STUDENT PERCEPTIONS OF ENGAGEMENT, CHALLENGE, SCAFFOLDING, AND CONFIDENCE WHEN COMPLETING HIGH SCHOOL ALGEBRA TASKS

by

Christopher S. Hlas

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Thesis Supervisor: Professor Emeritus Harold L. Schoen

Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

Christopher S. Hlas

has been approved by the Examining Committee for the thesis requirement for the Doctor of Philosophy degree in Education (Mathematics Education) at the July 2005 graduation.

Thesis Committee: ______________________________
Harold L. Schoen, Thesis Supervisor

____
Timothy Ansley

____
Joyce Moore

____
Paul S. Muhly

____
William Nibbelink

____
Thomas Rocklin

For Yoda.

Your problem may be modest; but if it challenges your curiosity and brings
into play your inventive facilities, and if you solve it by your own means,
you may experience the tension and enjoy the triumph of discovery.
Pólya, *How to Solve it*

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ABSTRACT

The study investigates student perceptions of high school algebra tasks. Students completed a short survey after each of 38 pre-selected tasks. These tasks focused on algebra content and were from the curriculum Contemporary Mathematics in Context. The survey asked students to rate their levels of interest, concentration, enjoyment, challenge, amount of help required (scaffolding), and confidence in their solutions. The average of the first three variables provides a measure of student engagement. Student scores on two unit examinations provide an achievement measure.

Data for 38 students was collected from three classes in two schools over a 14-week period. Most of the students were in the ninth grade. Data were analyzed by school because of statistical differences between schools on engagement variables and achievement. One school reported moderate engagement, while the other reported lower engagement. Concentration was rated almost two points higher than both interest and enjoyment.

For both schools, challenge and help required were both below the midpoint of the scale. Confidence was high, regardless of perceived challenge of the task. Correlation coefficients indicate school differences regarding the effects of challenge and scaffolding on affective variables (interest and enjoyment). There were no statistically significant correlations between survey variables and achievement.

Current ITBS Mathematics scores were used to create low, middle and high groups of entering mathematics ability. There were no significant differences between groups. This is likely due to school differences. There were also no significant differences by gender.

Mathematics tasks were investigated in three ways. First, there were no significant differences between tasks from the first half of an investigation versus the last half. Second, there were no significant differences between results for the two units. Finally, a post hoc analysis was done by task. There was variation between tasks, but no clear pattern in the results.

The overall results suggest that student engagement is a complex structure and is influenced by school and teacher factors. It is hypothesized that teacher's knowledge of the curriculum and quality of scaffolding are partially responsible for school differences.

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CHAPTER ONE

INTRODUCTION

Fewer and fewer students take mathematics as they continue through their academic lives. In fact, once mathematics ceases to be a requirement, students drop out at a rate of 50% per year (Steen, 1989). More recently, secondary students report they want less mathematics and they enjoy it less than other classes (Shernoff, Knauth, and Markis, 2001). It is difficult to imagine that such students enjoy being in class or are putting forth much effort to learn. Instead, it is more likely that these students are bored and feel that mathematics is a task to be suffered. One hypothesis to explain these behaviours is that students are not engaged during mathematics classes.

Student engagement refers to the psychological connection between students and classroom activities (Steinberg, Brown and Dornbusch, 1996). This broad definition allows for various interpretations of what constitutes engagement. In a meta-analysis of the subject, Fredricks, Blumenfeld, and Paris (2004) identify three general areas of engagement: behavioral, emotional, and cognitive. Behavioral engagement focuses on conduct, effort and participation. Emotional engagement involves affective variables such as boredom or happiness. Cognitive engagement includes attributes such as metacognition and a preference for challenges. Research in these areas tend to overlap because there are not precise definitions or standard measures for types of engagement (Fredrick, Blumenfeld, and Paris, 2004).

Measures of student engagement are more various than its interpretations. A few examples of measures include the following: time on task, disruptive behaviour, absences, attitudes, and cognitive demands (Fredricks, Blumenfeld, and Paris, 2004; Stein, Smith, Henningsen, and Silver, 2000; Steinberg, Brown and Dornbusch, 1996). Flow theory is frequently used to provide a theoretical background for measuring student engagement (Borman, et al. 2005; Shernoff, Csikszentmihalyi, Schneider, and Shernoff, 2003; Turner, Meyer, Cox, Logan, DiCintio, and Thomas, 1998).

Developed by Csikszentmihalyi, flow theory attempts to explain conditions that allow people to be totally absorbed by an activity (Csikszentmihalyi, 1990). People in such states describe themselves as "in the zone" or in flow. Through his research, Csikszentmihalyi discovered that people tend to be in flow when they are interested in the activity, they feel in control of the activity, and the activity affords a balance of challenge and skill (Egbert, 2003). It is important to note that flow represents an extremely high form of engagement. More details on flow theory are in Chapter Two.

Shernoff, Csikszentmihalyi, Schneider, and Shernoff (2003) present a model of student engagement that is based on flow theory. These researchers identify three qualities that together constitute student engagement: interest, concentration, and enjoyment. These and other researchers argue that all three variables are important in education. First, a desired outcome of education is *interest* in the topic of study (Ryan and Deci, 2000). Second, *concentration* is deemed important because talented students reported higher concentration on school work than their peers (Csikszentmihalyi, Rathunde and Whalen, 1997). Finally, students who *enjoy* learning a topic will continue to learn and pursue the topic (Shernoff, et al., 2003). The current study uses Shernoff, et al.'s definition of student engagement and elements of their study's design.

This model of student engagement was used to answer two questions in a longitudinal study of 526 high school students (Shernoff, et al., 2003). The first question was, "how do high school students spend their time in school?" (p. 162). The researchers found that students spent most of their time during a school day doing individual work (23%) and in lectures (21%). Further, small amounts of time were spent in interactive environments. For example, students were in class discussions or group work nine percent and six percent of the time, respectively.

The second question was, "what conditions promote engagement of secondary students?" (p. 158). Students reported high levels of both challenge and skills when engaged in an activity. Engaging activities included individual work and group work, as opposed to exams and passive activities such as listening to lectures or watching educational videos. Further, students were more engaged in non-academic courses such as art and computer science. Mathematics classes resulted in the lowest engagement, though results were not significantly different from other academic courses like history or science.

When considering these results with respect to mathematics, it is important to consider certain limitations. Although the study stated that students in mathematics classes reported the lowest level of engagement, it was not explicitly stated what kinds of tasks students worked on (Shernoff, et al., 2003). Recent research in mathematics education provides recommendations for improving engagement in mathematics tasks such as basing tasks on real-world contexts and using group work to promote student discussion and understanding (NCTM, 1989, 2000). Each of these recommendations runs counter to the mathematics class environments described above.

A second limitation is that specific attributes of activities are not considered. Rather, Shernoff, et al. (2003) used general instruments to account for the variety of activities that subjects participated in. The researchers themselves suggest that further research is needed to investigate the relationships between task-specific variables and student engagement.

Finally, learning mathematics is the most important goal in any mathematics classroom. Yet Steinberg, Brown, and Dornbush (1996) have noted that, "surprisingly little research has examined the role of engagement in student achievement" (p. 64). The study by Shernoff, et al. (2003), for example, does not include a measure of achievement.

These three limitations have helped to shape the current study. The first limitation involved the types of tasks that students were working on in mathematics class. The present study will address this limitation by focusing on mathematics tasks based on the NCTM recommendations mentioned above. Such tasks were developed for the curriculum Contemporary Mathematics in Context (Coxford, Fey, Hirsch, Schoen, Burrill, Hart, et al., 2003), which will be discussed in more detail in the section Mathematics Content Focus.

The second limitation had to do with the exclusive use of general measures. In the current study, engagement is investigated along with non-engagement variables that are specific to mathematics tasks. Three such non-engagement variables that relate to mathematics instruction are: perceived *challenge* of the task, amount of *scaffolding* received, and student *confidence* in their own solutions. Perceived challenge is a measure of how difficult a task is from the viewpoint of a student. Perceived challenge has been studied by researchers of both student engagement (Shernoff et al., 2003) and mathematical problem solving (Hiebert et al., 1996; Schoenfeld, 1982, 1985). Scaffolding refers to reducing the complexity of problems in various ways to make them more accessible to students (Kilpatrick, Swafford, and Findell, 2001). In moderation, scaffolding is a useful aid to learning, but such aid has come under some scrutiny. One finding is that too much scaffolding does not allow students to struggle enough with the content (Hiebert, et al., 1996; Stein, et al., 2000). Lastly, confidence refers to students' perception of skills in comparison to a task's challenge (Csikszentmihalyi, 1990; McLeod, 1992; Middleton & Spanias, 1999). When confidence is high, students believe they are able to meet the challenge. When confidence is low, students perceive that their skills might not be sufficient to meet the challenge of the task.

The final limitation was an absence of an achievement measure. To account for this, the current study will include mathematical achievement in the form of unit examinations. This will allow for the investigation of relationships among engagement, non-engagement, and achievement variables.

Research Questions

1. During class time, how do secondary students rate their engagement of mathematics tasks? Each factor of student engagement will be assessed through the following questions:
    a. How *interesting* are mathematics tasks?
    b. How well do students *concentrate* on mathematics tasks?
    c. How *enjoyable* are mathematics tasks?
2. During class time, how do secondary students rate non-engagement variables for mathematics tasks? Specifically,

   a. How do students rate the *challenge* of mathematics tasks?
   b. How much *help* do students report they receive on mathematics tasks?
   c. How *confident* are students in their solutions to mathematics tasks?
3. What are the relationships among engagement variables (interest, concentration, and enjoyment) and non-engagement variables (challenge, help required, and confidence)?
4. What is the relationship between engagement variables (interest, concentration, and enjoyment) and short-term achievement?
5. What is the relationship between non-engagement variables (challenge, help required, and confidence) and short-term achievement?

Mathematics Content Description

The curriculum Contemporary Mathematics in Context (CMIC) provide the tasks used in this study (Coxford, Fey, Hirsch, Schoen, Burrill, Hart, et al., 2003). The following description draws heavily on the CMIC Teachers Guide. This curriculum is based on NCTM (1989) recommendations and is designed around multi-day lessons centered on big mathematical ideas. Active learning and teaching are encouraged through the use of a four-phase cycle for each lesson: launch, investigate, share and summarize, and on your own.

The launch begins each lesson with a full class discussion. This discussion sets the context for the students and helps to generate student interest. It also provides an opportunity for the teacher to assess prior student knowledge.

The lesson continues by having students investigate and make sense of problem situations. This is done through investigations, sequences of focused problems and questions that extend the launch. During investigations, students often work in collaborative groups to gather data, look for patterns, construct models, and make and verify conjectures.

Following each investigation, a checkpoint allows students to share and summarize the mathematical ideas they encountered. This is usually done as a whole class discussion. Salient points, key concepts and methods that emerge during the investigation are explicitly summarized.

Finally, an on your own exercise is provided for students to complete individually. This exercise is directly related to the lesson objectives. Further, it provides an opportunity for individual students to show what they have learned and allows the teacher to assess each student's understanding of the lesson.

The four-phase cycle provides opportunities to learn various mathematics content. For this study, two units were selected that focus on algebra content. A description of these units follow.

Unit 2: Pattern of Change

The goals of Unit 2 are to develop students' abilities to recognize important patterns of change among variables and to represent those patterns using tables of numerical data, coordinate graphs, verbal descriptions, and symbolic rules. Mathematics topics in this unit include: coordinate graphs, tables, algebraic formulas (rules), relationships between variables, linear functions, nonlinear functions, and *NOW-NEXT* recurrence relations. Two tasks from each investigation are selected for this study. See Appendix E for an outline of objectives and lesson structure. Sample tasks can be found in Chapter Four.

Unit 3: Linear Models

The goals of Unit 3 are to develop student confidence and skill in using linear functions to model and solve problems in situations which exhibit constant (or nearly constant) rate of change or slope. Mathematics topics in this unit include: linear functions, slope of a line, rate of change, intercepts, distributive property, linear equations (including $y = a + bx$ and *NOW-NEXT* forms), solving linear equations and inequalities, using linear equations to model given data, and determining best-fit lines for scatter plot data. Two tasks from each investigation are selected for this study. See Appendix E for an outline of objectives and lesson structure. Sample tasks can be found in Chapter Four.

Definitions

Closing task

Indicates a task from the last half of the investigation, including the middle when the investigation has an odd number of tasks.

Introductory task

Indicates a task from the first half of investigation.

Investigation

A sequence of tasks consistent with the CMIC curriculum as described in the section Mathematics Content Focus.

Mathematics task

Used interchangeably with mathematical problem and mathematical exercise and usually refers to one item in an investigation.

Scaffolding

Refers to the help students receive in order to solve a mathematics task (Kilpatrick, Swafford, and Findell, 2001). For this study, scaffolding will be used interchangeably with "help required" as identified by research question #2b and question #5 of the survey instrument (see Appendix A).

Student engagement

A composite variable that is the average of the following three student perception variables: interest in the task, concentration on the task, and enjoyment of the task (Shernoff, et al., 2003).

CHAPTER TWO

REVIEW OF RESEARCH

Besides achievement, the dependent variables in this study fall into two general categories, engagement and non-engagement. Engagement variables include interest, concentration, and enjoyment. The average of these three variables provides the measure of student engagement for this study. This model for understanding and measuring student engagement is based on flow theory. The non-engagement variables in this study, as the name suggests, are not directly related to engagement. These variables are challenge, help required, and confidence.

Relevant research for both engagement and non-engagement variables is reviewed in this chapter to show how the current study investigates these variables in a unique way. First, flow theory is discussed by focusing on the theoretical background, how flow is studied, and previous studies of flow in mathematics classrooms. It is necessary to describe this framework because the theoretical background for student engagement and the design of this study both draw on flow theory. Second, a model of student engagement is discussed that is based on flow theory. Again, the focus is on results that are specific to mathematics classrooms. Third, relevant research on the three non-engagement variables is summarized. Fourth, a summary is provided that contains salient details of the current study and discusses how it extends previous research.

Flow Theory

Developed by Csikszentmihalyi (pronounced CHIK-SENT-ME-HI-LEE), flow theory provides a framework for understanding periods of optimal experience and high engagement of activities. In his doctoral research, Csikszentmihalyi investigated the activities of older, male artists (Csikszentmihalyi and Csikszentmihalyi, 1988). He observed that these artists were in a state of deep concentration and enjoyment while painting. Once the painting was completed, however, the artist would lose interest in it and move on to another project. This observation was puzzling. Why would artists spend so much time and energy to create a painting only to discard it?

Furthermore, Csikszentmihalyi noticed that there were few extrinsic rewards to painting. "Few artists expected any of their paintings to make them rich or famous … money and recognition appeared to play a minimal part [in painting]" (Csikszentmihalyi and Csikszentmihalyi, 1988, p. 4). The absence of extrinsic rewards and interest in the completed product led Csikszentmihalyi to conclude that the act of painting was motivation in itself.

This phenomenon is an excellent example of intrinsic motivation. Intrinsic motivation "refers to doing something because it is inherently interesting or enjoyable" (Ryan and Deci, 2000, p. 55). Currently, attributes of an activity such as challenge, curiosity, control and context are known to affect a person's intrinsic motivation (Lepper and Henderlong, 2000). Further, fostering intrinsic motivation has become an important goal in education because intrinsic motivation is superior to providing external motivators (Middleton and Spanias, 1999). During the time of Csikszentmihalyi's dissertation work, however, research on intrinsic motivation was a relatively new field with few researchers. Despite this, there were two results from this era that would have a large impact on Csikszentmihalyi's theory.

First, early research on intrinsic motivation had differentiated between the product and the process (Csikszentmihalyi and Csikszentmihalyi, 1988). Specifically, Maslow (1968) concluded that some people work hard because the work itself is enjoyable. This idea is similar to Csikszentmihalyi's finding that the act of painting was more rewarding to the artist than the finished painting itself. To explain this and similar phenomena, Maslow coined the term "self-actualization," the need to discover one's potential and limitations through strenuous activity (Csikszentmihalyi and Csikszentmihalyi, 1988).

Second, other research showed the important role of control in intrinsic motivation (Csikszentmihalyi and Csikszentmihalyi, 1988). In their research on schoolchildren, deCharms and Muir (1978) noticed that some students felt more control over their lives than other students. The students who perceived they had more control were deemed to be intrinsically motivated whereas the others were not. Other researchers also investigated control by studying how extrinsic contingencies influence intrinsic motivation (Amabile, DeJong, and Lepper, 1976; Deci, Koestner, and Ryan, 1999). These studies found that extrinsic rewards and other external controls can diminish a person's intrinsic motivation to engage in a task (Deci and Ryan, 1985; Ryan and Deci, 2000).

Work by Maslow, deCharms, Muir and other researchers cited in the previous paragraph appear to partially explain Csikszentmihalyi's findings concerning the influence of control on intrinsic motivation. However, the research does not explain why some activities are intrinsically motivating and others are not. In other words, what are the defining traits of an intrinsically motivating task?

To answer this question, Csikszentmihalyi continued his research by analyzing people who pursue strenuous activities. His early research methods were limited to controlled, laboratory settings. To continue his studies, he needed to develop an instrument to gather data from subjects in their natural environments with minimal intrusion. This need gave rise to the experience-sampling method.

Experience-Sampling Method

To continue research on intrinsically motivating tasks, the experience-sampling method (ESM) was developed (Csikszentmihalyi, 1990, 1997; Larson and Csikszent-mihalyi, 1987). Participants in studies involving ESM are usually required to carry a device that is programmed to give a random signal. When a signal is received, participants record information regarding their current activity by completing an experience-sampling survey. The survey consists of Likert-scale and short-answer questions covering the descriptive and affective variables of interest in the study. Notice that these surveys measure a person's subjective perceptions of their experience, an important point to understand about flow research (Moneta and Csikszentmihalyi, 1996).

Besides the signal-contingent variety of ESM described above, there are two other variations: interval-contingent and event-contingent (Scollon, Kim-Prieto, and Diener, 2003). The difference between these types of ESM is in how subjects know when to complete a survey. Interval-contingent ESM asks participants to complete surveys in predetermined increments of time, whereas the subjects in the event-contingent model complete a survey after certain events occur. The latter model is a popular method for collecting data that focuses on specific academic courses. For example, researchers have required students to complete experience-sampling surveys at the end of courses such as college statistics and middle school mathematics (Collins, 1995; Turner, et al., 1998).

