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AUTHOR	Barlia, Lily; Beeth, Michael E.
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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 conceptions to change, few have investigated the role that non-cognitive factors might play when students are exposed to conceptual change instruction. In this study, three research questions were examined: (a) what instructional strategies were used to promote learning for conceptual change and increase students' motivation for learning science? (b) what are the patterns of motivation to engage in conceptual change learning for the students in this study? and (c) what individual profiles can be constructed from four motivational factors (i.e., behavioral and cognitive engagement, goals, values, self-efficacy and control beliefs)? Answers to these questions suggest how these profiles are linked to student behavioral and cognitive engagement during conceptual change learning in science. The subjects for this study included eleven 12th-grade students (ages 17-18) in a traditional calculus-based physics class and their teacher. Data collected for this study included classroom observation of students and teacher, self-reported responses to the Motivated Strategies for Learning Questionnaire (MSLQ), and structured interviews with individual students. Analysis of these data resulted in a motivational factor profile for each student and a cross-case analysis for the entire group. Results from this study indicate that individual differences in the profile for each student did influence their engagement in learning science. Among these motivation factors, task value and control beliefs were most important for most 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. Furthermore, students' motivation to learn was also influenced by factors not captured by the MLSQ, such as the teacher's personality, which had a positive influence on student learning. The overall conclusion drawn from the study is that conceptual change instruction requires the teacher to be aware of the factors which motivate learning when that learning follows strategies for conceptual change. (Contains 20 references.) (Author/ASK)

HIGH SCHOOL STUDENTS' MOTIVATION TO ENGAGE IN CONCEPTUAL CHANGE LEARNING IN SCIENCE

Lily Barlia
The Ohio State University
and
IKIP-Bandung, West Java, Indonesia
(after June 30, 1999)

and

Michael E. Beeth
The Ohio State University
333 Arps Hall
1945 North High Street
Columbus, OH 43210-1172
USA

Paper presented at the meeting of the National Association for Research in Science Teaching, Boston, MA, March 28, 1999.
(correspondence to beeth.1@osu.edu)

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. In this study three research questions were examined: (a) What instructional strategies were used to promote learning for conceptual change and increase students motivation when learning science? (b) what are the patterns of motivation to engage in conceptual change learning for the students in this study? and (c) what individual profiles can be constructed from four motivational factors (i.e., goals, values, self-efficacy, and control beliefs). Answers to these questions suggest how are these profiles are linked to student engagement (i.e., behavioral and cognitive engagement) during conceptual change learning in science.

The subjects for this study included eleven twelfth grade US students (ages 17-18) in a traditional calculus-based physics class and their teacher. Data collected for this study included classroom observation of students and teacher, self-reported responses to the Motivated Strategies for Learning Questionnaire (MSLQ), and structured interviews with individual students. Analysis of these data resulted in a motivational factor profile for each student and a cross case analysis for the entire group. Results from this study indicate that individual differences in the profile for each student did influence their engagement in learning science. Among these motivation factors, task value and control beliefs were most important for most 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 life. Furthermore, students motivation to learn was also influenced by factors not captured by the MSLQ such as the teacher's unique personality which had a positive influence on student learning. The overall conclusion drawn from this study are that conceptual change instruction requires the teacher to be aware of the importance of these motivational factors to learning when that learning follows strategies for conceptual change.

Introduction

Research on student's concept learning in science 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 has been the focus of much attention and research in the science education community (Beeth, 1998; Beeth & Hewson, in press; Pintrich, Marx, & Boyle, 1993; Strike & Posner, 1992). The authors of the Conceptual Change Model (hereafter referred to as the CCM) look 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 knowledge change in the scientific communities. Thus, scientific knowledge is constructed based on a learners current understanding of a phenomenon and the impacts of new information or new ways of thinking about existing information that bear on that phenomenon.

