS QUESTIONNAIRE. THIS IS NOT A TEST. I want you to respond to the questionnaire as accurately as possible, reflecting your own attitudes and behavior in this class (course). Your answers to this questionnaire will be analyzed for further study.

Name (Print) ____________________________________________
Student ID Number ____________________________ Male Female
Ethnic background (circle one).
  a. Afro-American or black
  b. Asian American
  c. Caucasian
  d. Hispanic or Spanish Speaking
  e. Other
Reasons for taking this class (circle yes or no for each item)
  a. fulfills distribution requirement
  b. content seems interesting
  c. will be useful to me in other course
  d. is an easy elective
  e. will improve my academic skills
  f. is required for my major (program)
The following questions ask about your motivation for and attitudes about this class (Science class). REMEMBER THERE ARE NO RIGHT OR WRONG ANSWER, JUST ANSWER AS ACCURATELY AS POSSIBLE. Use the scale below to answer the questions. If you think the statement is very true of you, circle 7; if a statement is not at all true of you, circle 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

<table>
<thead>
<tr>
<th></th>
<th>1 not at all true of me</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7 very true of me</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>In a class like this, I prefer course material that really challenges me so I can learn new things.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2.</td>
<td>If I study in appropriate ways, then I will be able to learn the material in this course.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>3.</td>
<td>I think I will be able to use what I learn in this course in other courses.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>4.</td>
<td>I believe I will receive an excellent grade in this class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>5.</td>
<td>I'm certain I can understand the most difficult material presented in the readings for this course.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>6.</td>
<td>Getting a good grade in this class is the most satisfying thing for me right now.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>
7. When I take a test I think about items on other parts of the test I can answer.

8. It is important thing for me to learn the course material in this class.

9. The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.

10. I'm confident I can learn the basic concepts taught in this course.

11. If I can, I want to get better grades in this class than most of the other students.

12. I'm confident I can understand the most complex material presented by the instructor in this class.

13. In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.

14. I am very interested in the content area of this course.

15. If I try hard enough, then I will understand the course material.

16. I'm confident I can do an excellent job on the assignments and tests in this course.

17. I expect to do well in this class.
18. The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.

19. I think the course material in this class is useful for me to learn.

20. When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.

21. If I don't understand the course material, it is because I didn't try hard enough.

22. I like the subject matter of this course.

23. Understanding the subject matter of this course is very important to me.

24. I'm certain I can master the skills being taught in this class.

25. I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.

26. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.
Appendix D

CLASSROOM OBSERVATION GUIDELINE
(Lee, 1989)

I. HANDS-ON EXPERIMENT

Quality of Task Engagement

I. Behavioral Engagement

a. Student involvement, on-task behavior:
   What is the student’s apparent target of attention? (e.g., talk to
   friends, walk around the classroom, spend most time on
   experiment)

b. How does the student respond to distraction?

c. How enthusiastic does the student appear to be?

d. How many questions has the student finished in the activity
   book?

e. After the student finishes the experiment and the questions in
   the activity book, what does the student do next? (e.g., talk to
   friends read text, go to teacher to talk)

f. After the student finishes the questions in the activity book,
   does the student read over, check, or revise the answers?
2. Cognitive engagement
   a. What aspect of experiment does the student appear to be most concerned about? (e.g., set up equipment, measure or observe, interpret the results?)
   b. How well does the student follow the procedure of the experiment?
   c. When the student seems to be confused about the experiment, how does the student react? (e.g., simply complete it, check with friends, teacher or textbook)
   d. Where does the student get information for questions in the activity book?
   e. Which questions has the student finished in the activity book? What is the nature of the questions finished and those are not finished?
   f. If the student talks to friends or the teacher, who initiates the conversation? What is the conversation about? (e.g., content-related, socialization)
   g. One or two specific questions concerning the content of the experiment or questions in the activity book will be decided in advance and used to probe the student's content understanding.