In any version, ESM is usually used for two purposes. The first use is to construct a "time budget" regarding the activities that participants undertake. Of specific interest are the types of activities and how much time is spent on these activities (Larson & Csikszentmihalyi, 1987). Random-signaling and interval-contingent varieties of ESM are used more for this purpose.

The second use of ESM is to "research psychological reactions to everyday activities and experiences" (Larson & Csikszentmihalyi, 1987, p. 526). To assess psychological reactions, the experiences-sampling survey asks subjects what they think and feel about their current activity. However, it is not expected that subjects are consistent. "Contrary to a one-time measure, ESM is not based on the assumption that people are going to be entirely consistent in their responses … In general, however, it was expected that relative differences between respondents would tend to persist over time" (Csikszentmihalyi & Larson, 1987, pp. 530-531). Thus, averages of subject responses are used to identify stable psychological reactions. More discussion of ESM is in Chapter Three.

Possibly the most important contribution of ESM is that it has allowed researchers to gather data on subjects in their natural environments with minimal interference. As a result, researchers of flow are able to investigate a wide variety of activities. Such research has given rise to a model of flow experiences.

Theoretical model

Using ESM, Csikszentmihalyi continued his research by analyzing people who pursue strenuous activities, such as rock climbing, playing chess, composing music, and performing surgeries. Although the activities differ widely, there is an important commonality across these types of subjects. Csikszentmihalyi (1975) identifies this commonality when he states that, "some people climb mountains whereas others make up tunes at a piano or push chess pieces across a board is in a sense incidental to the fact that they are all exploring the limits of their abilities and trying to expand on them" (p. 30). In order to explain how and why people engage in such activities, Csikszentmihalyi developed a theory based on periods of optimal experience.

"Flow" is the common term for a state of mind of a person who is totally absorbed in an activity (Csikszentmihalyi, 1990). In general, there are common traits for situations in which people experience flow. These traits include: (i) a task that affords a feeling of balance between challenge and skill, (ii) an intense focus on the task so that time appears to "fly by", (iii) a task that is interesting or that invokes curiosity, and (iv) a sense of control regarding the activity (Egbert, 2003). Of these traits, the balance between challenge and skill is the most widely identified attribute across independent groups in studies of flow (Turner, et al., 1998). Therefore, flow researchers selected a balance of high challenge and high skill as the best indicator of flow as seen in Figure 2.1.

"The problem is that a state of flow does not depend entirely on the objective nature of the challenge present or on the objective level of skills; in fact, whether one is in flow or not depends entirely on one's perception of what the challenge and skills are" (Csikszentmihalyi, 1975, p. 50). Thus, the balance of challenge and skill is subjective, dependent on a person's own point of view.

Furthermore, this subjective balance of challenge and skills is dynamic. That is, a person is able to move between different states. For example, if a person is relaxed when doing an activity (see Figure 2.1), then she can increase the level of challenge to move toward a flow state. If a person is anxious when doing an activity, then she can improve her skills to move toward flow.

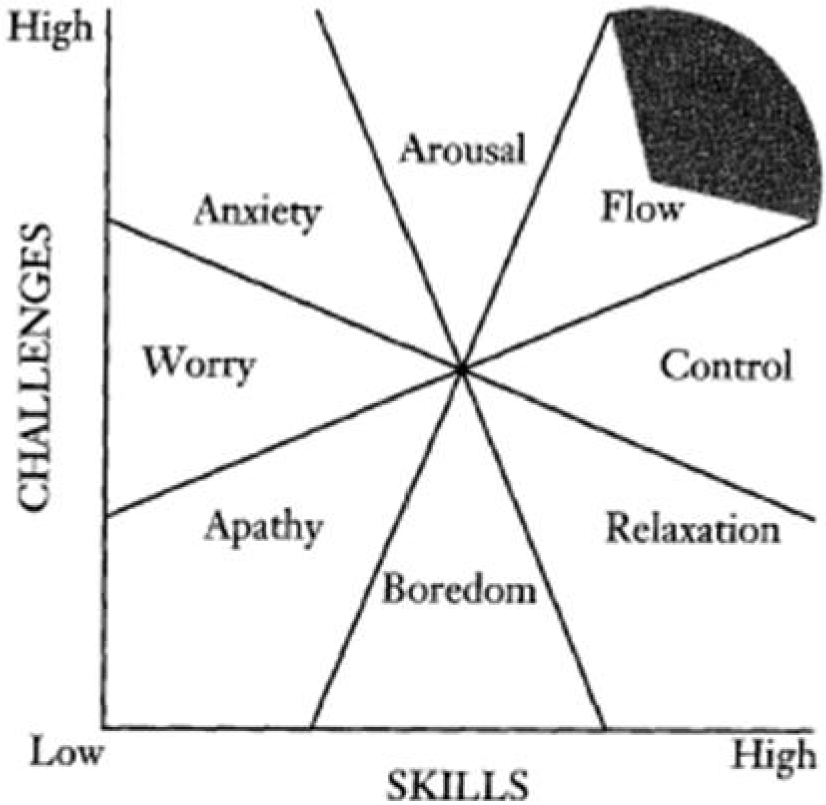

Figure 2.1 – Theoretical model of flow

Source: Csikszentmihalyi, M. (1997). *Finding flow: The psychology of engagement with everyday life*. New York: Basic Books. (p. 31)

This framework for flow theory has paved the way for research in several areas, including education, sports, gang behaviour, and differences between work and recreation (Csikszentmihalyi and Csikszentmihalyi, 1988; Csikszentmihalyi, 1990). In the present study, particular attention is paid to applications of flow theory and ESM within mathematics classrooms.

Research in Classrooms

With regard to education, flow theory provides a means for assessing student perceptions and improving instruction. For example, one component of flow theory is that students continually push the limits of their abilities when faced with appropriate challenge. "Thus the flow experience acts as a magnet for learning – that is, for developing new levels of challenge and skills" (Csikszentmihalyi, 1997, p. 33). Several researchers have investigated flow experiences within educational settings. This section focuses on research that has been conducted in mathematics classrooms from a flow theory perspective.

In a comprehensive study of talented teenagers, Csikszentmihalyi, Rathunde and Whalen (1997) investigated students with proficiencies in at least one of the following areas: mathematics, science, music, athletics, or art. A total of 208 ninth- and tenth-grade students took part in the study, 68 of whom were proficient in mathematics. All of these students were at least one year ahead of their class's average and many participated in mathematics competitions. The purpose of the study was to provide a profile of talented high school students. Results indicate that the study of mathematics is largely a solitary activity, with social interaction mostly limited to mathematics competitions. The result that mathematics is largely solitary will be seen in other research.

Shernoff, Knauth, and Markis (2001) synthesized information from studies of flow that relate to quality of experience in classrooms. Their results provide a profile of student experiences in school. Shernoff, et al. (2001) found that students spend approximately 55 percent of their time in academic classes (English, mathematics, science, etc.), 12 percent in non-academic subjects (art, music, vocational education, etc.), and almost a third of their day in unstructured activities (lunch, study hall, hallways, etc.). In mathematics classes, student's time was mostly spent in non-interactive activities such as lecture (27.6%), individual work (27.6%), and taking quizzes or tests (26.3%). Mathematics courses were also perceived to be, "the most challenging and important to their future goals. At the same time, students report wishing to do math less and enjoying it less than other subjects" (p. 152). On a positive note, students experienced the highest levels of flow in mathematics classes.

This study supports the notion that mathematics classes consist of mainly solitary experiences. It goes on to state that motivation for mathematics is low, but levels of flow are high. This finding is consistent with other research indicating that flow experiences may only be enjoyable in reflection (Csikszentmihalyi, 1990). The next study moved beyond the study of flow by investigating a variety of relationships within mathematics classrooms.

Schiefele and Csikszentmihalyi (1995) used flow theory to examine, "relationships [in mathematics classrooms] among interest, achievement motivation, mathematical ability, the quality of experience when doing mathematics, and mathematics achievement [grades and course level]" (p. 163). In this study, quality of experience was measured by ESM focusing on seven attributes: potency, affect, concentration, intrinsic motivation, self-esteem, importance, and perceived skill. Data were collected over a nine-month period for 108 talented freshman and sophomores. Results indicate that quality of experience is not a significant and independent predictor of achievement. In fact, the researchers hypothesized that the two constructs depend on different factors. Student interest in mathematics was the strongest predictor of the quality of experience in mathematics class. Achievement was most closely linked to mathematical ability.

The key results of these studies indicate that mathematics is mostly done alone, and students do not enjoy class despite a relatively large number of flow experiences. Also, interest is a strong predictor of quality of experience. Achievement, on the other hand, is not related to quality of experience and is instead strongly linked to mathematical ability. Besides studying quality of experience, flow theory has also been used to study student engagement of classroom activities.

Student Engagement and Flow Theory

Student engagement is a construct that is similar to motivation. Research on motivation investigates the reasons why people are moved to do an activity (Ryan and Deci, 2000). Such research analyzes causes of people's actions including beliefs (Middleton, 1995), deadlines (Amabile, DeJong, and Lepper, 1976), or extrinsic rewards (Deci, Koestner, and Ryan, 1999). Student engagement, however, is not a theory of motivation (Middleton and Spanias, 1999) and instead relies upon motivational theories such as flow theory.

Broadly defined, student engagement is based on the idea that students should be "psychologically 'connected' to what is going on in their classes" (Steinberg, Brown and Dornbusch, 1996, p. 15). Although this description is vague, it suggests how flow theory relates to student engagement, namely, a flow experience represents the highest level of engagement.

Shernoff (2001) developed an explicit definition of student engagement based on flow theory. His definition incorporated three phenomenological variables that are important to both flow theory and education. These three variables are interest, concentration, and enjoyment, and each is discussed in more detail below.

Interest

As early as 1913, the philosopher John Dewey noted the importance of interest in education. He writes, "When a child feels that his work is a task, it is only under compulsion that he gives himself to it. At every let-up of external pressure his attention, released from constraint, flies to what *interests* him" [emphasis added] (Dewey, 1913, p. 2). More recently, Csikszentmihalyi, Rathunde and Whalen (1990) note, "It is wasteful to teach someone who is not interested and so is not motivated" (p. 9). Further, interest can be a powerful predictor within education and flow theory. For example, "the quality of experience when doing mathematics was mainly related to interest" (Schiefele and Csikszentmihalyi, 1995, p. 163). These statements indicate that interest is a variable of increasing importance for education.

Current research on interest falls into two categories of study (Boekaerts & Boscolo, 2002, Mitchell, 1993): *individual* and *situational* (e.g., task, teacher, environment). The first category, individual interest, includes the beliefs and attitudes that a person has. For example, if a person believes that mathematics is a worthwhile task, then he or she should be predisposed to work on mathematical problems. Also, "students who are high on this type of interest, experience an inner drive to seek out opportunities to learn more about a specific topic" (Boekaerts & Boscolo, 2002, p. 378). Individual interest is a strong motivator, but is not generally susceptible to outside influence.

Situational interest, on the other hand, "is the real topic of concern as teachers have no influence over students' incoming personal interests" (Mitchell, 1993, p. 425). Situational interest is shaped by environmental and external factors interacting with a person's interest. Such factors may include teachers, parents, friends, and tasks (mathematics tasks are the focus of the present study). One way to understand the difference between the two types of interest is the following. Individual interest is the interest level that a person has for a topic or task, whereas situational interest is how the task promotes interest across many people. Situational and individual interest interact in education as Steinberg, Brown and Dornbusch (1996) note, "engagement in school is a two-way street - schools need to be interesting, but students need to be willing and able to be interested" (p. 63). Both the individual and situational perspectives on interest are important for understanding how interest influences engagement.

Concentration

Intense concentration is a central component of flow theory (Csikszentmihalyi, 1990). A person who is in flow is so absorbed in a task that he or she usually loses track of time. Concentration is also an important variable in education studies. For example, talented secondary students, "reported relatively higher levels of concentration than their peers when involved in class work" (Csikszentmihalyi, Rathunde, and Whalen, 1997, p. 97). The researchers conclude that the level of concentration attained by students is an important factor in the development of their talents.

Fredricks, Blumenfeld, and Paris (2004) distinguish between concentration in behavioral and cognitive areas of engagement. Behavioral engagement refers to the amount of effort expended, whereas cognitive engagement refers to cognitive processes that range from memorization to meta-cognitive strategies for learning. Effort (specifically persistence), metacognition, and self-regulation strategies are all central components for competent problem solvers (Schoenfeld, 1985, 1992). Further, high levels of all three are desired outcomes of mathematics instruction.

Enjoyment

The role of enjoyment in education is an issue that is often debated. Results from flow research suggest that enjoyment may have a negative correlation with being in a state of flow (Shernoff et al., 2003). A similar negative relationship was found between enjoyment and achievement across cultures. "Data from SIMS [Second International Mathematics Study] indicate that Japanese students had a greater dislike for mathematics than students in other countries, even though Japanese achievement was very high" (McLeod, 1992, p. 582). These results suggest that enjoyment is not an important component of achievement or of flow.

However, an important consideration for student engagement is that, "people will pursue an activity if they enjoy doing it" (Csikszentmihalyi, Rathunde and Whalen, 1990, p. 13). A desirable consequence of high levels of engagement is that students will pursue a topic. Further, research indicates that repeated emotional experiences such as enjoyment can develop into more permanent positive attitudes and beliefs (McLeod, 1992). Thus, enjoyment of activities can lead to a more permanent and comprehensive enjoyment of a school subject.

Student Engagement

Student engagement, then, is the average of the following three variables: interest, concentration, and enjoyment (Shernoff, et al., 2003). The researchers used this model of student engagement to assess conditions for engagement within secondary classrooms. Their results indicate that increased engagement occurs when skills and challenge are high and balanced, instruction is relevant to students' goals, and students perceive the environment to be under their control. Besides these general results, the researchers also compared engagement across classroom activities and courses.

In order to compare classroom activities, Shernoff, et al. (2003) classified student activities into categories such as lecture or group work, regardless of content of the course. Results indicate that engagement levels for group work and individual work were significantly higher than lecture, exams, and watching TV or videos. On a 0-9 scale, students reported averages of 6.18 and 5.98 for group and individual work, respectively. Further, results for group work were 5.46 for interest, 7.34 for concentration, and 5.84 for enjoyment. On these engagement variables, there were no significant differences between individual and group work.

Engagement was also compared between courses. Results indicate that electives had higher student engagement than academic courses. The classes with the highest engagement were computer science and art with engagement scores of 6.05 and 6.35, respectively. Mathematics had the lowest engagement of all courses at 5.35, though not significantly different from most other academic courses. Further results for mathematics class were 4.43 for interest, 6.65 for concentration, and 4.92 for enjoyment. There were no significant differences between any pair of courses on concentration, although differences by course were found for both interest and enjoyment.

These results provide few findings that are specific to mathematics classes. This lack of information is one motivation for the current study. In order to better understand engagement within mathematics classes, this study will focus only on mathematics tasks. The summary at the end of this chapter provides more information regarding how the current study extends the study by Shernoff, et al. (2003).

Non-engagement Variables

Besides engagement, the current study will measure the following variables: challenge, scaffolding, and confidence. These variables are referred to as non-engagement variables, because they are outside the definition of engagement. Each of the variables is important in mathematics education research and is discussed in more detail below.

Challenge

As noted earlier, the perception of high challenge is a necessary component of being in flow (see Figure 2.1). In fact, a delicate balance of high challenge and high skills are required for achieving flow. Challenge is also an important variable in constructs based on flow theory. For example, high challenge may be related to higher involvement (Turner, Meyer, Cox, Logan, DiCintio, and Thomas, 1998) and higher engagement (Shernoff, et al., 2003).

The perceived challenge of an activity is also an important variable in research on mathematical problem solving. For example, Hiebert et al. (1996) discuss the notion that students should be allowed to work on problems, that is, tasks that students find challenging and want to find a solution for. Further, Schoenfeld (1982, 1985) compared traits of novice and expert mathematical problem solvers. He found that more experienced problem solvers found a wider range of problems "easier" than their novice counterparts (Schoenfeld, 1982). These studies are just a few examples of a large body of research in which challenge has been studied in mathematics problem solving.

Scaffolding / Help Required

"The use of scaffolding is another factor that helps to maintain student engagement at a high level" (Kilpatrick, Swafford, and Findell, 2001, p. 336). The goal of scaffolding is to make tasks more accessible to a wider range of students. This is done by reducing the complexity of the task, without losing its integrity. Scaffolding, however, has come under scrutiny, because too much scaffolding may not allow students to struggle enough with the content (Hiebert et al., 1996).

For example, Stein, Smith, Henningsen, and Silver (2000) analyzed mathematics tasks of varying cognitive demands. These researchers found that highly demanding mathematics tasks are difficult to implement and are frequently transformed to less demanding tasks by the teacher. Further, the greatest gains in performance are in classrooms that encourage higher-order thinking and reasoning. Thus, keeping mathematics tasks at a high level is difficult for teachers, but beneficial for students.

Confidence

Student confidence is usually conceptualized as a belief about one's mathematical competence (McLeod, 1992). According to McLeod, achievement and confidence tend to be positively correlated. Further, confidence is a topic of many gender studies that show women tend to be less confident and take fewer advanced mathematics courses than men at college and secondary levels.

Also, it is important to note that the perception of confidence may be important for flow theory (see Figure 2.1). It is hypothesized that when confidence is high, students tend to have the skills to meet the given challenge. Further, when confidence is low, student skills are likely to be below those required for the task.

Summary

Flow theory provides a viable means to measure student engagement. However, a focus on mathematics tasks is missing from the literature. The current study will help fill the gap by applying Shernoff, et al.'s model of student engagement to mathematics tasks. The mathematics tasks are selected from a curriculum that is based on recommendations by the National Council of Teachers of Mathematics (1989). The curriculum is intended to be engaging for students.

Two studies showed that mathematics is largely a solitary activity (Csikszentmihalyi, Rathunde and Whalen, 1997; Shernoff, Knauth, and Markis, 2001). These studies state that mathematics classes consist of mostly lecture, individual work, and exams. The current study moves beyond these findings by focusing on tasks that are designed for collaborative group work.

Another study of flow examines relationships between quality of experience, motivation, achievement, and ability (Schiefele and Csikszentmihalyi, 1995). The researchers found that quality of experience is desirable, but different from achievement. Quality of experience is largely related to interest in mathematics, whereas achievement is more related to ability. Although quality of experience is not closely related to achievement, little is known about relationships between engagement and achievement. Steinberg, Brown, and Dornbush (1996) point out a lack of research comparing student engagement and achievement. The current study investigates how achievement relates to student engagement and other non-engagement variables.