Despite the fact that the CCM is widely accepted and has had considerable influence in science education research and curriculum development, science educators are still confronted with students who are unmotivated to work toward achieving scientific understanding. Many students spend their time and effort focusing on less important learning outcomes such as memorizing science vocabulary or factual information, rather than trying to achieve conceptual understanding (Anderson & Roth, 1989; Blumenfeld & Meece, 1988; Tobin & Gallagher, 1987). In addition, they also rely on inadequate explanations for science concepts by distorting scientific data to spare their existing knowledge (Chinn & Brewer, 1998), mindlessly answering questions, or copying answers from their text or peers (Anderson & Roth, 1989; Blumenfeld & Meece, 1988). This raises a concern among science educators about the relationship of student motivation to learn science when the teacher teaches for conceptual change.

A number of criticisms have been directed at the CCM. One specific criticism of the CCM is that it lacks attention to affective aspects of learning, including motivational constructs. Pintrich, Marx and Boyle (1993) argue that the CCM's highly rational view of learning (being driven solely by logic and scientific thinking) ignores motivational constructs such as goals, value beliefs, or self-efficacy beliefs. Indeed, Strike and Posner (1992) have indicated that affective factors are an important area that should be investigated.

Pintrich, Marx, and Boyle (1993) and Boyle, Magnusson, and Young (1993) believe that student motivation is an important factor that can lead to raising or lowering the status of a conception. For instance, accepting the fruitfulness of a new conception implies a role for student's value judgments about the applicability of a conception as well as his or her goals for learning, such as how new information might help in attaining a desired end. On the other hand, 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 to engaging students in conceptual change learning. This is to say that the process of conceptual change is influenced by personal, motivational, social, and historical processes (Cobb, 1994; Driver, Asoko, Leach, Mortimer, & Scott, 1994; Pintrich, Marx, & Boyle, 1993).

Research Methodology

This study attempted to bring together research on student's motivation with research on conceptual change learning in science. A specific goal of this study is to investigate the relationships between motivation factors and students engagement in conceptual change learning in science. Three research questions were examined in this study: (a) What instructional strategies were used to promote learning for conceptual change and increase students motivation when learning science? (b) What are the patterns of motivation to engage in conceptual change learning for the students in this study? and (c) what individual profiles can be constructed from four motivational factors (i.e., goals, values, self-efficacy, and control beliefs).

The study was conducted for nine weeks (42 days) during the 1997-1998 school year in a senior high school calculus-based physics class located in the greater Columbus metropolitan area. The teacher, Mrs. Scott, implemented principles of conceptual change instruction through her daily classroom activities. The eleven students selected for this study represented both genders (9 female, 2 male) and two ethnic backgrounds (10 Caucasian, 1 Hispanic).

Data collection for this study included student's self-reported responses to the Motivated Strategies for Learning Questionnaire (MSLQ), classroom observation of students and teacher, and structured interviews. The MSLQ is a self-report instrument. It has been under development formally 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 indicate that data obtained on the MSLQ show reasonable factor validity.

The first section of the MSLQ, a section that assess the motivational factors of goals, values, self-efficacy, and control beliefs, was used in this study. This was administered to all eleven students one week prior to beginning observation of instruction or interviewing of students.

Direct observation of classroom instruction focused on: (1) the sequence of events that the teacher presented to students, the strategies that teacher uses, and the materials presented during science lesson; (2) students behavior in response to the teacher instructions; and (3) instances when motivational behaviors were openly expressed by the students. Interviews were guided by a structured format. Each interview was conducted individually once a week lasting between 15 minutes and half an hour focused on (1) obtaining information on motivational factors that are not elicited through the self-report questionnaire (i.e., student's specific goals orientation of learning science), and (2) validating findings that result from student's self-report and observations.

The data analysis procedures are intended to identify information related to the research questions. Three general steps of data analysis are used: (a) analysis based on the researchers intuitive reasoning from a complete reading of all data, (b) analysis using a rating or frequency counts, and (c) developing case studies. Analysis of these data resulted in motivational factor profile for each student and cross case analysis for entire study participants.