Interpretations of Classroom tasks

1. Content Objectives (during informal interview)
   a. "What is new to you in this experiment?"
      "Did you learn anything new in this experiment?"
   b. "What is this experiment about?"
      "What is the main idea of this experiment?"
      "What does this experiment help you learn about?"
c. "Why do you think you do this experiment?"
   "What is its purpose?"

2. Perceived Difficulty (during informal interview)
   a. "How difficult is this experiment to you?"
      "How difficult are the questions in the activity book?"
   b. "What parts of the experiment are difficult? Why?"
      "Which questions in the activity book are difficult?"
      "Which questions are easy? Why?"

II. CLASS DISCUSSION.

Quality of Task Engagement

1. Behavioral Engagement
   a. Student involvement, on-task behavior:
      What is the student's apparent target of attention? (e.g., teacher, text, outside the window, look neighbors, draw or write on paper)
   b. How frequently does the student engage in class discussion?
      _____ raise his/her hand
      _____ ask questions
      _____ give answers to questions
      _____ make comments
      _____ called on by the teacher
   c. How enthusiastic or uninterested does the student appear to be? (e.g., volunteer to express ideas, wait until other students give their answers first, hesitate giving answers, tone of voice)

2. Cognitive Engagement
a. When called on by the teacher to give an answer, how does the student respond? (e.g., wait until the teacher calls on another student, give key words, do not respond)

b. Where or how do the student find the answer? (e.g., copy somebody's answer, copy from text)

c. What is the quality of the student's questions, comments, or answers? (e.g., not relevant to content being discussed, factual information; higher-order thinking)

Interpretations of Classroom Task:

1. Content Objectives (during informal interview)
   a. “What is the new during class discussion?”
      “Did you learn anything new during discussion?”
   b. “What is the discussion about?”
      “What is the main idea in the discussion?”
      “What does the discussion help you learn about?”
   c. “Why do you think you have class discussion today?”
      “What is the purpose?”

2. Perceived Difficulty (during informal interview)
   a. “How difficult was the discussion to follow?”
   b. “Which parts were difficult to follow? Why?”
      “Which parts were easy to follow? Why?”
Appendix E

INTERVIEW PROTOCOL: STUDENT ATTITUDE AND INTEREST TOWARD SCIENCE AND STUDENT SPECIFIC GOAL ORIENTATION IN LEARNING SCIENCE (Lee, 1989).

Note: This is the instruction for the interviewer. Five short sets of questions will be presented to the student on separate sheets during interview.

Introductory Direction to Student:

I: "Today we will talk about why you and other people do work in science class. First, we will talk about how you like science."

Opening Question:

I: "Suppose you had a choice between science class and free time. Which would you choose? Why?"

PART I: STUDENT ATTITUDE AND INTEREST TOWARD SCIENCE

1. Using sample of question, the interviewer explains to the student about how to answer the questions on Question Set I.

2. The student completes Question Set I by him/herself.

3. The interviewer asks the student about his/her reasons for the responses.

I: "Would you explain to me about each of your responses?"
### QUESTION SET 1: HOW I LIKE SCIENCE

<table>
<thead>
<tr>
<th>Really true for me</th>
<th>Sort of true for me</th>
<th>Really true for me</th>
<th>Sort of true for me</th>
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</tr>
<tr>
<td>Some students would rather play outdoor in spare time</td>
<td>BUT</td>
<td>Other students would rather watch TV</td>
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</tr>
<tr>
<td>1. Some students like science</td>
<td>BUT</td>
<td>Other students don't like science.</td>
<td>---</td>
</tr>
<tr>
<td>2. Some students think science is boring</td>
<td>BUT</td>
<td>Other students think science is fun and interesting.</td>
<td>---</td>
</tr>
<tr>
<td>3. Some students are curious to learn about science</td>
<td>BUT</td>
<td>Other students don't care to learn about science.</td>
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</tr>
</tbody>
</table>

189
PART II: STUDENT GOALS IN SCIENCE CLASS

1. The interviewer asks the student to explain what he/she thinks about science and science learning.

“What does science mean to you?”
“What does learning science mean to you?”
“Why do you study science?”
“Is science important? Why?”