Shernoff, Knauth, and Markis (2001) found that students in mathematics classes reported high levels of flow, low motivation, and high challenge. A similar result was reported by Shernoff, et al. (2003) who found that mathematics had the lowest engagement of all the classes, yet mathematics was seen as challenging and important for future goals. The current study further examines these variables using mathematics tasks from a curriculum that is designed to be more engaging for students.

Finally, Shernoff, et al. (2003) recommended the investigation of relationships between engagement and other variables. Three non-engagement variables were chosen for the present study based on their importance to student engagement and mathematics education research. Perceived challenge is an important indicator of engagement and a topic of study within mathematics problem solving research (Schoenfeld, 1985; Shernoff, et al., 2003). Scaffolding is important because it can promote engagement in mathematics tasks by making them more accessible (Kilpatrick, Swafford and Findell, 2001). Confidence has been shown to relate to mathematics achievement and is a self measure of a person's ability (McLeod, 1992). The current study includes these three variables to further examine relationships among engagement, non-engagement, and achievement variables.

CHAPTER THREE

METHODOLOGY

The purpose of this study is to assess student perceptions of high school algebra tasks. Of specific importance are the variables interest, concentration, and enjoyment, as they relate to student engagement. Further, student perceptions of challenge, help received, and confidence are studied. To investigate these topics, a survey was adapted from a previous study on student engagement (Shernoff, et al., 2003). Students had 38 opportunities to complete this instrument during two units of instruction, which lasted about 14 weeks. Details regarding the participants and the design of the study follow.

Participants

Informal contact was made with three teachers who use the curriculum Contemporary Mathematics in Context (CMIC) (Coxford, Fey, Hirsch, Schoen, Burrill, Hart, et al., 2001, 2003). This curriculum was developed under the Core-Plus Mathematics Project funded by the National Science Foundation. It is a four-year high school curriculum based on the curriculum standards developed by the National Council of Teachers of Mathematics (1989).

The curriculum uses an integrated approach for mathematics content. Each course contains interwoven strands of the following four content areas: algebra and functions, statistics and probability, geometry and trigonometry, and discrete mathematics. The units selected for this study both focus on the algebra and functions strand. The purpose of this strand is for students to develop the ability to "recognize, represent and solve problems involving relations among quantitative variables" (Coxford, et al., 2001, p. 7).

This goal is achieved through various methods including the use of functions as mathematical models, multiple representations, and symbolic reasoning and manipulations. Patterns of Change (pp. 98-156) and Linear Models (pp. 158-248) are the titles of the two units selected for this study, both units focus on algebra concepts and skills.

Three teachers who use this curriculum were contacted and given a brief overview of the study by e-mail or in person. Communications with these teachers indicated that the study involved student engagement when solving mathematics tasks and expectations of the teacher including the survey instrument (see Appendix A). Two teachers at different schools expressed interest in participating in the study. Following their expression of interest, an official request to do research in these classrooms was made though the Cooperating School Program at the University of Iowa. This program coordinates all University of Iowa research in K-12 classrooms.

To limit contact between the researcher and the students, the teachers were enlisted to provide their classes with an overview of the study (see Appendix B). After the overview, students were given consent forms. Teachers went through the consent form and survey, answering any questions that arose. Questions that the teacher could not answer were directed to the researcher. Students who agreed to participate in the study returned the consent forms during the following class.

To protect the identities of those involved, the schools in this study will be referred to as Tanner High School and Baker High School. Both are public schools that used CMIC curriculum with some students. Teachers in this study taught the only sections of CMIC Course 1 for their schools.

Besides gathering demographic data, the researcher conducted an observation of each classroom. The goal of the observations was not to judge the quality of instruction but to better understand the atmosphere and structure that was established during class work time (Rasmussen, Yackel, & King, 2003). Specifically the observations were conducted to answer the question: how do students spend their time in class? The results of these observations will be discussed in the descriptions of each school below.

Tanner High School

Data from the National Center for Educational Statistics (NCES) indicates that Tanner is in or near a mid-sized city. The population of the school is 1,721 students. Approximately 13.1 percent of these students qualify for free or reduced priced lunch.

Upon entering Tanner High School, students choose which mathematics course they will take. During the 2004-05 school year, one class of CMIC Course 1 was offered and it met the first period of the day. A total of 24 students were enrolled in the course and all agreed to be in the study. Of these, 21 students (11 male and 10 female) completed enough surveys to be included in the study. These minimum survey requirements will be discussed in Chapter 4.

The teacher of this class has 22 years experience teaching. She is active in professional development activities including mentoring other teachers, participating as a teacher leader for the University of Iowa's LEADERS workshops, and directing student teachers. In fact, a student teacher was in her classroom during the first half of this study. This teacher has taught the Contemporary Mathematics in Context curriculum for six years.

During the classroom observation, the teacher and students conducted class in a manner that appeared to be consistent with the goals of the curriculum. The teacher began and ended with a few administrative items, however, the bulk of class was focused on groups working through the investigations in the curriculum. During this time, most students were on task, actively discussing the problems and working towards understanding the investigations. Only a couple of students seemed off-task. During work time, the teacher walked around and responded to group questions. It is important to note that the teacher would only come over to a group if the entire group had a question. This was one of the many strategies the teacher use to make students responsible for their own learning. A detailed outline of the class is available in Appendix C.

Baker High School

Data from NCES indicates that Baker is in a rural community. The population of the school is 1,052 students. Approximately 15.1 percent of these students qualify for free or reduced priced lunch.

Students at Baker High School who enrolled in CMIC Course 1 comprise two classrooms of 30 total students, 24 of which agreed to be in the study. Of these students, 17 completed enough surveys to be included in the study (8 male, 8 female, and 1 gender unspecified). Gender information was missing for one student. Both sections of the class met before lunch. In eighth grade, parents of these students choose which mathematics curriculum their children will take based on recommendations from middle school teachers and high school counselors. Students who begin the algebra track in eighth grade continue with geometry and advanced algebra once in high school, so they did not take CMIC courses.

The teacher at Baker High School has been teaching mathematics for four years. Prior to her present position, she taught and worked with adult students in an alternative high school program for 11 years. Her highest degree is a Master of Arts in Mathematics Education. This is her first year with the Contemporary Mathematics in Context curriculum.

Two sections were observed at Baker High School, both on block day. Baker uses an modified block schedule during the school week. On Monday, Tuesday, and Friday all classes meet for a short period of time, about 40 minutes. On Wednesday, half the classes meet for an extended period of time, about 90 minutes with the other half of classes meeting for the extended time period on Thursday. The two sections that were observed will be referred to as Baker #1 and Baker #2.

The observed session of Baker #1 began in disarray. About half of the class was told to finish an exam while the other half was supposed to sit quietly and wait. During this time students were noisy and did not stay in their seats. After everyone completed the exam, the next unit began with the teacher assigning new groups. Next, the class began the investigation by having students volunteer to read from the textbook. Small group work began on the investigation problems. This investigation required data to be collected by the students, which was collected as a whole class. One group collected the data while other groups socialized. Small group work continued until the end of class. Students did not complete the investigation.

The observed session of Baker #2 went more smoothly. In fact, students completed the investigation and began working on homework exercises before class was over. As in Baker #1, class began with the assigning of new groups. The investigation proceeded in a similar way as well. Students read the introduction to the unit, small groups began working on problems, and data was collected by the whole class. During the data collection activity, students were more on task than in the earlier class. The investigation was completed with about 25 minutes left in class. During the remaining time students could work on homework for any of their classes, however, most students engaged in quiet conversation.

Summary

In all, the three classrooms had very different environments. The classroom at Tanner was well-organized, with almost every student on task and discussing the investigation. At Baker, the two sections behaved very differently. It is difficult, however, to isolate why the sections are so different. The earlier section, Baker #1, was generally off-task and noisy. Baker #2 was more on-task, though not as well organized as the Tanner classroom. There was evidence that the teacher at Baker made adjustments to the lesson from section 1 to section 2. The teacher's adjustments to the lesson plan may account from some of these differences, but there is too little information to be definite. The other substantial difference between the classrooms was the large amount of unstructured time given to students at Baker.

Regardless of classroom differences, it is important to notice that both teachers used similar lesson structure when implementing the curriculum. Students worked in small groups through the investigations. During group work, the teachers moved between groups, partially as a task master, but mostly to answer or redirect student questions. See Appendix C for a more detailed accounting of the classroom observations.

Design

At the beginning of each week, teachers handed out packets of surveys to all students in the study. These surveys were preprinted with the selected tasks for the week and the teacher's name. The purpose of the survey was to gather data regarding students' perceptions of the mathematical tasks they work on during class. Sixteen tasks were selected from Unit 2 and twenty-two tasks from Unit 3. In all, students were given 38 opportunities to complete surveys for the study. See Appendix D for more information.

Upon completion of a selected task, students filled out the survey regarding their experience with that task. See Appendix A. The first three survey questions ask about the students' perceptions regarding their engagement. The final three questions ask about non-engagement variables that relate to mathematics tasks. The survey also included an optional question requesting more information about the task. Students completed this survey twice for each investigation during two consecutive units of instruction, a period of about 14 weeks.

In addition to the survey instrument, students' scores on unit examinations were collected to provide achievement data for the participants. More details on these measures are provided after describing the design upon which this study is based – the experience-sampling method.

Experience-sampling Method

The definition of student engagement and design of the study are based on research on flow theory. To study instances of flow, the experience-sampling method (ESM) was developed (Csikszentmihalyi, 1990, 1997; Larson & Csikszentmihalyi, 1987). The key characteristics of experience-sampling revolve around two purposes. The first use of ESM is to understand about activities that participants undertake, specifically to identify these activities and gather how much time is spent on them (Larson & Csikszentmihalyi, 1987). For the current study, the activities in question are the same for all participants, namely tasks completed during mathematics class.

The second purpose of ESM is to "research psychological reactions to everyday activities and experiences" (Larson & Csikszentmihalyi, 1987, p. 526). To collect data on everyday situations, ESM usually uses a method of random signaling to alert participants to complete a survey (Csikszentmihalyi, 1990). However, other signaling methods such as event-contingent and interval-contingent models have been used (Scollon, Kim-Prieto, and Diener, 2003). Fluctuating school schedules and the relatively small window of time that students spend in mathematics classes necessitated the use of an event-contingent form of ESM (Collins, 1995; Scollon, Kim-Prieto, and Diener, 2003). For this study, the event in question is the completion of a pre-selected mathematics task, after which students completed a survey.

To select mathematics tasks for the study, stratified random sampling was used. Two mathematical tasks were chosen from each investigation by dividing the investigation in half, then randomly selecting a problem from each half (see Appendix D). The first half of the investigation is denoted as *introductory* tasks, whereas the second half is called *closing* tasks. If an investigation had an odd number of tasks, the middle task was included as a closing task. This sampling method uses random selection of mathematical tasks while guaranteeing balance of tasks from the beginning and end of investigations. This is important because the complexity of mathematics tasks tend to increase throughout a given investigation.

The reliability of ESM data is discussed in detail by Csikszentmihalyi and Larson (1987). These authors cite studies of reliability that analyzed subject responses over time and found significant correlations between student responses during the first half of the week and the second half. Further, in a study of mathematics classrooms, Schiefele and Csikszentmihalyi (1995) again tested the reliability of ESM data. Correlations between two time intervals, Time 1 and Time 2, were all statistically significant and ranged from .44 to .64 with a mean correlation of .52.

Validity of ESM data is also discussed by Csikszentmihalyi and Larson (1987). These authors cite five studies that investigate how individual differences using ESM correlate to independent measures of similar constructs. For example, one of these studies found significant correlations between independent measures of intrinsic motivation and several ESM variables (Csikszentmihalyi and Larson, 1987; Hamilton, Haier, and Buchsbaum, 1984). Other studies investigated relationships between ESM data and alienation, need for intimacy, self-esteem, and multiple personality disorders (Csikszentmihalyi and Larson, 1987). In all, ESM data have been used to investigate a variety of psychological properties, depending on the survey questions that subjects respond to.

Repeated Survey

The current study builds on traditions already set forth in the field of academic motivation. Specifically, "studies of the antecedents of educational outcomes have used questionnaires to assess children's perceptions of the context, their intrinsic motivation for learning, and their self-perceptions" (Deci, 1992, p. 64). For the present study, a survey was adapted from an instrument developed by Shernoff et al. (2003). This earlier instrument used the ESM to assess student perceptions regarding student engagement.

Each survey was preprinted with the teacher's name and the mathematics task that would prompt completion of the survey. Students were required to enter the current date and to initial each survey for identification purposes. The instructions for the survey were as follows: "Compare the current task to other mathematics tasks. Then indicate your responses to the following questions. Please place an '**X**' through the appropriate value on the scale to the right of each question." See Appendix A for a copy of the survey.

The current study bases student engagement on optimal experience or flow theory (Shernoff et al., 2003). Typically, all survey items in such studies measure students' subjective experiences (Moneta & Csikszentmihalyi, 1996). Thus, the survey for the current study consists of six Likert-scale questions and one optional open-ended item. For the Likert-scale items, three involve student engagement and three involve the non-engagement variables that relate to solving mathematics tasks.

The student engagement questions are the following:

Item 1: How interesting was the task? This item is an adaptation of a more general item, "Did you find the activity interesting?" from Shernoff (2001) and Shernoff et al. (2003).

Item 2: How well were you concentrating on the task? Intense concentration is a key characteristic of being in flow. This item is an adaptation of a more general item, "How well were you concentrating?" from Shernoff (2001) and Shernoff et al. (2003).

Item 3: Did you enjoy the task? Enjoyment of learning is seen as a desired result from education (Shernoff, et al., 2003). This item is an adaptation of a more general item, "Did you enjoy what you were doing?" from Shernoff (2001) and Shernoff et al. (2003).

In addition to questions regarding engagement variables, the second-half of the survey included non-engagement variables that were based on research on flow theory, mathematical problem solving, and affective variables within mathematics education. The items are the following:

Item 4: Rate the challenges of the task. Perceived challenge is a variable that appears in research on student engagement (Shernoff, 2001; Shernoff et al., 2003), flow theory (Csikszentmihalyi, 1990, 1997), and problem solving (Hiebert et al., 1996; Schoenfeld, 1982, 1985). The specific item used in the instrument for this study is adapted from Shernoff et al. (2003), who administered a 9-point Likert scale (1=Low, 9=High) for the follow statement, "Rate the challenges of the activity" (Shernoff, 2001, p. 225; Shernoff, et al., 2003). To be more consistent with the other survey items in the present study, the Likert scale was extended to 10 points where 0=Low and 9=High.

Item 5: How much help did you need to solve the task? This measure of scaffolding was prompted by current research that indicates the richness of mathematics problems can be reduced during instruction by too much scaffolding (Heibert et al., 1996; Henningsen and Stein, 1997; Stein, Smith, Henningsen, and Silver, 2000).

Item 6: How confident are you that the solution(s) is correct? A measure of student confidence is included in this study because research on problem solving and motivation both indicate that confidence is an important variable of study (McLeod, 1992; Middleton & Spanias, 1999).

Optional open-ended item: Is there anything else about the task that you wish to include? Upon seeing the survey instrument, both teachers in the study requested a free-response item. This item is intended to shed light on student responses, but is not a central component of the study.

The coding of the surveys was straight-forward. Student responses were entered into the software program Statistical Package for Social Sciences (SPSS). In the rare occasion that an item was left blank, no score was entered into SPSS. If a student was careless and marked two adjacent survey items, then the average of the two scores was inputted into SPSS. One hundred sixty-six of 6,767 survey responses fit this category. If a student marked two non-adjacent scores for a survey item, then no score was entered into SPSS because there was not a clear response. Only two survey responses were not included because of this criterion.

Unit Examinations

The tests given at the end of each curricular unit provide measures of student achievement. Based on the design of the study, the selection of testing materials was at the discretion of the teachers. Both teachers in the study used unit examinations provided by the CMIC curriculum. There are two forms for each, A and B, that teachers can choose between. The teacher at Tanner High School chose Form B for both unit examinations, whereas the teacher at Baker used Forms B and A for Units 2 and 3, respectively. Exam scores are standardized and summed to provide an overall achievement measure for the students.

Analysis

The research questions are focused on student perceptions of engagement and non-engagement variables that are related to specific mathematics tasks. Of further interest are the relationships between these variables and achievement. Student means on each item across the 38 tasks are the unit of analysis as recommended by Larson and Delespau (1992). Thus, each student has a mean response for each variable in the study: interest, concentration, enjoyment, engagement, challenge, scaffolding, and confidence.

In order to have valid student means, Larson and Delespau (1992) discuss requirements for a minimum number of completed surveys by each student. “Contrary to a one-time measure, the ESM is not based on the assumption that people are going to be entirely consistent in their responses … In general, however, it was expected that relative differences between respondents would tend to persist over time” (Csikszentmihalyi & Larson, 1987, pp. 530-531). Because of the variability, one or two scores may not accurately reflect a subject's view. For this study, each student needed to complete at least 50 percent of the available surveys in order to be included in the analysis.

The remainder of this section gives each research question and describes the statistical methods used to analyze the data for that question. Data analysis was conducted using the Statistical Package for Social Sciences (SPSS).

Research Questions

During class time, how do secondary students rate their levels of engagement for mathematics tasks?

This research question asks for a description of student reports of engagement. Thus, the mean, standard deviation, minimum and maximum values are reported for each engagement variable of the survey. The engagement variables are: interest, concentration, and enjoyment. Student engagement is a composite variable defined as the average of those three variables (Shernoff et al., 2003).

During class time, how do secondary students rate non-engagement variables (challenge, help required, and confidence) for mathematics tasks?

This research question asks for a description of student reports for non-engagement variables. Thus, the mean, standard deviation, minimum and maximum values are reported for each non-engagement variable of the study. These variables are: challenge, help received, and confidence.

What are the relationships among engagement variables (interest, concentration, and enjoyment) and non-engagement variables (challenge, help required, and confidence)?

This research question requires analysis of relationships between engagement variables and other non-engagement variables. Correlation coefficients are computed and scatter plots are examined for each pairwise combination of these variables. For student engagement, there are four variables: interest, concentration, enjoyment, and the composite variable student engagement. There were also three non-engagement variables: challenge, help received, and confidence. In all, 12 correlation coefficients are computed for this research question.

What is the relationship between engagement variables (interest, concentration, and enjoyment) and short-term achievement?