Students' Responses to the Teaching Instruction

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 learning. Her 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 similar to the principles of conceptual change instruction suggested by Hewson and Hewson (1988) with one notable exception. Mrs. Scott's instructional strategies are combined with her ability to successfully develop a personal relationship with each student. While she was successful in implemented conceptual change instructions in her daily teaching activities, Mrs. Scott also possessed a great personality, as perceived by her students, and was highly dedicated to teaching science well.

In her students' eyes Mrs. Scott was an energetic and a creative science teacher. The conceptual change instruction employed by Mrs. Scott in daily activities, and her personal approach to the students, 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 daily life. 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 suggest that science teachers need to create a teaching-learning climate that presents science concepts in ways that are meaningful to students. Therefore, a major finding of this research is that students motivation to engage in conceptual change learning in science is influenced by the teacher's personality and instructional strategies in combination with students personal goals. Students in Mrs. Scott's classroom engaged in conceptual change learning for each of these reasons.

Patterns of Students' Motivation to Learn

Three key aspects of students' task engagement (self-initiated cognitive, cognitive, and behavioral engagement) were selected as the categories for determining the patterns of a student's motivation to engage in learning science (Lee, 1989; Lee & Anderson, 1993; Lee & Brophy, 1996). These three key aspects of students' engagement are based on Lee's (1989) descriptions as follows: Self-initiated cognitive engagement is defined as when a student explains his thinking or express his/her ideas that are not solicited by the teacher. Cognitive engagement is defined as when a student actively expresses his own knowledge as they try to integrate personal knowledge. Behavioral engagement is defined as when a student appears attentive and involved in class activities.

In light of these three key aspects of student's task engagement, three patterns of student engagement in learning science were identified: These patterns included (1) intrinsically motivated to learn, (2) intrinsically motivated to learn but not consistently engaged each day, and (3) extrinsicly motivated to learn to fulfill an academic requirement. Intrinsically motivated to learn, and intrinsically motivated to learn but not consistently engaged each day are described as the students seemed to be motivated to learn science because they found learning science as intrinsically interesting and enjoyable. These students (Rina, Asri, Novy, Rini, Ella, Rudy, and

Fany) learn mainly to understand and elaborate the science concepts by actively constructing their own knowledge as they tried to integrate their existing ideas with scientific ideas. They also applied these ideas to understand and explain phenomena found in their immediate surrounding. Students extrinsicly motivated to learn to fulfill an academic requirement are described as the students' major goal in learning of science mainly to fulfill graduation requirement. These students (Nur, Riva, and Dewi) tried to integrate their existing ideas with scientific ideas and apply these ideas in order to explain and understand phenomena found in the world around them. Understanding science concepts is also a major goal for the students belong to this category, although it is not the first priority. Thus, an overall conclusion drawn from this pattern of student motivation is that learning goals do play an important role in motivating these two groups of students to engage in conceptual change learning. These goals also 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.

Student Motivational Factor Profile

Student motivational factor profiles were constructed from responses to questions on the seven point Likert-scale MSLQ instrument. In 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, scales were constructed by taking the mean of the items for each subscale. For example, intrinsic goal orientation was evaluated by four items. So, individual's score for intrinsic goal orientation was computed by summing the four MSLQ items and taking the average. Raw scores on the seven-point scale were as follow: score 4, 5, 6, or 7 were higher than score of 1, 2, or 3 (Pintrich at al., 1991). The score for each motivational factor (i.e., goals, values, self-efficacy, and control beliefs) was transferred to create a motivation profile for each student. The overall results as measured by the MSLQ instrument show that all of the students in the class were motivated to learn science (class average of MSLQ score = 5.6 -- standard error 0.16). A cursory analysis of the MSLQ data also indicated that the motivational factor profile for each student was unique. Each student had MSLQ profile that was different from all other students. These differences create individual profiles that portray different motivation factors that impact on an individual's learning. Furthermore, scores on the task values and control beliefs sub-scales indicated 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. The implications of these findings are that teachers need to encourage students to connect the science concepts taught in the classroom with students' everyday lives.