2. The interviewer asks the student to generate his/her own list of goals in science class.

I: “What are some reasons you do work in science class?”

I: “What might other people give as reasons for doing work in science class? (e.g., classmates, science teachers, parents, or parents)

3. The interviewer presents the following list of goals (in a random order arranged on a sheet of paper) to the student and briefly talks about the goals on the list.

I: “Here are some reasons that people sometimes give for doing work in science class.”

The interviewer makes sure that the student understands the questions
Possible Reasons for Students' Doing Work in Science Class

a. Understanding
   to use science to understand the world
   to make sure my ideas are scientifically correct

b. Fact Acquisition in Class
   to learn vocabulary and definitions
   to memorize facts and information

c. Performance in Class
   to get work done on time
   to do well in class activities
   to get good grades
   to do better than other students

d. Expectations of Significant Others
   to please my parents
   to please my teacher
   to show that I am a smart person

e. Extrinsic Rewards
   to receive rewards from parents (e.g., extra money)

e. Work Avoidance
   to do as little work as possible
1. ABOUT MYSELF

1). The interviewer asks the student to complete Question Set II.
   I: “After reading each question, mark the number that you think applies to yourself most closely.”

2). The student completes question Set II by himself/herself.

3). The interviewer asks the student to report three primary reasons (goals) in order.

4). The interviewer asks the student to explain the responses.
   I: “Would you explain to me about each of your responses?”

2. VERY GOOD SCIENCE STUDENT

1). This time, the interviewer asks the same set of questions with reference to a very good science student.
   I: “Now, let’s imagine a student who is really good in science. How do you think this student would respond to the following questions?”

2). The student completes Question Set III by himself/herself.

3). The interviewer asks the students to report three primary reasons (goals) in order.

4). The interviewer asks the student to explain the responses.
   I: “Would you explain to me about your responses?”

3. SCIENCE TEACHER

1). The interviewer asks the student about why his/her science teacher would like him/her to do work in science class.

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I: “Think about your science teacher. Why do you think he wants you to do work in science class?”

2). The student completes Question Set IV by him/herself.

3). The interviewer asks the student to report three primary reasons (goals) in order.

4). The interviewer asks the student to explain the responses.

I: “Would you explain to me about your responses?”

4. PARENTS

1). The interviewer asks the student about why his/her parents would like him/her to do work in science class.

I: “Think about a scientist. Why do you think he wants you to do work in science class?”

2). The student completes Question Set V by him/herself.

3). The interviewer asks the student to report three primary reasons (goals) in order.

4). The interviewer asks the student to explain the responses.

I: “Would you explain to me about your responses?”
**QUESTION SET II: ABOUT MYSELF**

"I do work in science class..."

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<tr>
<th></th>
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</tr>
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<tbody>
<tr>
<td>a. to get work done on time</td>
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<td></td>
</tr>
<tr>
<td>b. to memorize facts and information</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>c. to learn vocabulary and definitions</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>d. to receive rewards (e.g., extra money) from parents</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>e. to do better than other students</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>f. to use science to understand the world</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>g. to please my parents</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>h. to get good grades</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>i. to make sure my ideas are scientifically correct</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>j. to do as little work as possible</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>k. to show that I am a smart person</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>l. to do well in class activities</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>m. to please my teacher</td>
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**QUESTION SET III: VERY GOOD SCIENCE STUDENT**

"A very good science student would do work in science class...."  

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<tr>
<td>b. to memorize facts and information</td>
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<td>c. to learn vocabulary and definitions</td>
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<td></td>
</tr>
<tr>
<td>d. to receive rewards (e.g., extra money) from parents</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>e. to do better than other students</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>f. to use science to understand the world</td>
<td>1 2 3 4 5 6 7</td>
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<td>g. to please parents</td>
<td>1 2 3 4 5 6 7</td>
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<td>h. to get good grades</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>i. to do as little work as possible</td>
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<tr>
<td>j. to make sure his/her ideas are scientifically correct</td>
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<tr>
<td>k. to show that he/she is a smart person</td>
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<tr>
<td>l. to do well in class activities</td>
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195
**QUESTION SET IV: SCIENCE TEACHER**

"My science teacher wants me to do work in science class...."