This research question requires analysis of relationships between student engagement and achievement. Correlation coefficients are computed and scatter plots are examined for the variables of achievement and student engagement. The achievement score is the sum of standardized student scores for two unit examinations. Thus, there is a single achievement score for each student. For student engagement, there are four variables: interest, concentration, enjoyment, and the composite variable student engagement. In total, there are four correlation coefficients computed for this research question.

What is the relationship between non-engagement variables (challenge, help required, and confidence) and short-term achievement?

This research question requires analysis of relationships between non-engagement variables and achievement. Correlation coefficients are computed and scatter plots are examined for the variables of achievement and non-engagement variables. The achievement score is the sum of standardized student scores for two unit examinations. Thus, there is a single achievement score for each student. Also, there are three non-engagement variables: challenge, help received, and confidence. In total, there are three correlation coefficients computed for this research question.

Independent Variables

The data can be categorized into various independent groups that may suggest avenues for further study. These independent groups are: classrooms, gender, task location, and prior knowledge. Each of these groupings is next discussed briefly.

Classroom and school differences. Three classrooms from two different schools participated in this study. Are there differences in student responses between the classrooms? Are there differences in student responses between the two schools?

Gender. There is a large body of research that investigates differences between mathematics abilities of male and female students (e.g., Hyde, Fennema, Lamon, 1990; Tobias, 1995). For the current study, each of the schools has a fairly even split of male and female students. Are there differences in student responses between males and females?

Mathematics ability. Researchers have noted that mathematics ability is a good predictor of achievement (Schiefele and Csikszentmihalyi, 1995). Using the Iowa Tests of Basic Skills (ITBS) as a measure of ability, are there differences in student responses among high, middle, and low ability students?

Task location. Recall that a stratified random-sampling was used to select mathematics tasks for this study. A task from the first half of a problem set was called an introductory task and a task from the second half was called a closing task. Are there differences in student responses for introductory tasks and closing tasks?

Finally, it may prove useful to compare student responses by mathematics task in a post hoc analysis. Such results might identify tasks with particularly high or low levels of interest, concentration, enjoyment, engagement, challenge, scaffolding, or confidence. The procedure for this is discussed at length in Chapter Four.

CHAPTER FOUR

DATA ANALYSIS

Beginning in late October and continuing through mid-February, data on ninth-grade students were collected during the 2004-05 school year. In all, data were collected over approximately 14 weeks after removing holidays and snow days. Three classrooms from two different schools participated in this study. There were a total of 54 students in these classrooms, 48 of whom elected to participate.

Students in the study completed surveys regarding their perceptions of mathematics tasks. In total, there were 38 tasks selected for the study, 16 from Unit 2 and 22 from Unit 3 of Course 1 of the CMIC curriculum. Therefore, students were expected to complete an average of 2.8 surveys per week.

For each survey item, a student's mean across tasks was used as the unit of analysis based on recommendations by Larson and Delespau (1992). They state, "Subject-level significance tests are conservative tests and tread on fewer statistical assumptions … we should try whenever possible to aggregate the situational information to one score per subject datum" (p. 67). Thus, each subject has seven scores, a mean across tasks for each of the six survey variables and one score for the composite variable engagement.

Further, Larson and Delespau (1992) warn that caution should be exercised when using student means for analysis. They state, "a mean based on one or two self-reports is not a very reliable estimate of that person's true value" (Larson and Delespaul, 1992, p. 67). In fact, internal inconsistencies are expected in research using the experience-sampling method (ESM). "Contrary to a one-time measure, the ESM is not based on the assumption that people are going to be entirely consistent in their responses … In general, however, it is expected that relative differences between respondnts would tend to persist over time" (Csikszentmihalyi and Larson, 1987, pp. 530-531). In order to account for subject inconsistencies, Larson and Delespau (1992) discuss minimum requirements for ESM data. Based on their recommendations, it was decided that only students with survey completion of 50% or greater would be included in the present study. This requirement reduces the total amount of eligible subjects to thirty-eight, 21 at Tanner High School and 17 at Baker High School. Results for students with less than 50% completion are reported in Appendix F.

For convenience, the name of the high school will identify the classrooms in the study. Therefore, Tanner refers to students in the class at Tanner High School and Baker refers to students in both classes at Baker High School. Notice that the classes at Baker High School are combined, since a 2-tailed, independent t-test revealed no significant differences between the two classes on any of the survey variables (see Table 4.1). On many dependent variables, however, school differences are significant, so the analysis is done separately by school and school differences are discussed in greater detail.

The analysis of the data follows. The analysis begins with the dependent variables. This includes descriptive reports of engagement, non-engagement, and achievement variables. Next, relationships are examined between pairs of dependent variables. After describing and examining relationships among dependent variables, the analysis continues with comparisons of independent variables. Finally, a post-hoc examination is conducted to compare outcomes by task.

Table 4.1

Independent t-tests of survey variables by classrooms at Baker High School (2-tailed)

Classroom	*N*	Mean	*SD*	*df*	*t*	*p*
			Interest			
Baker #1	6	2.64	1.536	15	-.239	.814
Baker #2	11	2.84	1.685			
			Concentration			
Baker #1	6	5.34	1.915	15	1.239	.234
Baker #2	11	4.31	1.477			
			Enjoyment			
Baker #1	6	2.49	1.488	15	-.203	.842
Baker #2	11	2.65	1.619			
			Challenge			
Baker #1	6	2.66	1.579	15	-.859	.404
Baker #2	11	3.33	1.488			
			Help required			
Baker #1	6	1.78	1.167	15	-1.367	.192
Baker #2	11	2.71	1.426			
			Confidence			
Baker #1	6	6.44	1.928	15	-.460	.652
Baker #2	11	6.96	2.404			

Dependent Variables

Description of Student Reports of Engagement

The model of student engagement used in this study relies on the following three components: interest, concentration, and enjoyment. Before analyzing student engagement, data from each of these components are presented separately. A brief summary of important points follows the presentation of results. Findings are discussed fully in Chapter Five.

Interest. After completing each of the selected tasks, students rated their interest by responding to the following survey item, "How interesting is the task?" Students respond to this item by marking their level of interest on a 10-point Likert scale, where 0 is low and 9 is high.

Interest levels at Tanner (4.98) are higher than at Baker (2.77). The maximum student mean at Baker is a little over a point above the midpoint (4.50) of the scale, whereas, the maximum mean at Tanner is more than two points above the midpoint. The minimum mean at both schools is near zero. See Table 4.2 for more information. Using the standard deviation for the entire sample, the effect size is (4.98-2.77)/2.292 = 0.964 *SD*, favoring Tanner.

Concentration. After completing each of the selected tasks, students rated their concentration by responding to the following survey item, "How well were you concentrating on the task?" Students respond to this item by marking their level of concentration on a 10-point Likert scale, where 0 is low and 9 is high.

The range of student means is similar in both schools, although the standard deviation is larger at Tanner. School means indicate that students at Tanner have higher

Table 4.2

Description of interest by school

Classroom	*N*	Mean	*SD*	Min	Max
Tanner	21	4.98	2.326	0.49	7.73
Baker	17	2.77	1.588	0.32	5.89
Total	38	3.99	2.292	0.32	7.73

levels of concentration, 6.74 and 4.68 for Tanner and Baker, respectively. The minimum student mean is similar for both schools, as is the maximum student mean. See Table 4.3 for more information. The effect size is (6.74-4.98)/1.904 = 0.924 *SD*, favoring Tanner.

Table 4.3

Description of concentration by school

Classroom	*N*	Mean	*SD*	Min	Max
Tanner	21	6.74	2.385	2.35	8.35
Baker	17	4.68	1.663	2.33	8.52
Total	38	5.81	1.904	2.33	8.52

Enjoyment. After completing each of the selected tasks, students rated their enjoyment by responding to the following survey item, "Did you enjoy the task?" Students respond to this item by marking their level of enjoyment on a 10-point Likert scale, where 0 is low and 9 is high.

The school mean at Tanner is 4.66, slightly above the midpoint of the scale. The school mean at Baker, however, is almost two points below the scale's midpoint. The minimum at both schools is near zero. Tanner has the maximum mean for enjoyment, 7.97. This is more than two points above the maximum student mean at Baker, 5.79. See Table 4.4 for more information. The effect size is (4.66-2.59)/2.275 = 0.910 *SD*, favoring Tanner.

Table 4.4

Description of enjoyment by school

Classroom	*N*	Mean	*SD*	Min	Max
Tanner	21	4.66	2.385	0.30	7.97
Baker	17	2.59	1.529	0.52	5.79
Total	38	3.74	2.275	0.30	7.97

Student engagement. Recall that student engagement is a composite variable of the previous three variables (Shernoff, et al., 2003). The school mean for Tanner (5.46) is almost a point above the midpoint of the scale and more than two points above the school mean at Baker (3.35). The minimum student means are similar for the two schools, however, Tanner has a maximum student mean of 7.98 and Baker has a maximum student mean 5.80 (see Table 4.5). The effect size is (5.46-3.35)/1.960 = 1.077 *SD*, favoring Tanner.

Table 4.5

Description of student engagement by school

Classroom	*N*	Mean[a]	*SD*	Min	Max
Tanner	21	5.46	1.929	1.44	7.98
Baker	17	3.35	1.270	1.43	5.80
Total	38	4.51	1.960	1.43	7.98

[a]. Engagement is the average of interest, concentration and enjoyment (Shernoff, et al., 2003).

Summary. The minimum scores for all survey items relating to engagement differed little by school. However, there are large school differences in the means and the maximum values. The effect sizes show that Tanner is about one standard deviation above Baker on all variables of student engagement and, of course, on student engagement itself. Comparing data by variable, concentration has the highest school means and enjoyment has the lowest. The relatively high levels of concentration and low levels of interest and enjoyment caused the engagement score to balance out near the middle of the scale (see Figure 4.1).

Two important findings are evident from these data. First, concentration is higher than both interest and enjoyment within each school. Second, variables that contribute to student engagement appear to be related to school differences.

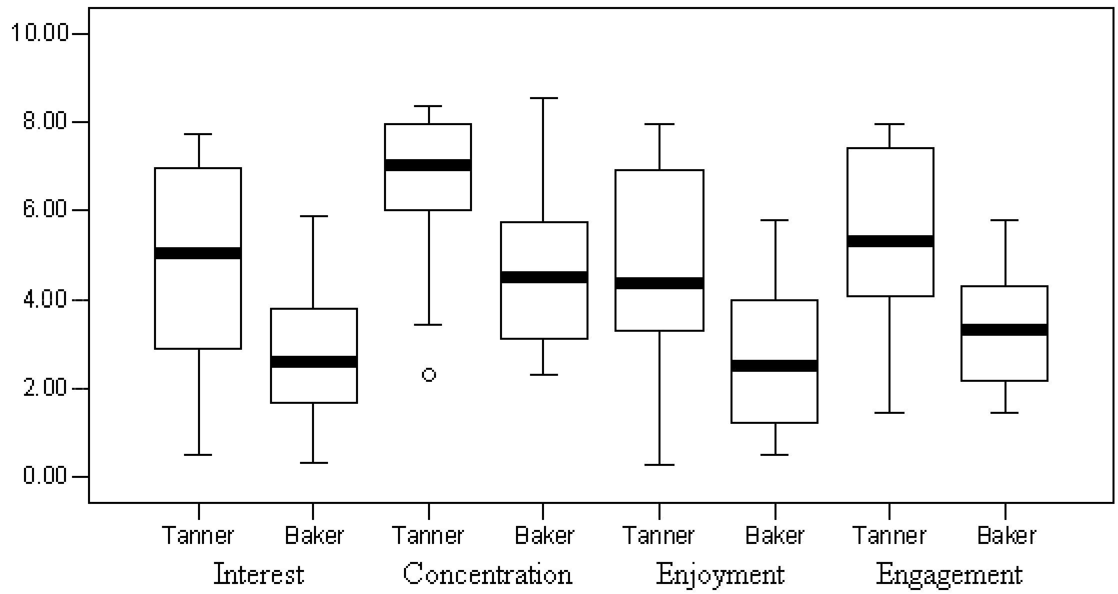

Figure 4.1 – Box plots of survey items and engagement` grouped by school

Description of Students Reports of Non-engagement Variables

The three non-engagement variables included in this study are: challenge, help required, and confidence. Results for each of these variables will be presented separately. A brief summary of salient details follows the discussion of non-engagement variables. Findings are discussed fully in Chapter Five.

Challenge. After completing each of the selected tasks, students rated challenge by responding to the following survey item, "Rate the challenges of the task." Students respond to this item by marking the level of challenge on a 10-point Likert scale, where 0 is low and 9 is high.

The school means are similar, differing by less than half a point (Tanner, 3.53 and Baker, 3.09). The minimum mean in each school is close to zero. The maximum means differed by less than half a point and are 6.03 and 5.67 for Tanner and Baker, respectively (see Table 4.6). The effect size is (3.53-3.09)/1.479 = 0.297 *SD,* favoring Tanner.

Table 4.6

Description of challenge by classroom

Classroom	*N*	Mean	*SD*	Min	Max
Tanner	21	3.53	1.463	0.64	6.03
Baker	17	3.09	1.506	0.09	5.67
Total	38	3.33	1.479	0.09	6.03

Scaffolding. After completing each of the selected tasks, students rated how much help they required by responding to the following survey item, "How much help did you need to solve the task?" Students respond to this item by marking how much help they needed on a 10-point Likert scale, where 0 is low and 9 is high.

Both school means are more than two points below the midpoint of the scale. Tanner's mean is 1.99 and Baker's mean is 2.38. Minimum student means are near zero at both schools. The maximum student means at both schools are near 4.8, which is near the midpoint of the scale (see Table 4.7). The effect size is (2.38-1.99)/1.297 = 0.301 *SD* in favor of Baker.

Confidence. After completing each of the selected tasks, students rated their confidence in their solutions by responding to the following survey item, "How confident are you that the solution(s) is correct?" Students respond to this item by marking their level of confidence on a 10-point Likert scale, where 0 is low and 9 is high.

School means are both more than two points above the midpoint of the scale. Tanner has the higher school mean at 7.61, and the school mean at Baker is 6.78. The minimum scores and standard deviations for the schools indicate that Baker may have

Table 4.7

Description of help required by classroom

Classroom	*N*	Mean	*SD*	Min	Max
Tanner	21	1.99	1.232	0.14	4.84
Baker	17	2.38	1.381	0.00	4.80
Total	38	2.16	1.297	0.00	4.84

outliers in the data. Tanner's standard deviation is below one, with a minimum student mean of 5.95. Baker, however, has a larger standard deviation at 2.2 and a minimum student mean near 0. Looking more closely at the data, three student means at Baker are below five on the confidence scale, 0.93, 3.00, and 4.46 (see Table 4.8). The effect size is (7.61-6.78)/1.628 = 0.510 *SD*, favoring Tanner.

Table 4.8

Description of confidence by classroom

Classroom	*N*	Mean	*SD*	Min	Max
Tanner	21	7.61	0.839	5.95	9.00
Baker	17	6.78	2.200	0.93	8.91
Total	38	7.24	1.628	0.93	9.00

Summary. Across schools, challenge and scaffolding are below the midpoint of the scale. Confidence, on the other hand, is more than two points above the midpoint for each school (see Figure 4.2). The effect sizes ranged from 0.297 to 0.510 *SD* in favor of Tanner. Perhaps the most interesting finding is that school differences are less pronounced for the non-engagement variables than for engagement variables.

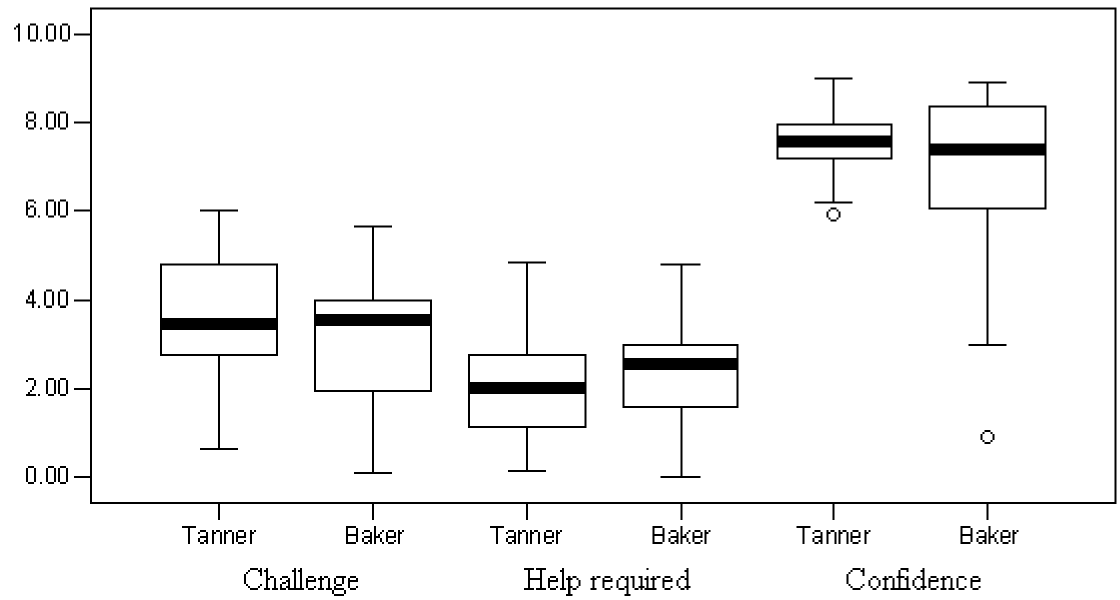

Figure 4.2. School means for non-engagement variables

Description of Achievement

Exam scores from each unit in the study are combined to provide a measure of achievement. Teachers in the study used unit examinations provided by the CMIC curriculum. Exams were graded by the teacher and each has 100 possible points.

This section briefly describes data for each unit examination. The description of each unit exam contains raw scores and no curve or weight has been applied. To standardize across the different exams, z-scores for each unit were computed. The sum of these z-scores from each unit provides a single achievement measure for each student called the exam total score. This score will be the focus of further discussions regarding achievement. The section ends with a brief summary of important details. Findings are discussed fully in Chapter Five.

Unit 2. Both schools used Form B of the unit examination provided by the CMIC curricular materials. Achievement data are not available for one student at Baker. This student also does not have an exam score for Unit 3, nor are her ITBS data available.