Together, instructional strategies and students' motivational factors contributed to their engagement in learning for understanding. Instructional strategies that were implemented based on conceptual change teaching and student's motivational factors such as goals, values, self-efficacy, and control beliefs provided crucial effect on the quality of student engagement in learning activities. This findings suggest that both traditions, student's motivation and conceptual change approaches to learning science, have important implications for those who wish to improve science teaching/learning. Teacher's interaction with the individual students in ways that would help student to more motivated to engage in learning within social contexts of the classroom seemed to be the important factor to be considered by the teacher in daily teaching-learning activities. 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 can be a crucial factor that should be considered to maximize student engagement in learning for conceptual change. Following are two case studies of student motivational profiles that represent extreme cases for the students in the study.

RINA

Rina's mean total MSLQ score is 5.3. Rina's average for individual motivation factors is: 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 consists of 20% goal orientation, 32% task value, 21% self-efficacy, and 27% control beliefs (see Figure 1). Task values comprise an extremely large portion of Rina's motivation score. According to the MSLQ data, this means that task value is the most crucial motivational factor for her when learn science.

Compared to the overall mean of the class, Rina's score is slightly below that of the class (5.3 for Rina compared to 5.6 for the class). From the four sub-scale factors, her task value seems to contribute most to her motivation to learn science (see Figure 2). On the other hand, goal orientation is less of a priority for her as indicated by a mean of 4.2, which is 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 slightly below that of the class mean. Rina's motivation factor profile is located in the middle 50% 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 perceives the need for science course materials to be 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 mean of discovering things, of understanding how the 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 opens 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 starts are found out in the space. Science is an ongoing thing that must change as the world changes.

Rina connects everyday phenomenon with the science she is learning. This may fertilize her curiosity and lead her to more involvement in conceptual change 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.

Rina continues her explanation of how science concepts need to be useable, interesting, and important to her in the following.

> Since I have begun studying physics, I apply my new physics perspective to more things that are 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 important an understanding of physics concepts is to understanding the world around her. Further, Rina explains why learning science is so interesting to her. 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 the 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, external 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 her efforts in this physics class.

> I am hoping to receive a high "B" at least for this class [physics class]. If I could get an "A" 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 good 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.

> 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 class and rarely participated in extraneous social conversations, even with student sitting next to her tried to engage her. In the group activities, like hands-on experiments, she worked with Nur and Fany. Rina set up the equipment for the group and the group remained on task during the experiments.

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.

NUR

Nur has a mean total MSLQ 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 3).

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). Her motivation to learn science is the lowest one 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 it is fun do I like to study [physics].

From the statement above, it is clear that Nur's interests in physics are not because she finds the concepts useful, but because the course is required for her to graduate. Although, Nur doesn't like physics very much, she tries to do her best to receive for a good grade. This is clearly indicated in the following statement.

> The important thing for me [when learning 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.

The teacher and Nur's classmates play important roles in helping her learn what she can. Mrs. Scott teaching and Nur's classmates lend her valuable support that motivates her 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, it can relate some type of ideas with it.

During most daily class activities Nur spent time alone. This might be related to her language and cultural background since Nur is the only student who comes from a Spanish speaking background. Mrs. Scott frequently assisted her in group activities with two other students, Rina and Fany. Although Nur's overall MSLQ score is the lowest in this class, this might be related to her language and cultural differences rather than to her interest in the subject. Differences in language and culture might affect her comprehension, and this may contribute to the motivation score she received on the MSLQ.