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<td>b. to make sure my ideas are scientifically correct</td>
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<td>c. to do well in class activities</td>
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<td>d. to get work done on time</td>
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<td>e. to memorize facts and information</td>
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<tr>
<td>f. to learn vocabulary and definitions</td>
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<td>g. to do better than other students</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>h. to use science to understand the world</td>
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<td></td>
</tr>
<tr>
<td>i. to get good grades</td>
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**QUESTION SET V: PARENTS**

"My parents want me to do work in science class...."

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<th>very important of me</th>
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</thead>
<tbody>
<tr>
<td>a. to show that I am a smart person</td>
<td>1 2 3 4 5 6 7</td>
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<td>b. to make sure my ideas are scientifically correct</td>
<td>1 2 3 4 5 6 7</td>
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<tr>
<td>c. to memorize facts and information</td>
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<td>d. to learn vocabulary and definitions</td>
<td>1 2 3 4 5 6 7</td>
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<td>e. to use science to understand the world</td>
<td>1 2 3 4 5 6 7</td>
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### Overall Motivation Scores Based on MSLQ Data

<table>
<thead>
<tr>
<th>STUDENT'S NAME</th>
<th>ISTI</th>
<th>NOVY</th>
<th>RINA</th>
<th>DEWI</th>
<th>RUDY</th>
<th>NUR</th>
<th>ELLA</th>
<th>FANY</th>
<th>RIMI</th>
<th>RIVA</th>
<th>ASRI</th>
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<td>6.4</td>
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<td>6.5</td>
<td>6.0</td>
<td>5.6</td>
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<td>6.0</td>
<td>5.6</td>
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</tbody>
</table>
\[
\begin{array}{c|c}
X & X^2 \\
\hline
5.2 & 27.04 \\
5.9 & 34.81 \\
5.3 & 28.09 \\
5.2 & 27.04 \\
6.3 & 39.69 \\
4.6 & 21.16 \\
6.1 & 37.21 \\
5.8 & 33.64 \\
6.3 & 39.69 \\
4.8 & 23.04 \\
6.0 & 36.00 \\
\end{array}
\]

\[\sum X = 61.6\]
\[N = 11\]
\[\text{Mean} = 5.6\]

Sum Square (SS) = \[\frac{\sum X^2 - (\sum X)^2}{N}\]

\[= \frac{348.46 - 3,794.56}{11}\]

\[\rightarrow \text{SS} = 3.5\]

\[
\text{Standard Deviation} = \sqrt{\frac{\text{SS}}{N}}
\]

\[= \sqrt{\frac{3.5}{11}}\]

\[\rightarrow \text{SD} = 0.56\]

\[
\text{Standard Error} = \frac{\text{SD}}{\sqrt{N}} = 0.16
\]

199
Standard score $z = \frac{X - \mu}{\sigma}$

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
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<tr>
<td>NOVY</td>
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</tr>
<tr>
<td>RENA</td>
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<tr>
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Appendix G

Individual Motivation Scores for Subscales of the MSLQ

a. Students’ goal orientation

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<th>Extrinsic goal orientation question no</th>
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<tr>
<td>RINA</td>
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</tr>
<tr>
<td>DEWI</td>
<td>5 6 7 4 5.5 5 7 4 3 4.8 5.2</td>
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<tr>
<td>RUDY</td>
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<tr>
<td>NUR</td>
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<tr>
<td>ELLA</td>
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201
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<td>RINI</td>
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## c. Self-efficacy

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### d. Control beliefs

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Appendix H

Frequency of Involvement in Classroom Activities (Behavioral engagement)

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<th>Answering questions (volunteer)</th>
<th>Becoming a role model (demonstration)</th>
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Appendix I

Frequency of student initiated cognitive and cognitive engagement in classroom activities

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<th>Student</th>
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Bibliography


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