Tanner has the higher exam mean at 94.10. Baker's mean is 80.42. Tanner has four and Baker has one student who received the maximum score of 100. The minimum scores, however, are very different between the schools. The minimum exam score at Tanner is 85.00, which is above the school mean at Baker. The minimum exam score at Baker is 33.33 (see Table 4.9).

Table 4.9

Description of achievement by school and examination

School	*N*	Mean	*SD*	Min.	Max.
		Unit 2 examination			
Tanner	21	94.10	4.721	85.00	100.00
Baker	16	80.42	15.148	33.33	100.00
		Unit 3 examination			
Tanner	21	85.67	12.611	60.00	100.00
Baker	13	67.44	8.623	46.67	76.67

Unit 3. The schools used different forms of the unit examination provided by the CMIC curricular materials. Tanner used Form B and Baker used Form A. At Baker, achievement data are not available for four students. ITBS standard mathematics scores are available for two of these students, who scored 249 and 267, 34th and 72nd percentiles, respecitvely. The mean for ITBS math scores at Baker is 271.69.

Again, Tanner has the higher exam mean at 85.67. Baker's mean is 67.44. Three students at Tanner received a perfect score of 100. Baker's maximum score is 76.67. The minimum score at Tanner is 60, whereas the minimum score at Baker is lower at 46.67 (see Table 4.9).

Exam total. The sum of standardized examination scores from Unit 2 and Unit 3 are used to provide an overall achievement score for each student. This score will be called the "exam total" and will be the achievement measure used in further analyses. An examination score is missing for at least one of the units for four students, so they are omitted from this analysis.

The mean of standardized exam totals is higher at Tanner at .96. Baker's mean z-score is -1.07. One student at Tanner has perfect scores on both exams, with a maximum z-score of 2.44. The maximum exam total is .81 at Baker. The minimum score at Tanner is -1.08, slightly below Baker's school mean. The minimum score at Baker is -2.53 (see Table 4.10).

Summary. Tanner's school means are higher than Baker's on both unit exams, which contributes to the higher exam total score. The means at Baker may have been influenced by outliers in the data, as indicated in Figure 4.3. However, the medians are less susceptible to outliers and are still higher at Tanner as seen in Figure 4.3.

Table 4.10

Description of standardized exam total scores by school

School	*N*	Mean	*SD*	Min	Max
Tanner	21	.96	1.086	-1.08	2.44
Baker	13	-1.07	.997	-2.53	.81

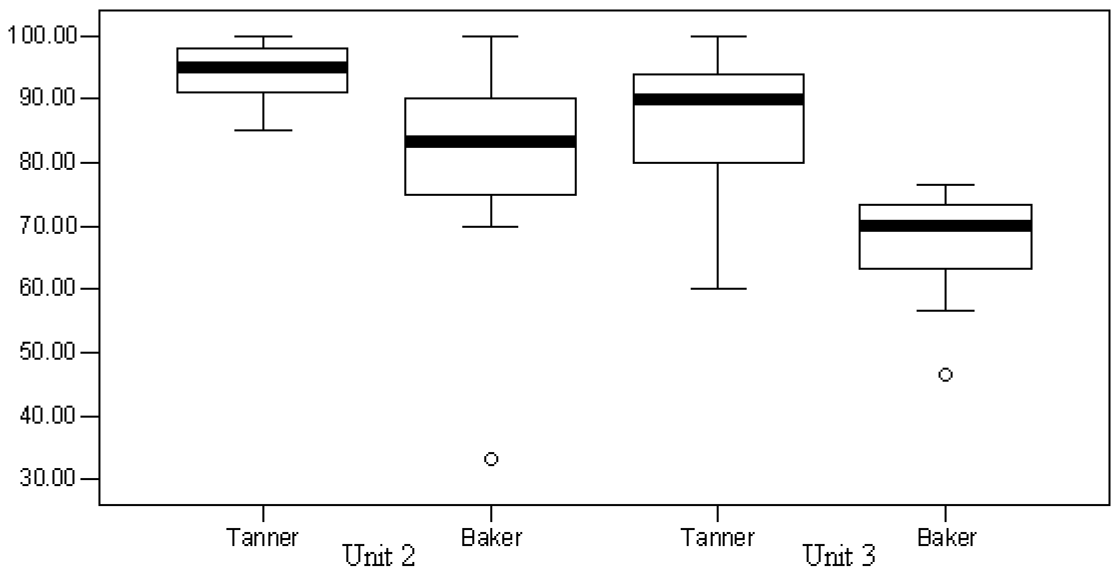

Figure 4.3 – Box plots of achievement scores by unit and school

Relationships among Dependent Variables

This section focuses on relationships between pairs of dependent variables in this study. In total, there are eight dependent variables for consideration: interest, concentration, enjoyment, engagement, challenge, help required, confidence, and exam total. In order to investigate relationships, a Pearson's correlation is computed for pairwise combinations of these variables. Results are discussed by school to be consistent with earlier reports.

The discussion for each school begins by examining relationships between dependent variables. Next, the school discussion focuses on relationships between engagement variables and then between non-engagement variables. A brief summary follows the discussions of the schools. Findings are discussed fully in Chapter Five.

Tanner. There are no significant correlations between engagement and non-engagement variables at the 0.05 level (see Table 4.11). However, there are moderate correlations (above 0.30) between challenge and other engagement variables. Challenge and interest are negatively correlated at -0.36, challenge and enjoyment are negatively correlated at -0.34, and challenge and engagement are negatively correlated at -0.30.

All correlations between pairs of engagement variables are significant. Engagement is positively correlated with the other engagement variables, which is, of course, expected because engagement is defined as the average of these variables. Further, interest, concentration and enjoyment are all positively correlated with one another above 0.60.

Two correlations among non-engagement variables are significant. First, there is a positive correlation of 0.70 between challenge and help required. This is expected because students require more help when challenge is high, and less help when challenge is low. Second, there is a negative correlation of -0.62 between confidence and help required. Again this is expected because students require more help if they are not confident in their solutions and less help if they are confident.

Table 4.11

Correlations among dependent variables for Tanner (N=21) and Baker (N=17)

	Conc.	Enjoy	Eng.	Chal.	Help	Conf.	Exam[a]	ITBS[b]
Interest								
Tanner	.62**	.96**	.97**	-.36	-.30	.27	-.01	-.26
Baker	.23	.95**	.90**	.56*	.35	.17	-.29	.31
Concentration								
Tanner	1	.62**	.78**	-.08	.00	.13	.05	-.26
Baker	1	.21	.62**	-.23	-.38	.58*	.01	.44
Enjoyment								
Tanner	-	1	.97**	-.34	-.17	.22	.02	-.27
Baker	-	1	.89**	.66*	.43	.21	-.29	.32
Engagement								
Tanner	-	-	1	-.30	-.19	.23	.02	-.29
Baker	-	-	1	.39	.15	.41	-.18	.40
Challenge								
Tanner	-	-	-	1	.70**	-.29	.22	.03
Baker	-	-	-	1	.87**	.00	-.17	.13
Help required								
Tanner	-	-		-	1	-.62**	.16	-.05
Baker	-	-	-	-	1	-.12	-.25	.01

Table 4.11-continued

	Conc.	Enjoy	Eng.	Chal.	Help	Conf.	Exam[a]	ITBS[b]
Confidence								
Tanner	-	-	-	-	-	1	-.31	-.37
Baker	-	-	-	-	-	1	-.46	.65*
Exam total								
Tanner	-	-	-	-	-	-	1	.43
Baker	-	-	-	-	-	-	1	.03

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

[a]. N=13 for Baker.

[b]. N=13 for Baker, N=20 for Tanner.

Finally, there are no significant correlations between survey variables and the exam total score. There is, however, a moderate negative correlation between help required and exam total (-0.31). This is not expected because other research has shown that confidence tends to positively correlate with achievement (McLeod, 1992). Further, there were no significant correlations between dependent variables and ITBS scores. ITBS scores will be discussed in the section Mathematics Ability.

Baker. Unlike Tanner, three correlations are significant between engagement and non-engagement variables at the 0.05 level. Challenge and interest are positively correlated at 0.56. Challenge and enjoyment are positively correlated at 0.66. Confidence and concentration are positively correlated at 0.58.

There are five other moderate correlations (above 0.3) that are not significant, but worth mentioning because of the small sample size. Help required is positively correlated with interest (0.35) and enjoyment (0.43). Further, help required is negatively correlated with concentration (-0.38). Engagement is positively correlated with challenge (0.40), possibly due to the significant correlations between engagement and the variables interest and enjoyment. Engagement is also positively correlated with confidence (0.41).

Only one correlation among engagement variables is significant, compared to all three at Tanner. Interest and enjoyment are positively correlated are 0.96. Engagement is positively correlated with the variables interest, concentration, and enjoyment, which is expected because engagement is the average of these three variables. It is curious that concentration did not have a high correlation with interest or enjoyment given the high correlations at Tanner.

Only one correlation among non-engagement variables is significant. Challenge and help required are positively correlated at 0.84. This is expected because students who find a task challenging, also seek help. Further, students are not likely to require as much help for tasks they do not find challenging.

Finally, there are no significant correlations between survey variables and the exam total score. As at Tanner, there is also a moderate negative correlation between confidence and exam total (-.46). This is not expected because other research has shown that confidence tends to positively correlate with achievement (McLeod, 1992). Further, there were no significant correlations between dependent variables and ITBS scores. ITBS scores will be discussed in the section Mathematics Ability.

Summary. The significant correlations between engagement and non-engagement variables at Baker are not expected given the results at Tanner. Specifically, Tanner has moderate negative correlations between challenge and interest, and challenge and engagement. Baker has significant positive correlations between these two sets of variables. Differences between school correlations will be explored in the section on school differences.

Independent Variables

Besides the dependent variables, there are various independent variables that may provide insight into the data. Thus far, the data analysis indicates differences between schools. These differences are now explored in more detail. Also, there are other independent variables such as gender, task location, unit scores, and prior knowledge, which may provide useful ways of examining the data.

School Differences

In the introduction to this chapter, it was stated that significant statistical differences exist between the two schools in this study. This section explores these differences by comparing means and correlation coefficients by school.

Differences between school means. This study was conducted at three classrooms in two schools. Independent t-tests of the survey variables indicates no significant differences on any survey variables between the two Baker classrooms at the 0.05 level (see Table 4.1). There is a statistical difference between the Baker classrooms for the exam total score. This will be discussed as a limitation for this study in Chapter Five.

Also, an independent t-test was done to examine school differences. Significant differences exist at the 0.05 level for all component engagement variables and achievement. Tanner has a significantly higher mean for interest, concentration, enjoyment and the exam total (see Table 4.12). These differences suggest that engagement and achievement are more susceptible to school or classroom differences than the non-engagement variables.

Differences between correlation coefficients. The Pearson correlation coefficients for each school are given in Table 4.11. The magnitudes of these correlations suggest that some may differ by school. In this section, these differences between correlations are tested for statistical significance.

Given two independent samples, correlation coefficients can be compared using Fisher's $\bar{z}$. First, it is necessary to convert Pearson correlation coefficients to Fisher's z coefficients. The standard error for Fisher's $\bar{z}$ is given by the formula,

$$\sqrt{\frac{1}{N_1 - 3} + \frac{1}{N_2 - 3}}.$$

From the data for this study, $N_1 = 21$ and $N_2 = 17$, so the standard error is approximately 0.3564. The formula for $\bar{z}$ is,

$$\frac{z_1 - z_2}{\text{standard error}}.$$

This distribution is approximately normal. Table 4.13 identifies significant differences between correlation coefficients at the .10 and .05 levels (two-tailed).

Table 4.12

Independent t-tests of dependent variables by school (2-tailed)

Classroom	*N*	Mean	*SD*	*df*	*t*	*p*
			Interest			
Tanner	21	4.98	2.326	36	3.331	.002
Baker	17	2.77	1.588			
			Concentration			
Tanner	21	6.74	1.579	36	3.907	.000
Baker	17	4.68	1.663			
			Enjoyment			
Tanner	21	4.66	2.385	36	3.240[a]	.003
Baker	17	2.59	1.529			
			Challenge			
Tanner	21	3.53	1.463	36	.913	.367
Baker	17	3.09	1.506			
			Help required			
Tanner	21	1.99	1.232	36	-.914	.367
Baker	17	2.38	1.381			
			Confidence			
Tanner	21	7.61	.839	36	1.480[a]	.117
Baker	17	6.78	2.200			

Table 4.12-continuted

			Exam total			
Tanner	21	.96	1.086	32	5.477	.000
Baker	13	-1.07	.997			

[a]. Equal variances not assumed.

Table 4.13

Differences between correlation coefficients at Tanner and Baker

Comparison	Tanner *r*	Baker *r*	$\bar{z}$
Interest - Challenge	-.36	.56	-2.834**
Enjoyment - Challenge	-.34	.66	-2.834**
Engagement - Challenge	-.30	.39	-2.020**
Interest - Help	-.30	.35	-1.908*
Enjoyment - Help	-.17	.43	-1.768*
Confidence - Help	-.62	-.12	-1.712*

**. $p < 0.05$

*. $p < 0.10$

To further examine these differences, scatter plots are given for both schools for each pair of variables with a significant difference. The first comparisons that are discussed involve challenge. There are three significant comparisons that include challenge, interest-challenge, enjoyment-challenge, and engagement-challenge. Interest and enjoyment are both components of engagement, so the discussion will focus on the larger issue of engagement.

The scatter plot for engagement-challenge reveals that the data for Tanner clearly does not fall into a linear pattern (see Figure 4.4). For Baker, however, the data are mostly centered on a line, with one outlier who rated challenges as moderate, but engagement low. When this outlier is removed, the correlation is 0.58, which is significant at the 0.05 level. Removing this outlier increases the correlation difference between schools.

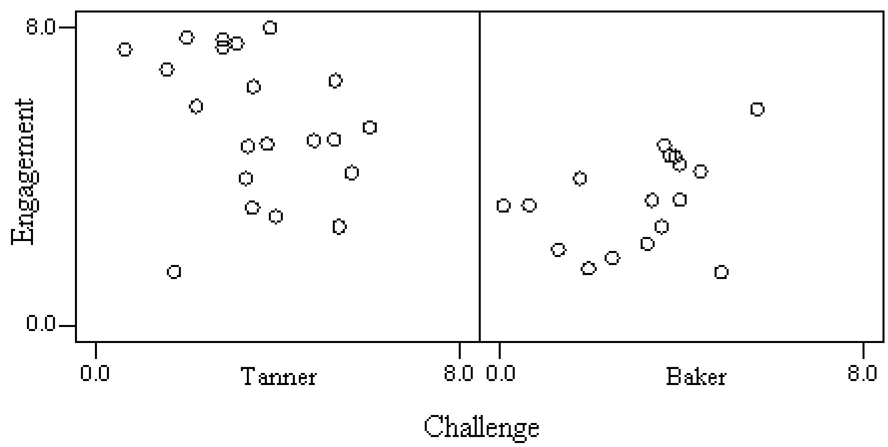

Figure 4.4 – Scatter plots of challenge and engagement by school

There are three significant differences between correlations that involve help required. Two comparisons involved the engagement variables interest and enjoyment. Interest and enjoyment are highly correlated so their results are discussed together. The last comparison is for correlations between confidence and help received.

The scatter plots of help received-interest and help received-enjoyment are very similar, so the former is given in Figure 4.5. The data for Tanner does not fall into a linear pattern. At Tanner, there is an outlier who has required moderate help, but has low interest. When this outlier is removed, the correlation is -.09, suggesting less of an association than the coefficient for all data (-.30).

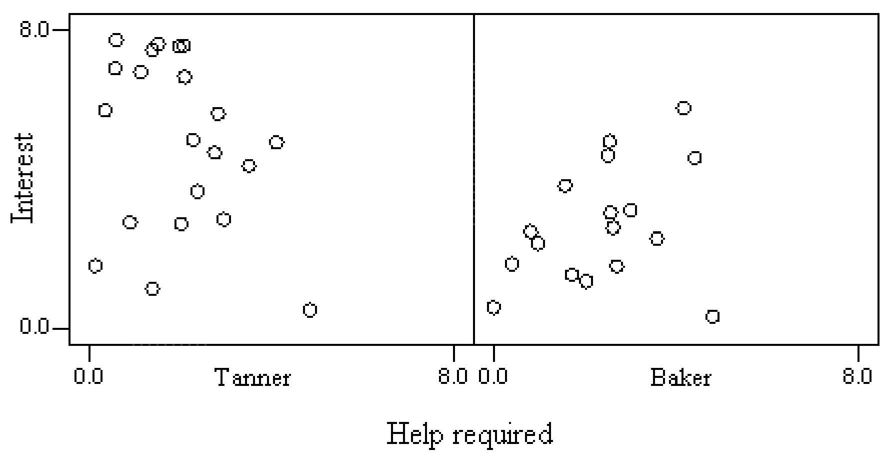

Figure 4.5 – Scatter plots of help required and interest by school

At Baker, the data more closely fit a line. There is one outlier who reported a moderate amount of help required and low interest. When this outlier is removed, the correlation is 0.65, which is significant at the 0.01 level. Notice that removing one outlier at each school makes the differences in correlations coefficients even more pronounced than those for the entire set of students.

In addition to engagement variables, there were also differences between correlation coefficients for help required and confidence. Scatter plots show that most of the data for both schools are in the area of high confidence and low help required (see

Figure 4.6). There are two outliers at Baker that do not fit this pattern. If the most extreme outlier is removed, the correlation at Baker is -.22, and the Fisher $\bar{z}$ it -1.401 (SE = .3640), which is not significant at the 0.10 level. Thus, this school difference in correlation coefficients may be of little practical significance.

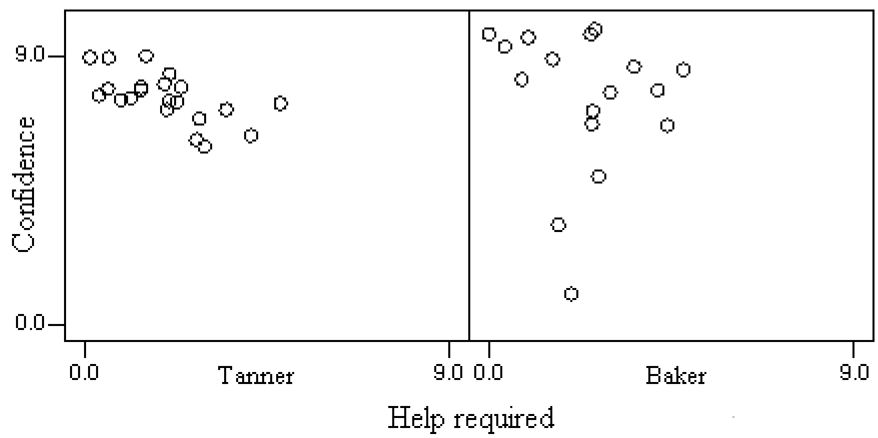

Figure 4.6 – Scatter plots of help required and confidence by school

Summary. This section indicates that there are differences between the two schools. An independent t-test showed that the differences between dependent variables are limited to engagement and achievement. Non-engagement variables appear to be less susceptible to school and classroom factors.