Cross Case Analysis

From the cross case analysis, students' motivation to learn science for conceptual understanding was also influenced by other factors that are not directly related to the four subscale factors assessed by the MSLQ, these factors were obtained through student interviews 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 important/useful to student's daily life, and (e) the course was required for graduation.

The teacher's personality was found to be the most crucial contribution to motivating student. All of students participating in this study mentioned their teacher's personality as the most important factor for them to get involved in the learning process. They agreed that Mrs. Scott's sincere love for them as both students and individuals became a powerful extrinsic motivator for them to learn for understanding. This finding suggests that developing students-teacher interaction within the social contexts of the classroom is crucial in the teaching-learning process.

The power of developing positive relationship between teacher and students was that it contributed to motivating students to engage in conceptual change learning is clearly found in statements made by Dewi, Riva, and Nur. Dewi, Riva, and Nur were identified as students who do not really like science and placed a low value on the goal of scientific understanding. However, Mrs. Scott's success in developing positive personal relationship with these students helped them succeed in developing learning strategies for conceptual understanding. Their lack of interest toward science (i.e. physics) was reduced by their effort in daily science class activities to satisfy their teacher, "they don't want to let her (Mrs. Scott) down" (Riva's statement). Consequently, the students were actively engaged in conceptual change learning in daily classroom activities and developed learning strategies such as study parties and after class discussions with the teacher to enhance their understanding of physics concepts. This suggests that in the teaching learning process teachers need to interact with students in the ways that would promote greater engagement within each other and the science content to be learned.

Implications for Science Teachers and CCM

The following discussion covers implication related to the findings of this study. This discussion is focused on implication of the study for science teachers interested in improving the quality of student engagement in conceptual change learning.

Teachers' roles in teaching-learning process seemed to be the most significant factor to raise students' motivation to learn in meaningful ways, especially for students who have low value in the goal of understanding, negative attitudes toward science, and low quality of task engagement. Although, they were reasonable successful in getting a good grade. For students who have been already intrinsically motivated to learn and high value in the goal of scientific understanding might have been successful without extensive support from the teacher (see Rina's case). They could have demonstrated 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, low value in the goal of scientific understanding, and negative attitudes toward science, require extensive teacher's supports necessary to energize their efforts to engage in learning for understanding.

If we look at the reality of public schools closely. The public schools are generally faced the same problems. The problems include class size (mostly between 20 to 30 students), more diversity students with different needs, short class session, and ill prepared and overloaded teachers. In addition, teaching instructional strategies are sometimes not tied to real life. All of these problems are reasonable reasons to create students who are lack of motivation to learn. Consequently, this affects on low quality of students' engagement in learning, especially for students who possess low value in the goal of scientific understanding and negative attitudes toward science. Further, these problems can be the potential source of creating more and more students who are lack of motivation to engage in conceptual change learning of science. This group of students has low expectancy of success in science class altogether if they don't receive proper intervention from the teacher.

Teaching instructional strategies based on conceptual change teaching and extensive teacher support to students as needed seem to effectively help students' motivation to learn in meaningful ways. The effectiveness of these two factors (conceptual change teaching and teacher support) is clearly described, for example in Nur case. This can be one of the valuable solutions to help these students population to increase their expectations to be accountable for their learning outcomes instead of just finishing the work or course assignment.

Furthermore, the implication of the result of this study for science teachers is to help students to increase their motivation to learn for conceptual change through understanding and reducing factors that are identified as the barriers for students' motivation in the social contexts of classrooms. At least two factors related to students' motivation constrains to engage in conceptual change learning are identified. These constrains include students' lack of value in the goal of scientific understanding, and students' lack of interest in learning science.

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

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

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

The important of scientific understanding for daily life has been recognized by most of students. However, they did not put it as the priority of their personal goal (e.g., see Nur's case). In learning science they were more concerned with getting a good grade, fulfilling course requirement for graduation or sometimes just for competing goal. Lack of an intrinsic motivation to learn in meaningful ways seemed to be the major problem for them because they have low value in the goal of understanding.