Differences between correlation coefficients are less clear. There is evidence that some correlations are influenced by one or two outliers, mostly due to the small *N* of the sample. However, only one comparison with an outlier reduced the difference between the two schools when the outlier was removed. Once removed, there was no longer a significant difference between schools for the correlation between help required and confidence. The other differences between correlation coefficients remained.

Gender Differences

Both schools have a fairly even split of male and female students. For each school, independent t-tests reveal no significant differences between male and female students on any dependent variable. The means and standard deviations of these students are reported by school and gender in Table 4.14.

Table 4.14

Student means (and standard deviations) on dependent variables by school and gender

	Tanner		Baker	
Variable	Female (N=10)	Male (N=11)	Female (N=8)	Male (N=8)
Interest	4.85 (2.458)	5.09 (2.313)	2.84 (1.607)	2.48 (1.620)
Concentration	6.84 (1.590)	6.64 (1.641)	4.26 (1.375)	5.16 (1.994)
Enjoyment	4.60 (2.508)	4.73 (2.389)	2.78 (1.378)	2.22 (1.701)
Challenge	3.48 (1.312)	3.58 (1.652)	3.58 (1.057)	2.49 (1.811)
Help required	1.82 (1.014)	2.15 (1.432)	2.64 (1.304)	1.86 (1.289)
Confidence	7.58 (1.008)	7.64 (0.7002)	7.26 (1.408)	6.39 (2.925)
Exam total	181.80 (13.156)	177.91 (17.044)	145.56 (8.344)[a]	157.62 (14.622)[b]

[a]. N = 6

[b]. N = 7

Task Location

Recall that a stratified-random sampling was used to select mathematics task for this study. This wsa done because mathematics problems tend to increase in inclusiveness and perhaps in difficultly throughout an investigation. A dependent t-test is used to compare student means across the 19 introductory tasks and the 19 closing tasks within each school. There are no significant differences between introductory and closing tasks on any of the survey variables at the 0.05 level (see Table 4.15).

Table 4.15

Student means (and standard deviations) for survey variables by school and task location

	Tanner (N=21)		Baker (N=17)	
Variable	Introductory	Closing	Introductory	Closing
Interest	4.90 (2.238)	5.07 (2.448)	2.79 (1.519)	2.75 (1.747)
Concentration	6.76 (1.536)	6.71 (1.654)	4.58 (1.689)	4.80 (1.750)
Enjoyment	4.67 (2.343)	4.65 (2.452)	2.64 (1.461)	2.53 (1.681)
Challenge	3.61 (1.382)	3.45 (1.612)	3.09 (1.582)	3.07 (1.479)
Help received	1.89 (1.084)	2.10 (1.436)	2.43 (1.411)	2.31 (1.379)
Confidence	7.54 (0.861)	7.70 (0.881)	6.89 (2.145)	6.64 (2.321)

Unit Differences

Recall that student participated in two units of instruction during the study, units 2 and 3. A dependent t-test is used to compare student means over Unit 2 and Unit 3 within each school. There are no significant differences between units 2 and 3 on any of the survey variables at the 0.05 level (see Table 4.16).

Table 4.16

Unit means (and standard deviations) for survey variables by school and curricular unit

	Tanner (N=21)		Baker (N=17)	
Variable	Unit 2	Unit 3	Unit 2	Unit 3
Interest	4.98 (2.140)	4.89 (2.700)	3.04 (1.817)	2.66 (1.760)
Concentration	6.78 (1.511)	6.65 (1.748)	5.26 (1.674)	4.26 (2.100)
Enjoyment	4.87 (2.261)	4.42 (2.577)	2.81 (1.761)	2.60 (1.784)
Challenge	3.72 (1.554)	3.31 (1.599)	3.16 (1.444)	3.09 (1.803)
Help received	1.94 (1.270)	1.98 (1.435)	2.16 (1.632)	2.54 (1.514)
Confidence	7.67 (0.704)	7.58 (1.037)	6.72 (2.033)	6.84 (2.313)

Mathematics Ability

ITBS mathematics data were collected as a measure of prior mathematics ability. These data were available for 33 of the 38 students. The scores that are reported are national standard scores. The range of scores is from 195 to 320.

At Tanner, the mean and standard deviation are 278.55 and 20.049. The mean corresponds to a national student percentile rank of 88. At Baker the mean is 271.6, which corresponds to the 79th national student percentile, and standard deviation is 27.127. Notice that the mean is lower at Baker but the standard deviation is higher. This higher standard deviation is due to one low outlier. If this outlier is removed, the mean for Baker is 278.55 and the standard deviation is 14.951, which are more similar to Tanner's scores.

Table 4.11 reveals one statistically significant correlation between survey variables and ITBS standard scores. At Baker, there is an expected positive correlation (0.65) between confidence and prior mathematics ability, but this correlation is negative at Tanner. In fact, Table 4.17 indicates three significant differences between correlation coefficients at the schools including the coefficient for ITBS-confidence. The standard error for Fisher's z is 0.3985 for this table.

Table 4.17

Differences between ITBS correlation coefficients at Tanner (N=20) and Baker (N=13)

Variable	Tanner *r*	Baker *r*	$\bar{z}$
ITBS - Concentration	-.26	.44	-1.857*
ITBS - Engagement	-.29	.40	-1.807*
ITBS - Confidence	-.37	.65*	-2.936**

**. $p < 0.05$

*. $p < 0.10$

Concentration is a component of engagement, so this discussion will focus on the larger issue of engagement. At both schools, most students have a standard mathematics score of 240 or above. In fact, there is only one student with a score below 240. If this outlier is removed, the correlation at Baker is 0.34, indicating that outlier had some effect on the correlation coefficient (see Figure 4.7). Scatter plots further indicate a wider range of engagement scores at Tanner compared to Baker, which may have contributed to the correlation difference between schools.

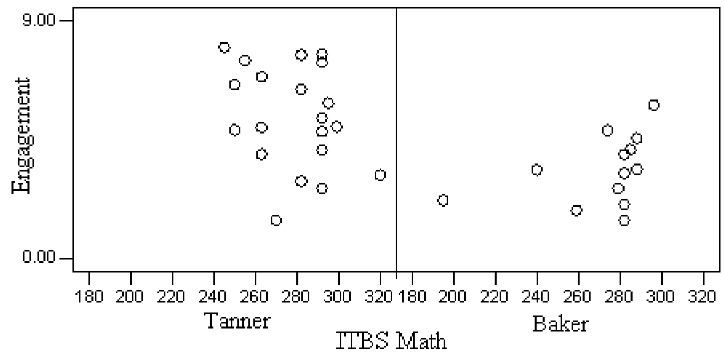

Figure 4.7 – Scatter plots of engagement and prior mathematics ability by school

The other significant difference for correlation coefficients is between confidence and prior mathematics ability. Again removing the outlier gives Baker a correlation of 0.53, indicating that outlier had some effect on the correlation coefficient (see Figure 4.7). The scatter plots also indicate a wider spread of ITBS mathematics standard scores at Tanner. This observation will be collaborated by further analysis below.

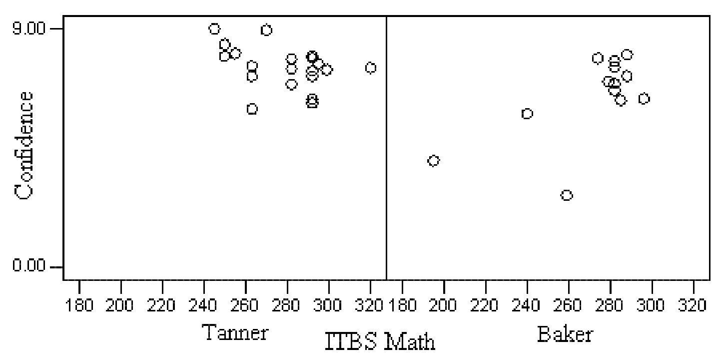

Figure 4.8 – Scatter plots of confidence and prior mathematics ability by school

In the scatter plots above, it is worth noting that ITBS mathematics scores appear to be more variable at Tanner over Baker. Table 4.18 confirms this suspicion as students at Baker consist of mostly a narrow range of abilities, whereas students from Tanner mostly make up the lower and higher groups. This indicates that the students at Tanner are more diverse, while the students at Baker are more homogeneous. Student differences may have also had an effect on the differences between correlation coefficients.

Table 4.18

Number of students per national student percentile rankings by school

School	0-78	79-96	96-99
Tanner	8	1	9
Baker	3	10	2
Total	11	11	11

Post Hoc Analysis

It is also of interest, especially to mathematics curriculum developers, to examine data for each task, across students. Doing so will provide an idea of which tasks students rated especially high or low on the survey variables. This will be done by converting each student's raw score into a standardized z-score (Schiefele and Csikszentmihalyi, 1995; Shernoff, et al., 2003). A discussion of this process is followed by results for each of the survey variables and engagement.

The standardized z-scores used in this section of the analysis are based on each student's individual experience. To illustrate this process, suppose S_1 is a student and this student has the following raw scores for the dependent variable interest: $x_{1,1} \ldots x_{1,38}$, where 38 indicates the total number of tasks. These scores have a mean, $\overline{x_1}$, and a standard deviation, σ_1. Based on the student's mean and standard deviation, the raw scores $x_{1,k}$ are transformed to z-scores by the following formula,

$$z_{1,k} = \frac{x_{1,k} - \overline{x_1}}{\sigma_1}.$$

This z-score is a measure of the number of standard deviations a given score is from the student's mean. Thus, a z-score of zero on a task indicates that the level of interest for that task is at the student's average, whereas a z-score of one indicates that the level of interest in the task is one standard deviation above the student's average.

For each variable, standardized z-scores are computed in this way for each student relative to his or her own mean. Thus, task one would have the following z-scores across students: $z_{1,1} \ldots z_{n,1}$, where n is the number of students. The mean of these z-scores across students is an indicator of the overall level of interest for task one. This process is repeated for all tasks and all variables. The cut score of $\pm 0.25\,SD$ is used to identify tasks with particularly high or low ratings on a variable. Results across all tasks and variables are given in Appendix G.

On the whole, it is difficult to identify any patterns in the data. However, there does appear to be a pattern involving the variables engagement, challenge, and confidence. On one hand, tasks that students found particularly engaging tended to be less challenging, and students were more confident in their solutions. On the other hand, tasks that students found to be less engaging than others tended to be high on challenge and low on confidence. Five tasks are chosen for illustration here. Two of these tasks (2.13 and 2.14) fit the pattern of high engagement and confidence, but low challenge.

Two other tasks (2.03 and 3.22) fit the pattern of low engagement and confidence, but high challenge. The fifth task (2.03) is an exception to these patterns and is particularly low on these variables (see Table 4.19).

Table 4.19

Mean z-scores across students for selected tasks

Task	Engagement	Challenge	Confidence
2.02	-.25	-.35	-1.07
2.03	-.26	.43	-.55
2.13	.75	-.34	.55
2.14	.79	-.35	.46
3.22	-.51	.20	-.30

The two tasks with relatively high engagement and confidence, but low challenge (2.13 and 2.14) come from the same lesson. This lesson is divided into four experiments, each involving a different type of function. The lesson is very interactive as each group member is given a task, then the group comes together to identify patterns and make conjectures regarding the functions. Further, it may be important that neither task is set in real-world context (see Figures 4.9 and 4.10).

Unit 2, Lesson 4.2

Experiment 1

1. Do the following for each rule listed below:
   - Produce a table of values and a graph. Use the standard viewing window: Xmin = –10, Ymin = –10, Xmax = 10, Ymax = 10, Xscl = 1, and Yscl = 1.
   - On a separate sheet of paper, write the rule and make a sketch of the graph. How does the pattern of values in the table match the pattern in the graph?
   - Have each member of your group examine how the graph appears using a different viewing window. Compare your graphs and viewing windows.

   a. $y = 2x - 4$ **b.** $y = 2x + 4$ **c.** $y = 0.5x + 2$
   d. $y = -0.5x + 2$ **e.** $y = 10 - 1.5x$ **f.** $y = x^2 - 4$

Figure 4.9 – Task 2.13

Source: Coxford, A.F., Fey, J.T., Hirsch, C.R., Schoen, H.L., Burrill, G., Hart, E.W., Watkins, A.E. (with Messenger, M.J., & Ritsema, B.). (2003). *Contemporary mathematics in context: A unified approach* (Course 1). New York: Glencoe/McGraw-Hill. (p. 144)

Unit 2, Lesson 4.2

Experiment 4

1. Do the following for each rule listed below:
   - Produce a table of values and a graph. Decide as a group on a common viewing window to use.
   - On a separate sheet of paper, write the rule and make a sketch of the graph. How does the pattern of values in the table match the pattern in the graph?
   - Have each member of your group examine how the graph appears using a different viewing window. Compare your graphs and viewing windows.

   a. $y = 2^x$ **b.** $y = (1.5)^x$ **c.** $y = 3^x$
   d. $y = x^3$ **e.** $y = (0.5)^x$ **f.** $y = x^{0.5}$

Figure 4.10 – Task 2.14

Source: Coxford, A.F., Fey, J.T., Hirsch, C.R., Schoen, H.L., Burrill, G., Hart, E.W., Watkins, A.E. (with Messenger, M.J., & Ritsema, B.). (2003). *Contemporary mathematics in context: A unified approach* (Course 1). New York: Glencoe/McGraw-Hill. (p. 146)

The two tasks that have relatively low engagement and confidence, but high challenge (2.03 and 3.22) appear to have very little in common. Task 2.03 is a contextual task asking students to interpret information about population change. The high challenge involved in this task may be due to the complexity or unfamiliarity of the context. Task 3.22, however, is not set in a context. It asks students to solve a system of equations with two variables. The high challenge in this task may be due to its abstract nature or the fact that this is the last task in the review section of Unit 3. Its content has not been a major emphasis of this unit (see Figures 4.11 and 4.12).

Unit 2, Lesson 2.1

Brazil is the largest country in South America, and its 1990 population was about 145 million people. Census statisticians estimated the population of Brazil from one year to the next using small surveys and the following facts about patterns of change:

Population Change in Brazil

- Based on recent trends, births every year equal about 2.6% of the total population.
- Deaths every year equal about 0.7% of the total population.
- The net change due to births and deaths is an increase of 1.9% each year.

Source: *World Population Data Sheet (1992)*, Population Reference Bureau, Washington, D.C., 1992.

Working with your group, use these facts to estimate Brazil's population after 1990.

1. What was the estimated change in Brazil's population by 1991 due to

a. births? **b.** deaths? **c.** both causes combined?

Figure 4.11 – Task 2.03

Source: Coxford, A.F., Fey, J.T., Hirsch, C.R., Schoen, H.L., Burrill, G., Hart, E.W., Watkins, A.E. (with Messenger, M.J., & Ritsema, B.). (2003). *Contemporary mathematics in context: A unified approach* (Course 1). New York: Glencoe/McGraw-Hill. (p. 111)

Unit 3, Lesson 4, Item 5d.

d. Solve the following system of equations using calculator or computer-based methods and by reasoning with the symbolic forms.

$$y = 35 + 0.2x$$
$$y = 85 + 0.7x$$

Figure 4.12 – Task 3.22

Source: Coxford, A.F., Fey, J.T., Hirsch, C.R., Schoen, H.L., Burrill, G., Hart, E.W., Watkins, A.E. (with Messenger, M.J., & Ritsema, B.). (2003). *Contemporary mathematics in context: A unified approach* (Course 1). New York: Glencoe/McGraw-Hill. (p. 248)

An exception to these patterns is task 2.02, which has relatively low engagement, challenge, and confidence. This task asks students to compare data with other groups and look for patterns. Tasks 2.13 and 2.14 also ask students to find patterns, but in a more structured way that gives each group member a share of the responsibilities. The lack of structure on Task 2.02 may have left students not knowing what was expected of them. This uncertainty may account for the task's low ratings. Clear goals are one of the attributes of flow identified in previous research (Csikszenthimalyi, 1990) (see Figure 4.13).

Unit 2, Lesson 1.1

3. Compare your results to those of other groups who might have used more, fewer, or different rubber bands; different weights; or different methods for collecting the data pairs.

The data from tests of your model bungee apparatus are ordered pairs of numbers in the form (*weight*, *stretch*). Looking for patterns in these kinds of data is often easier if the data pairs are presented in a graph like the one shown here.

The sample graph shows specific information (*weight*, *stretch*) and also a pattern in the relation between the two *variables*.

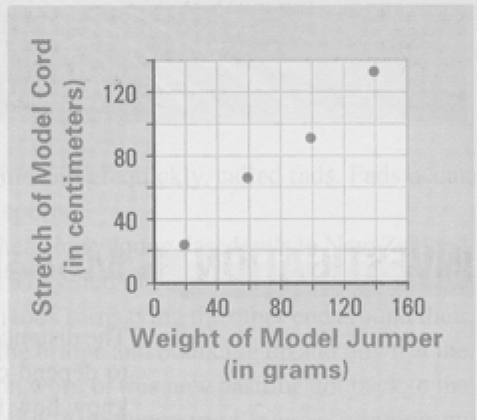

Figure 4.13 – Task 2.02

Source: Coxford, A.F., Fey, J.T., Hirsch, C.R., Schoen, H.L., Burrill, G., Hart, E.W., Watkins, A.E. (with Messenger, M.J., & Ritsema, B.). (2003). *Contemporary mathematics in context: A unified approach* (Course 1). New York: Glencoe/McGraw-Hill. (p. 100)

Summary

The first two tasks discussed resulted in high engagement and confidence, but low challenge. The interactive nature of these tasks may account for these findings. The second two tasks discussed had little in common, but resulted in low engagement and confidence, and high challenge. The unfamiliarity and complexity of the population growth context and the abstract nature of the systems of equations may explain the high challenge involved with these tasks. The last task was the only one of 38 tasks that resulted in low engagement, challenge, and confidence. This task was part of an investigation that was intended to be very interactive (collecting bungee jump data), but the goals of the tasks did not appear to be clear as the first two reported tasks. The lack of clear goals may explain the low student ratings on engagement, confidence, and challenge. Student comments available in Appendix H do not provide much insight for explaining these patterns.

CHAPTER FIVE

DISCUSSION

The research questions from Chapter One are answered in the following section. Next, further interpretation and implications are drawn from the results. Limitations of the study are then discussed, followed by suggestions for future research.

Research Questions

Research Question 1: During class time, how do secondary students rate their levels of engagement for mathematics tasks?

Each school's mean for engagement was close to the midpoint of the scale, 4.5. The school mean at Tanner was almost one point above the midpoint and the school mean at Baker was a little more than a point below the midpoint.

These engagement means are mainly the result of relatively high concentration, but lower enjoyment and interest at both schools. At Tanner, interest and enjoyment were close to the midpoint, whereas concentration was high at 6.74. At Baker, concentration was close to the midpoint, but interest and enjoyment were low, 2.77 and 2.59, respectively. Students at each school tended to rate levels of concentration two points above levels of interest and enjoyment. This suggests that students felt they were concentrating hard, but they generally did not find the tasks very interesting or enjoyable.

The current study focuses on mathematics tasks done mainly as group work. The findings can be compared to earlier results from Shernoff, et al. (2003). Before making such comparison, it is important to note that results from the two studies are not strictly comparable. Students in the Shernoff, et al. study were responding to the instructional activities they were involved in, not to specific mathematics tasks as in the present study. Thus, results are presented as a benchmark for the current study, but comparisons should be made with caution.

Shernoff, et al. (2003) report the following group work means across all courses: 6.18 for engagement, 5.46 for interest, 7.34 for concentration, and 5.84 for enjoyment. Although the pattern of scores is similar, these results are approximately a point higher than findings at Tanner and more than 2.5 points higher than findings at Baker. This earlier research suggests that group work in mathematics class may be less engaging than in other classes.

Shernoff, et al. (2003) also reported the following means for mathematics classes: 5.35 for engagement, 4.43 for interest, 6.65 for concentration, and 4.92 for enjoyment. Although these scores are higher than reports from Baker, the pattern of higher concentration and lower interest and enjoyment was evident at both schools in the current study.

The results in the present study indicate a pattern of relatively high concentration, coupled with lower interest and enjoyment. Perhaps most importantly, results indicate that there are striking differences between schools on variables of engagement. These differences were verified by independent t-tests and will be discussed in the Conclusions and Implications section.

Research Question 2: During class time, how do secondary students rate non-engagement variables (challenge, help required, and confidence) for mathematics tasks?

For the non-engagement variables, school differences are smaller than for engagement variables. Both schools rated challenge as moderately low, 3.5 at Tanner and

3.1 at Baker. Given the level of challenge, students at Tanner required less help than those at Baker. At Tanner, help required is 1.5 points lower than challenge, but only 0.7 points lower than challenge at Baker. This may indicate that Baker students sought more help even though they generally did not think the tasks were very challenging. Relationships between challenge and help required are explored further in the discussion of the next research question.

The other non-engagement variable is confidence. Both schools report high levels of confidence, 6.8 at Baker and 7.6 at Tanner. Confidence is rated higher at Tanner, where challenge was also rated higher. This indicates that students were confident despite relatively high challenge. Relationships between these and other variables are explored in more depth following the next research question.

Research Question 3: What are the relationships among engagement variables (interest, concentration, and enjoyment) and non-engagement variables (challenge, help required, and confidence)?

School differences dictated that correlations be computed by school. For Tanner, correlations among engagement variables were all significantly different from zero. At Baker, only interest and enjoyment were significantly correlated. There were no significant differences by school between correlation coefficients for these comparisons. These correlations help to confirm the validity of a model of student engagement based on interest, concentration, and enjoyment. Further, high correlations between interest and enjoyment suggest the instrument may have been measuring the same construct.

The pattern of relationships was different among non-engagement variables. Neither school had a significant correlation between challenge and confidence. As hypothesized earlier, students were highly confident of their responses despite the perceived level of challenge of the task. Further, both schools had significant correlations (above .70) between challenge and help required, indicating that students tended to seek more help when faced with increasing challenges, which is expected.

Although both correlations between confidence and help required were negative, the correlation coefficients were significantly different by school. The difference, however, was no longer significant following the removal of one outlier at Baker. This suggests that the difference between confidence and help required correlation coefficients by school has little practical significance, perhaps partly due to the small N of the sample.

Correlations between engagement variables and non-engagement variables were more complex. At Tanner, there were no significant correlations between engagement variables and non-engagement variables, though a few correlations were moderately strong. At Baker, there were three significant correlations, two of which were in the opposite directions from Tanner. These correlations were between challenge and the affective components of engagement, interest and enjoyment. Scatter plots revealed that data at Tanner were more dispersed, while data at Baker were more linear. This may be due to the differing abilities of the two classes, as indicated by the ITBS data.

Research Question 4: What is the relationship between engagement variables (interest, concentration, and enjoyment) and short-term achievement?

Overall, there appears to be no significant relationship between engagement variables and the standardized exam total score. All correlations between engagement variables and achievement were near zero at Tanner. Correlations at Baker were stronger, but not statistically significant. Schiefele and Csikszentmihalyi (1995) hypothesize that affective variables and achievement may be dependent on different factors. The results of this study appear to agree with their hypothesis.

Research Question 5: What is the relationship between non-engagement variables (challenge, help required, and confidence) and short-term achievement?

There were no significant correlations between non-engagement variables and achievement. There was, however, a moderate negative correlation between confidence and achievement in both schools. This indicates that students who were confident during the investigations tended to have lower scores on the unit examinations. This is unexpected because research shows that confidence is positively correlated with achievement (McLeod, 1992). The confidence scores were the highest of all the survey variables. Perhaps students were so confident of their abilities that they did not adequately prepare for the examinations.

Interpretations and Implications

This study is descriptive in nature; therefore it raises questions more than provides answers. The significant differences between schools were not expected as earlier research on flow and student engagement did not indicate school differences (Schieffele and Csikszentmihalyi, 1995; Shernoff, et al., 2003). Therefore, the existence of school differences is an important finding. Two likely candidates for explaining these school differences are the teachers and the students, but various differences in school environments may also be contributors.

The most noticeable difference between teachers is their familiarity with the CMIC curriculum. The teacher at Tanner has been teaching the curriculum for six years, including participating in professional development focused on the curriculum during these years. The teacher at Baker is in her first year teaching the CMIC curriculum. Earlier CMIC research showed the importance of teacher professional development focused on the curriculum (Schoen, Cebulla, Finn, and Fi, 2003), a finding supported by the present study.

Another difference between the two teachers in this study may be their use of scaffolding. Previous research indicates that appropriate scaffolding can increase student learning (Stein, Smith, Henningsen and Silver, 2000; Turner, Meyer, Cox, Logan, DiCintio and Thomas, 1998). The current study did not assess the quality of teacher scaffolding, rather it assessed students' perceptions of how much help they required on specific tasks. Teacher differences were found between correlation coefficients involving help required and the two affective components of engagement, interest and enjoyment. Perhaps the quality of scaffolding was different at the two schools in ways that affected student engagement. This suggests that further research on teacher scaffolding is needed.

Yet another difference between the two teachers was their use of time during the class period. At Tanner, nearly all students were observed to be engagement for virtually the entire class period. At Baker, both observed classes included a substantial amount of unstructured time for the students. In the first class, students were supposed to sit quietly as others finished an exam. In the other class, the investigation ended with over 20 minutes of class time remaining where students were in conversation or doing homework for other classes. This suggests that a more effective use of the class time may be related to engagement, and teachers should work to keep students engaged throughout class periods.

Besides teacher differences, there are indications of initial student differences by school. ITBS data suggest that students at Baker generally fall into a narrow range of ability, whereas students at Tanner are more heterogeneous. ITBS data also indicates that three students at Baker were not in ninth grade. This was confirmed through discussions with the teacher who stated that some of the students had failed algebra one or CMIC Course 1 in previous years. Further research is needed to determine what effects these student differences may have on the results. Possible explanations for the school differences are mainly speculation, but these results suggest that engagement variables are particularly affected by differences in classroom or school environments.

Other student differences include gender and entering mathematical ability (ITBS Mathematics), neither of which indicate any significant differences on any dependent variable. Both these results are somewhat unusual as gender and entering ability are often found to be related to measures such as confidence and challenge (McLeod, 1992). Perhaps the design and small sample in this study made it difficult to detect differences of this type, or there was something about the teaching or tasks that reduced the differences that are often found. There were many post hoc differences by task, but these differences are not easily explained by the examination of the tasks.

Regarding the CMIC curriculum, there are no significant differences between introductory and closing tasks. This is surprising because the early tasks in an investigation tend to introduce a topic, while closing tasks require more summary skills from the student. The school means indicated a low level of perceived challenge by the students, so one interpretation is that all tasks were perceived as relatively easy and that limited potential differences by task on all survey variables. However, the report of challenge in Appendix G indicates variability in the perception of challenge between tasks. Perhaps the investigations are perceived by students as one unit rather than as separate tasks, but further research is needed to better understand the role of specific tasks within a mathematics curriculum.

Further, there were no significant differences on survey variables between units. As discussed in the previous paragraph, this is surprising because mathematical ideas build on themselves to form new ideas. As such, mathematics content tends to become more abstract and complex. Appendix G gives the variability by task for each survey variable, but there are no discernable differences in variability patterns between Units 2 and 3.

These results together indicate that student engagement is a complex construct. Steinberg, Brown, & Dornbusch, (1996) stated that some students tune out because they cannot keep up. For others, disengagement is a response to having too few demands. The low challenge in the present study indicates that the latter may have been true. However, neither school had a significant positive correlation between challenge and engagement. Therefore, the results of this study suggest that increasing engagement is more complex than increasing the challenges students face. In fact, the school differences are evidence that there are many factors that affect engagement in the mathematics classroom.

Limitations

This study was not designed to compare schools, yet school differences made it necessary to do the analysis by school. This reduces the size of the sample and limits the generaliziability of the results. Further, moderate correlations were discussed because of the small sample size. Another limitation on generalizability is that the teachers in this study were volunteers, so the classrooms were not randomly selected.

The present study relies on self-reported data. Nisbett and Wilson (1977) showed that subjects' reports of their own behavior are subject to outside influences and beliefs. The current study attempts to compensate for this limitation by relying on student means over time instead of a single measure. Further, only students who completed a minimum of 50% of the surveys were included in the analysis. This requirement ensures that student means are based on a minimum of 19 responses, which is designed to prevent a few abnormal surveys from effecting the data.

There is no independent scoring of the achievement measure. Instead, teachers scored the exams for their own students. This is a common practice, but the potential for unreliability and inconsistency in scoring is a limitation of the study. There were also significant differences on the exam total score by classroom, further indicating that the achievement measure is a limitation of the study.

Student group work may have affected results on survey variables. For example, the scaffolding measure is limited because it is not known who provided help for the students. Recall that the item states, "How much help did you need to solve the task?" This item does not distinguish between help from the teacher and help from fellow students. This issue arises because the investigations were done as group work and students are encouraged to help one another. Further, the confidence variable may have been reporting group confidence. The confidence scores were report high by both schools, which may indicate that at least one member of the group was confident in the solution.

Finally, the current study lacks qualitative measures for survey variables. This limits the research's ability to provide reasons for the quantitative outcomes. For example, it is not possible to assess the quality of scaffolding or why one task is more interesting than another. Discussion of possible reasons is based on the researcher's interpretations of the data and of the tasks themselves.

Future research

The present study suggests that there are teacher differences regarding student engagement. The following variables may have substantial influences on engagement: a teacher's familiarity with and professional development on the curriculum, the quality of scaffolding, and the teacher's use of class time. Further research should test for relationships between these variables and engagement.

In the present study, there were differences between how the teachers used class time. One teacher had activities planned for the entire class period, but the other teacher allowed students to have unstructured time. These differences may have been partly the result of block scheduling, but research is needed that examines the use of class time and its relationship to student engagement.

There were also differences between students at the two schools in this study. Using ITBS mathematics standard scores as a measure of entering ability, the students at Baker were a more homogenous group than students at Tanner. Various studies have researched differences between homogenous and heterogeneous groupings with mixed results (Kilpatrick, Swafford, and Findell, 2001). The results of the current study indicate that the heterogeneous class had higher engagement, but controls were not in place to eliminate other school differences. Future studies should put such controls into place.

Wilson (1983) also found that student differences relate to affect and achievement. The researcher found that affect for young students is determined by achievement. However, as students increase in age the relationship between affect on achievement reverses. The present study involved only ninth-grade students, but it may prove useful to study engagement of students in mathematics classes at different age levels.

Other student differences also require more research. The present study did not find any statistical differences on dependent variables for gender or prior mathematics ability. This is surprising given that previous research has found such differences (McLeod, 1992). Future research needs to continue to include such variables to verify results of the current study.

Besides student differences, this study suggests that there are differences between the mathematics classes in the two schools. Shernoff, et al. (2003) compare instructional activities across the school day regardless of the content. Thus individual work in mathematics and in history class are considered equivalent. The results for group work in the present study are lower than results in Shernoff, et al. (2003). For mathematics classes, results for one school, but not the other, are lower than in Shernoff, et al.'s mathematics classes. This may be due to the small N of the present study, but further research is needed to isolate course variables that affect engagement.

Course differences can also be extended to different curricula. The current study investigated engagement in mathematics tasks that were from a curriculum based on recommendations by NCTM (1989). Future research could compare tasks based on these recommendations and tasks that are more traditional.

Another potentially important difference between mathematics classes is the use of and quality of scaffolding. Turner, Meyer, Cox, Logan, DiCintio and Thomas (1998) indicate that high-involvement classrooms contain more challenges, which were adjusted by appropriate teacher scaffolding. Further, Stein, Smith, Henningsen and Silver, (2000) found that mathematics tasks may begin at a high level, but are frequently transformed to less demanding tasks. More research is needed to determine the effects of different types of scaffolding.

Research on interest identifies two categories: situational and individual interest. Deci (1992) argues for the importance of both types of interest:

> Beginning with the definition of interest as an affect that occurs in the interaction between a person and an activity, one can then move to a focus either on the activity or the person. For example, one can explore the characteristics of activities that tend, on average, to make them interesting to a group of people … By knowing what characteristics of tasks tend to be interesting to children one can design educational materials that, on average, will be more interesting (and thus more intrinsically motivating) for the children. (p. 46)

The methodology of the present study may provide a way to measure both types of interest. Situational interest was examined in the post hoc analysis. This analysis examined interest for each task across students by standardizing student data across their own means. Individual interest, on the other hand, was measured by the student means themselves. More research is needed to test whether this methodology provides valid and reliable measures of situational and individual interest.

APPENDIX A

SURVEY INSTRUMENT

Student initials:________________________________ **Date:**____________________

Task: ____ **Teacher:** _________________

Compare the current task to other mathematics tasks. Then indicate your responses to the following questions. Please place an "**X**" through the appropriate value on the scale to the right of each question.

		Not at all								Very much	
1.	How interesting was the task?	0	1	2	3	4	5	6	7	8	9
		Not at all								Very much	
2.	How well were you concentrating on the task?	0	1	2	3	4	5	6	7	8	9
		Not at all								Very much	
3.	Did you enjoy the task?	0	1	2	3	4	5	6	7	8	9
		Low									High
4.	Rate the challenges of the task.	0	1	2	3	4	5	6	7	8	9
		None									A lot
5.	How much help did you need to solve the task?	0	1	2	3	4	5	6	7	8	9
		Not at all								Very much	
6.	How confident are you that the solution(s) is correct?	0	1	2	3	4	5	6	7	8	9

(optional) Is there anything else about the task that you wish to include?

APPENDIX B

INFORMED CONSENT DOCUMENT

FOR IRB USE ONLY
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$STAMP_APPRV_DT
$STAMP_EXP_DT

INFORMED CONSENT DOCUMENT

Project Title: **Student engagement within the reform mathematics classroom**
Research Team: **Christopher S. Hlas, BS**

- If you are the parent/guardian of a child under 18 years old who is being invited to be in this study, the word "you" in this document refers to your child. You will be asked to read and sign this document to give permission for your child to participate.
- If you are a teenager reading this document because you are being invited to be in this study, the word "you" in this document refers to you. You will be asked to read and sign this document to indicate your willingness to participate.

WHAT IS THE PURPOSE OF THIS STUDY?

This is a research study. The purpose of this research study is to better understand how students interact with and engage mathematics problems. We are inviting you to participate in this research study because you are currently enrolled in Course 1 of the Core-Plus Mathematics Project. Approximately 50-100 people will take part in this study.

HOW LONG WILL THE STUDY TAKE AND WHAT WILL HAPPEN?

If you agree to take part in this study, your involvement will last for the duration of two curricular units, approximately two months. During this period, you will be asked to fill out a brief, six-question survey during days of instruction. This survey will ask questions about one of the mathematics tasks given during that class. Feel free to skip any questions you would prefer not to answer. See the last sheet for a sample of the questionnaire.

WHAT ARE THE RISKS and COSTS OF THIS STUDY?

There are no foreseeable risks in participating in the study and there may be no personal benefits. You will not have any costs for being in this research study other than the amount of time to fill out the survey.

WHAT ARE THE COMPESENTATIONS and BENEFITS OF THIS STUDY?

You will not be compensated for participating in this project. However, it is hoped that future mathematics classrooms will benefit from the information gathered by your responses.

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WHO IS FUNDING THIS STUDY?

The University and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study. It is being completed as part of a degree from the University.

WHAT ABOUT CONFIDENTIALITY?

We will keep your participation in this research study confidential to the extent permitted by law. However, it is possible that other people may become aware of your participation in this study. For example, federal government regulatory agencies and the University of Iowa Institutional Review Board (a committee that reviews and approves research studies) may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies you.

To help protect your confidentiality, we will keep hard copies of surveys in a locked university office. These copies will be shredded after the study is completed. All computer data files will be password protected. Further, if we write a report or article about this study or share the study data set with others, we will do so in such a way that you cannot be directly identified.

IS BEING IN THIS STUDY VOLUNTARY?

Taking part in this research study is completely voluntary. You may choose not to take part at all. If you decide to be in this study, you may stop participating at any time. If you decide not to be in this study, or if you stop participating at any time, you won't be penalized or lose any benefits for which you otherwise qualify.