Relating course materials and teaching strategies to real daily life can help students to realize the value of scientific understanding to their daily life. Science teachers have to place students in the process of learning science by giving them chance to explore the application of science and technology in their real life at the first hand. This brings students to the conceptions that in the scientific society, daily life can not be separated from science and technology. As students got experience the value of scientific understanding for everyday using, science teachers can guide them to internalize the goal of scientific understanding as the priority of students' personal goal as end of itself in learning science.

<u>Help students to develop positive attitude toward science.</u>

As described before, one of the teacher responsibilities is to help students learn in meaningful ways. A lot of students do not really like science. Some of them develop negative feeling such as uninterested course materials, boring daily class activities, and uninterested teachers. Consequently, they thought science is a hard course. This can be some of the reasons for students to develop negative affective orientation toward aspects of a science class. These negative attitudes toward science can be the factors of students motivation constrains in learning science for understanding.

To reduce students' negative attitude toward science, teaching instructional strategies should incorporate students' awareness of affective orientation in learning science. Science teachers should provide well-conducted teaching-learning strategies that accommodates every individual student needs. They should provide extensive support for individual student, especially for students who have less background of science knowledge and less intrinsic motivation to learn science for understanding. Science teachers need to pay more attention to individual needs and keep closely communicating with them accommodating for their learning. Helping students to reduce negative attitude toward science, science teachers have to determine the best way to implement teaching instructional strategies (CCM) that develop quality of social environment in science classroom activities. Thus, in implementing CCM, teachers need to consider the affective aspects of students' learning including motivational constructs would lead to change in students' learning.

Finally, if conceptual change instruction is to become a widespread means of instruction, and becomes one of the alternative solutions to improve the quality of students' learning, it needs to be introduced to my home country (Indonesia) that faced quite serious problems in the quality of students learning outcomes. One of the possibilities introducing the CCM is by teaching it in preservice science education programs including Master and Doctorate programs, at least in the institution where the first author is directly involved in teacher preparation programs at the Institute of Teacher and Education Sciences (IKIP) Bandung, West Java, Indonesia.

Recommendation for Future Research

This study is the first attempt to identify the relationships between students' motivation factors and their engagement in conceptual change learning. The rich descriptions in this study provide a deeper understanding of the link between students' motivational factors and students' engagement in conceptual change learning of science. Furthermore, these descriptions 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 where this study findings can be used as a starting point.

There are a lot of questions coming up related to students motivation factors in conceptual change learning valuable to find out for future research such as "how would motivation factor profiles look like if student participants were more heterogeneous in achievements, ethnic and cultural backgrounds, with the same teacher (Mrs. Scott)?" and "how are the student motivation factors related to the condition of status (process of raising and lowering status) of students' conception (intelligibility, plausibility, and fruitful) in the process of students' conceptual change learning of science?"

Answers to questions are crucial if science educators are to understand more of 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 and motivational factors of students learning. Teachers have to decide how to conduct instruction within positive social environments so that they can facilitate every individual student's needs for learning science in meaningful ways. The complexity of the relationships among factors that influence students learn in a science classroom are worthwhile to understand if we are to serve better educate students in the future.

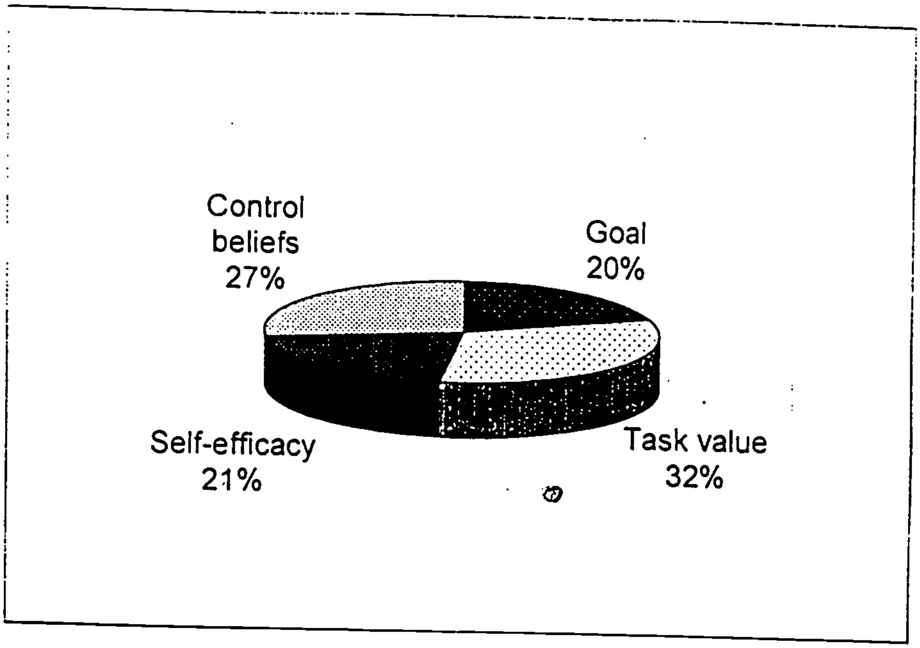

Figure 01 : Rina's motivational factor percentage

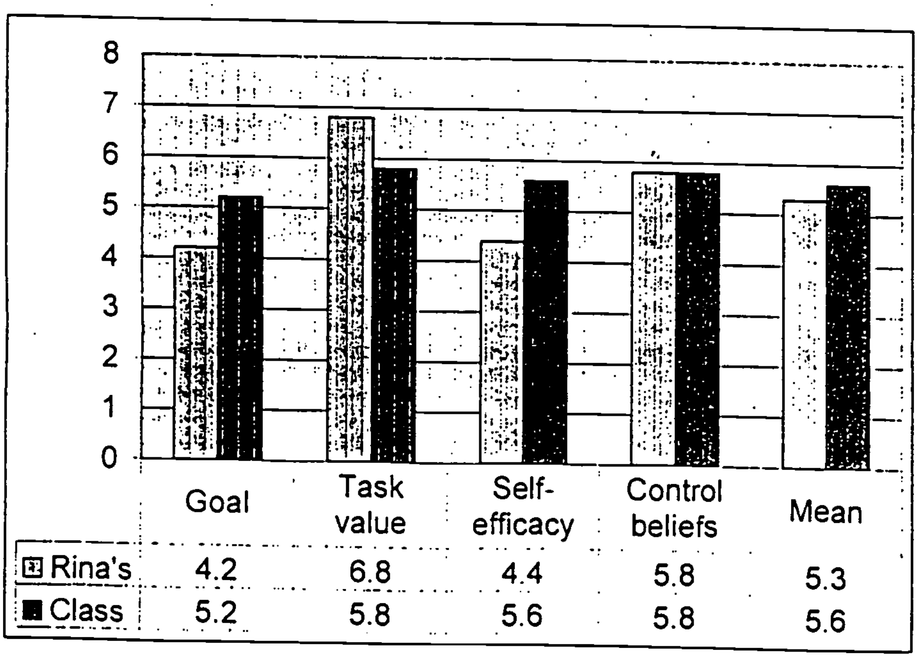

Figure 02: Rina's motivational factor scores compared to those of the class.

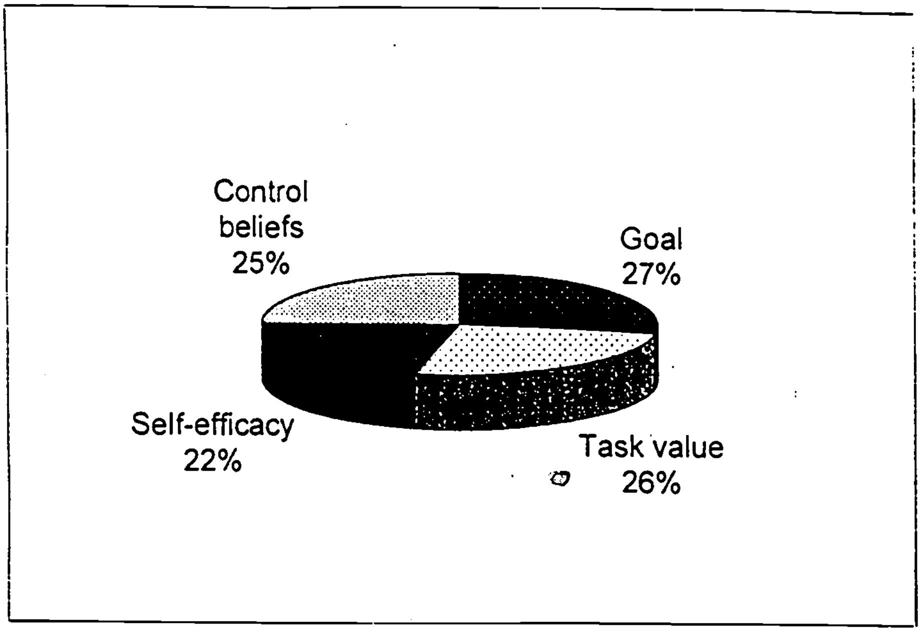

Figure 03 : Nur's motivational factor percentage

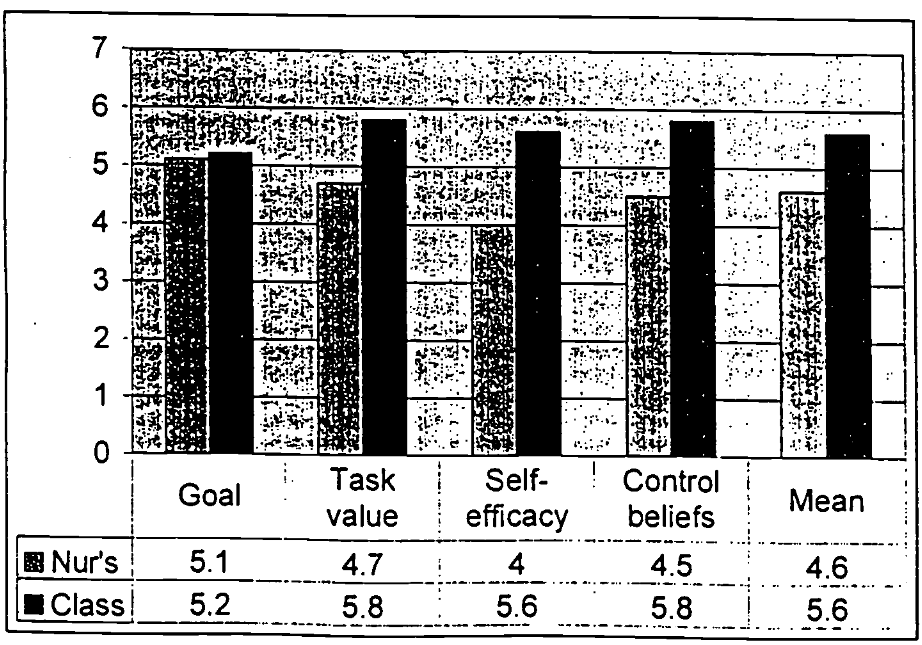

Figure 04 : Nur's motivational factor scores compared to those of the class

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Signature: Michael E. Beeth

Printed Name/Position/Title: Michael E. Beeth, Ph. D. Assistant Professor

Organization/Address: The Ohio State University
333 Arps Hall
1945 N. High Street
Columbus, OH 43210-1172

Telephone: 292-5377

FAX: 292-7695

E-Mail Address: beeth.1@osu.edu

Date: 3/23/99