WHAT IF I HAVE QUESTIONS?

We encourage you to ask questions. If you have any questions about the research study itself, please contact myself or my advisor at:

Christopher S Hlas		**Harold L. Schoen**
daytime phone:	or	daytime phone:
e-mail:		e-mail:

If you have questions about the rights of research subjects or research related injury, please contact the Human Subjects Office, 300 College of Medicine Administration Building, The University of Iowa, Iowa City, Iowa, 52242, (319) 335-6564, or e-mail irb@uiowa.edu. General information about being a research subject can be found by clicking "Info for Public" on the Human Subjects Office web site, http://research.uiowa.edu/hso.

If you agree to be a part of the study, please return this form by October 30, 2004.

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$STAMP_APPRV_DT
$STAMP_EXP_DT

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subject's Name (printed): ____

______________________________ ______________________
(Signature of Subject) (Date)

Parent/Guardian or Legally Authorized Representative's Name and Relationship to Subject:

______________________________ ______________________
(Name - printed) (Relationship to Subject - printed)

______________________________ ______________________
(Signature of Parent/Guardian or Legally Authorized Representative) (Date)

<u>Statement of Person Who Obtained Consent</u>

I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative. It is my opinion that the subject understands the risks, benefits, and procedures involved with participation in this research study.

______________________________ ______________________
(Signature of Person who Obtained Consent) (Date)

SAMPLE QUESTIONNAIRE

Name: SAMPLE ______________________ **Teacher:** ______________

Task number & page: ______________________ **Date:** ______________

Please indicate your responses to the following questions on the scale to the right of each question. Place an "X" through the appropriate value.

1. How interesting was the task?	Not at all 0	1	2	3	4	5	6	7	8	Very much 9
2. How well were you concentrating on the task?	Not at all 0	1	2	3	4	5	6	7	8	Very much 9
3. Did you enjoy the task?	Not at all 0	1	2	3	4	5	6	7	8	Very much 9
4. Rate the challenges of the task.	Low 0	1	2	3	4	5	6	7	8	High 9
5. How much help did you need to solve the task?	None 0	1	2	3	4	5	6	7	8	A lot 9
6. How confident are you that the solution(s) is correct?	Not at all 0	1	2	3	4	5	6	7	8	Very much 9

APPENDIX C

CLASSROOM OBSERVATION NOTES

Tanner HS

8:05 warm-up activity

8:12 review assignments / administrative tasks

8:14 group work with calculators, T walks around (short comments/help, clarifies repeats problem, helps groups when the entire group has question, demonstrates/corrects calculator syntax, task master, student teacher in room, helping students), S on task, asking questions and sharing solutions (especially on calculator), some groups have an outsider who is not engaged in the group activity, students loudly sharpened their pencils at the front of the room

8:46 end group work, seats to normal, checkpoint as class (lecture with questions), S didn't write down vocabulary, T used trivia and asked for S personal experience

8:56 administrative (surveys collected) & homework assigned

9:00 class ends

Baker HS: Section #1

8:20 announcements, 15min to finish exam from books, noisy, students assigning groups

8:40 assess previous group members

8:49 assign groups (each group member has task)

8:53 began investigation as whole class (Unit 3, Lesson 1.1)

9:03 small groups began investigation, collected data as whole class

9:24 continued investigation, conversation meandered, short attention span

9:45 class discussion & checkpoint

9:50 class ends

Baker HS: Section #2

9:56 intercom announcements

10:00 assigned new groups

10:07 investigation began with class reading (Unit 3, Lesson 1.1)

10:13 groups began investigation

10:16 began data collection as class

10:23 investigation continued in groups, mostly on task, surveys collected after problem completed, groups relatively independent

10:51 checkpoint as class

10:55 assigned HW, if done early could work on other classes, "find the rule" game

11:30 class ends

APPENDIX D

CLASSIFICATION OF MATHEMATICAL TASKS

Table D.1

Classification of mathematics tasks

Unit.Lesson.Investigation	Introductory tasks	Closing tasks	Tasks chosen
2.1.1	1-2	3-4	2, 3
2.2.1	1-3	4-7	1, 7
2.2.2	1-3	4-6	2, 4
2.3.1	1-4	5-8	3, 6
2.3.2	1-4	5-8	4, 8
2.4.1	1-3	4-6	2, (4 or 6)
2.4.2	1-4	5-9	1-1, 4-1
2.5	1-2d	2e-3	2d, 3d
3.1.1	1-2	3-5	2, 4
3.1.2	1	2-3	1, 2
3.1.3	1	2-3	1, 2
3.2.1	1-3	4-7	2, 7
3.2.2	1-3	4-7	3, 7
3.2.3	1	2-3	1, 2
3.3.1	1-4	5-8	3, 5
3.3.2	1-4	5-8	1, 8
3.3.3	1-2	3-4	2, 3
3.3.4	1-3	4-6	1, 6
3.4	1-2	3-5	2a, 5d

The "task chosen" column includes one randomly-chosen introductory task and one randomly-chosen closing task from each investigation. For Investigation 2.4.1, a typographical error caused Tanner to do item #6 and Baker to do item #4.

APPENDIX E

OVERVIEW OF MATHEMATICS CURRICULUM

The following gives an overview of the topics and objectives for the units used in the current study. This is done by through an outline of the unit including the lesson objectives.

Unit 2: Pattern of Change

- Lesson 1 – Related variables
  - Objectives:
    - identify key variables in a modeled situation,
    - collect data,
    - look for patterns in tables and graphs, and
    - make predictions that go beyond the data
  - Investigation 1: Modeling a Bungee Apparatus
- Lesson 2 – What's Next?
  - Objectives:
    - examine patterns of change in variables,
    - explore iterative or recursive change,
    - examine *NOW-NEXT* functions,
    - use iterative capabilities of a graphing calculator or computer software
  - Investigation 1: People-Watching
  - Investigation 2: The Whale Tale

- Lesson 3 – Variables and Rules
    - Objectives:
        - summarize patterns relating variables using rules,
        - use a graphing calculator or computer software to utilize rules
        - explore difficult questions relating variables by using rules and technology
    - Investigation 1: Money Matters
    - Investigation 2: Quick Tables and Graphs
- Lesson 4 – Linear and Nonlinear Pattern
    - Objectives:
        - appreciate the essential role of algebraic rules in providing directions for technology-generated tables and graphs
        - examine connections between two-variable relationships and their graphs
    - Investigation 1: What Goes Up … Must Come Down
    - Investigation 2: The Shape of Rules
- Lesson 5 – Looking Back
    - Objective: Review patterns of change relating variables and express patterns of change relating variables in other useful forms of representation (i.e., tables, graphs, symbolic rules, and verbally-stated conditions).

Unit 3: Linear Models

- Lesson 1 – Predicting from Data

- Objectives:
  - organize and interpret sets of data from real-world situations
  - use a variety of methods to estimate the graph and equation of a line that fits a given set of data
  - draw and use a modeling line to predict the value of one variable given the value of the other
  - describe the rate at which one variable changes as the other changes
- Investigation 1: Where Should the Projector Go?
- Investigation 2: The Ratings Game
- Investigation 3: Choosing a Good Linear Model

- Lesson 2 – Linear Graphs, Tables, and Rules
  - Objectives:
    - construct a table of values from a given graph and examine both for patterns
    - write an equation of a line given its slope and y-intercept
    - write an equation of a live given two points on the line and explain the process for doing so
    - interpret the meaning of slope, y-intercept and equations of a line in real-world problem situations
    - produce a linear regression model using technology and interpret the meaning

        - write equations in slope intercept form given a graph or appropriate points of a graph
        - explain the relationships between a graph, table and y-intercept equation of a linear model
        - use and interpret the meanings of linear graphs, tables, and rules in real-world contexts
    - Investigation 1: Stretching Things Out
    - Investigation 2: Finding Linear Equations
    - Investigation 3: Lines All Over the Plane
- Lesson 3 – Linear Equations and Inequalities
    - Objectives:
        - write linear equations and inequalities for linear models or real-world situations
        - solve linear equations and inequalities, explain methods of solutions and interpret the meaning in real-world contexts
        - use "undoing" and "balancing" methods to solve simple linear equations, explain methods of solutions, and interpret the meaning in real-world contexts
        - rewrite linear models in equivalent forms using the commutative and distributive prosperities
        - test the equivalence of equations by comparing their tables and graphs
    - Investigation 1: Using Tables and Graphs

    - Investigation 2: Quick Solutions
    - Investigation 3: Making Comparisons
    - Investigation 4: Equivalent Rules and Equations
- Lesson 4 – Looking Back
    - Objective: The lesson includes major explorations of modeling situations requiring collection and analysis of data, and extensive use of calculators to find linear models.

APPDNDIX F

DESCRIPTION OF STUDENTS WITH LESS THAN 50% SURVEY COMPLETION

Forty-eight students agreed to be a part of this study. Of these students, 38 completed at least 50% of the surveys and were included in the analysis. Ten students completed fewer than 50% of the surveys. Information regarding these students is below.

Table F.1

Number of surveys completed by student

Student	School	Unit 2 surveys	Unit 3 surveys
S1	Tanner	6	10
S2	Tanner	8	0
S3	Tanner	8	8
S4	Baker	8	8
S5	Baker	0	17
S6	Baker	4	0
S7	Baker	4	0
S8	Baker	5	5
S9	Baker	0	2
S10	Baker	5	10

Table F.2

Description of students with fewer than 50% survey completion by school

	Tanner (N=3)		Baker (N=7)	
Variable	Mean	*SD*	Mean	*SD*
Interest	3.10	.308	2.62	1.492
Concentration	4.37	.704	4.19	1.713
Enjoyment	3.02	.613	2.65	1.389
Engagement	3.50	.072	3.15	1.378
Challenge	3.81	.798	3.50	.953
Help required	2.25	1.111	3.14	.986
Confidence	7.06	.710	4.09	1.776
Exam total	118.33	49.94	101.67	37.37

APPENDIX G

TABLE AND FIGURES FOR THE POST HOC ANALYSIS

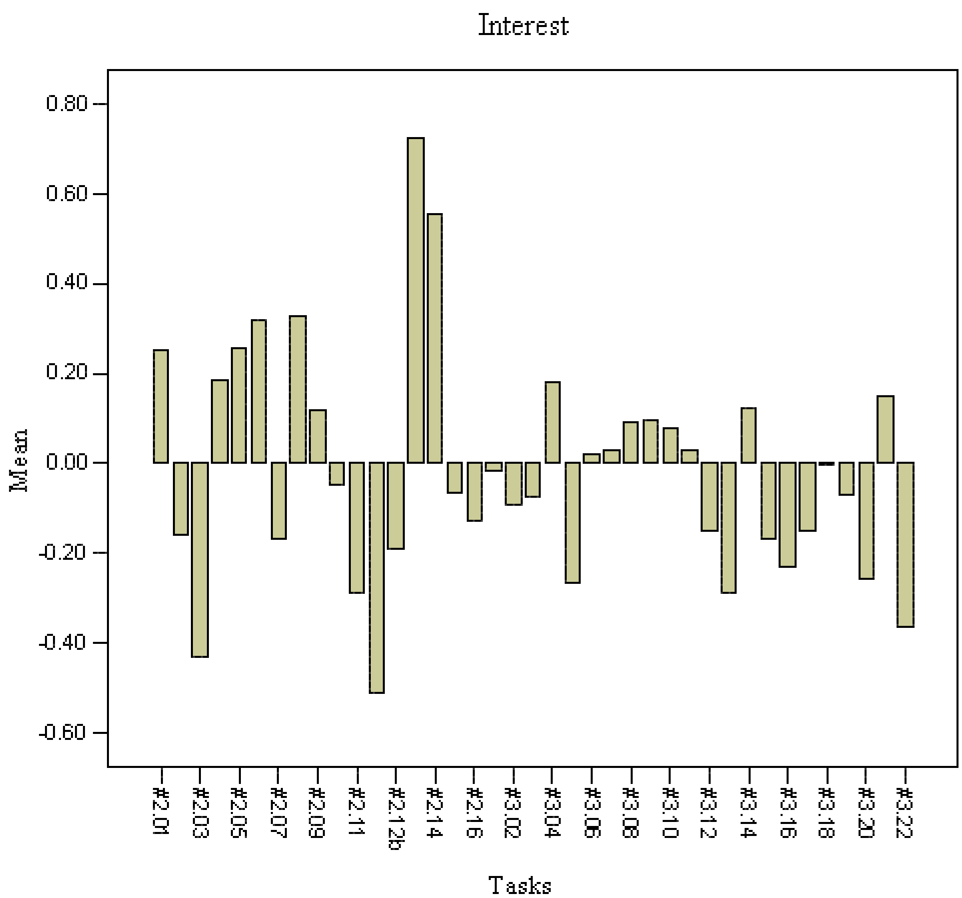

Figure G.1 – Mean z-scores for interest by task

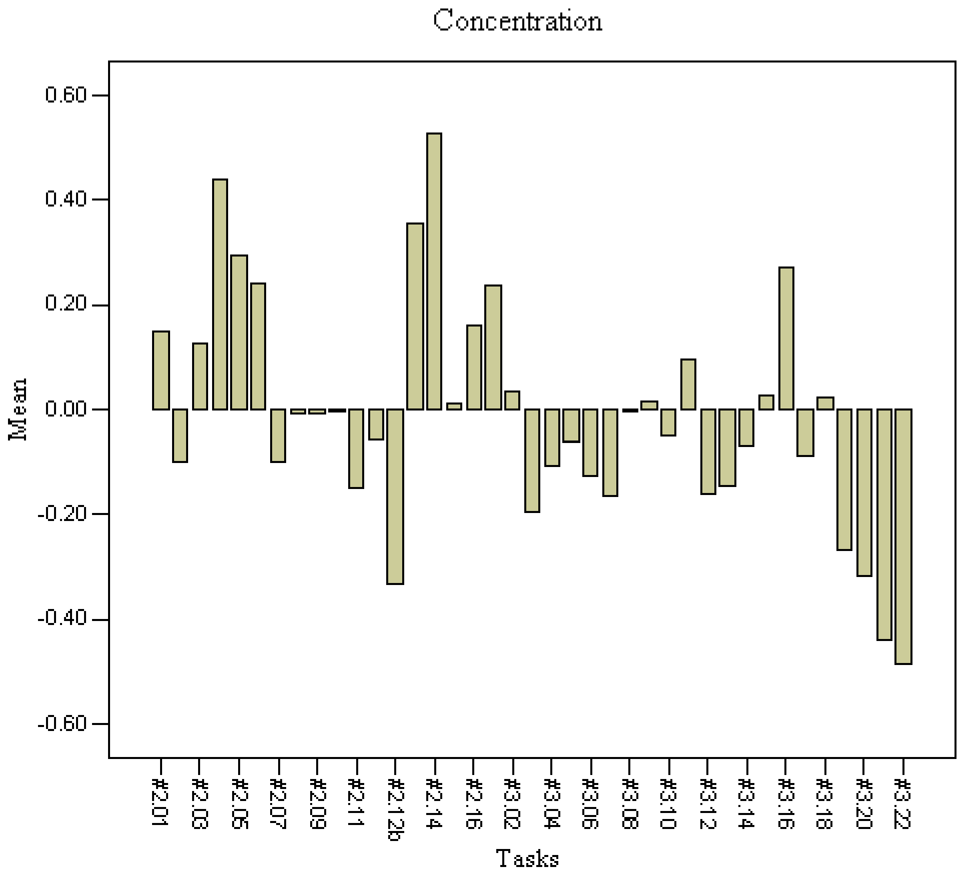

Figure G.2 – Mean z-scores for concentration by task

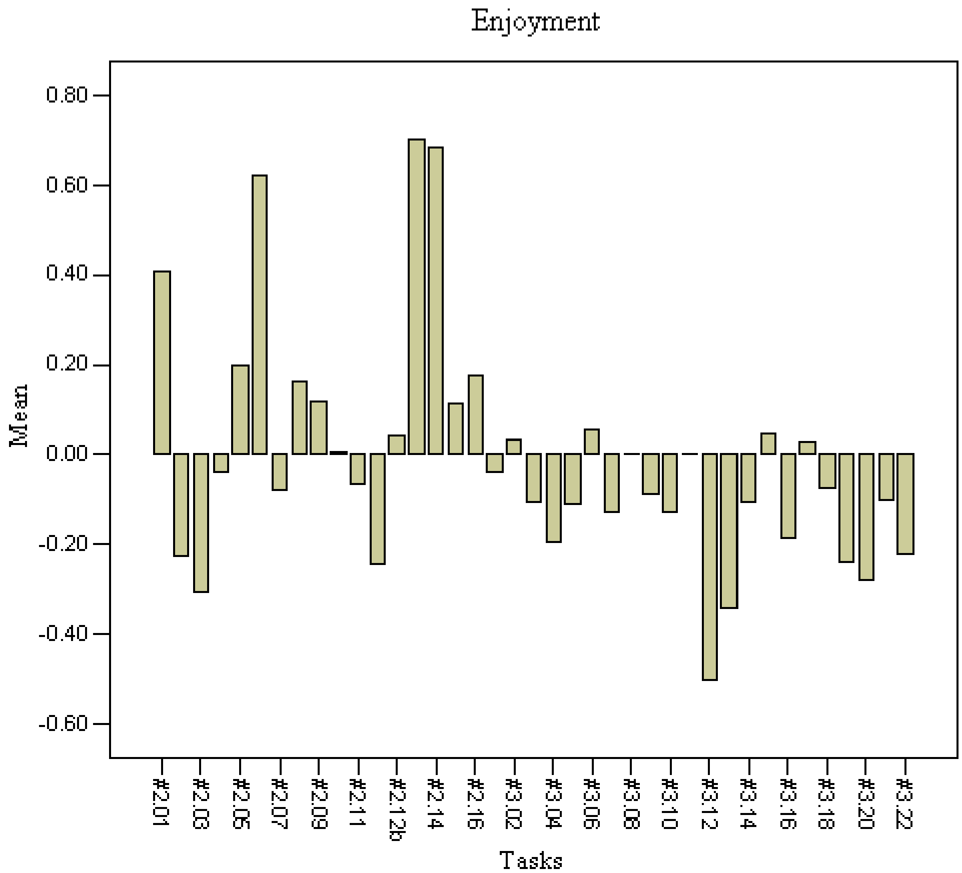

Figure G.3 – Mean z-scores for enjoyment by task

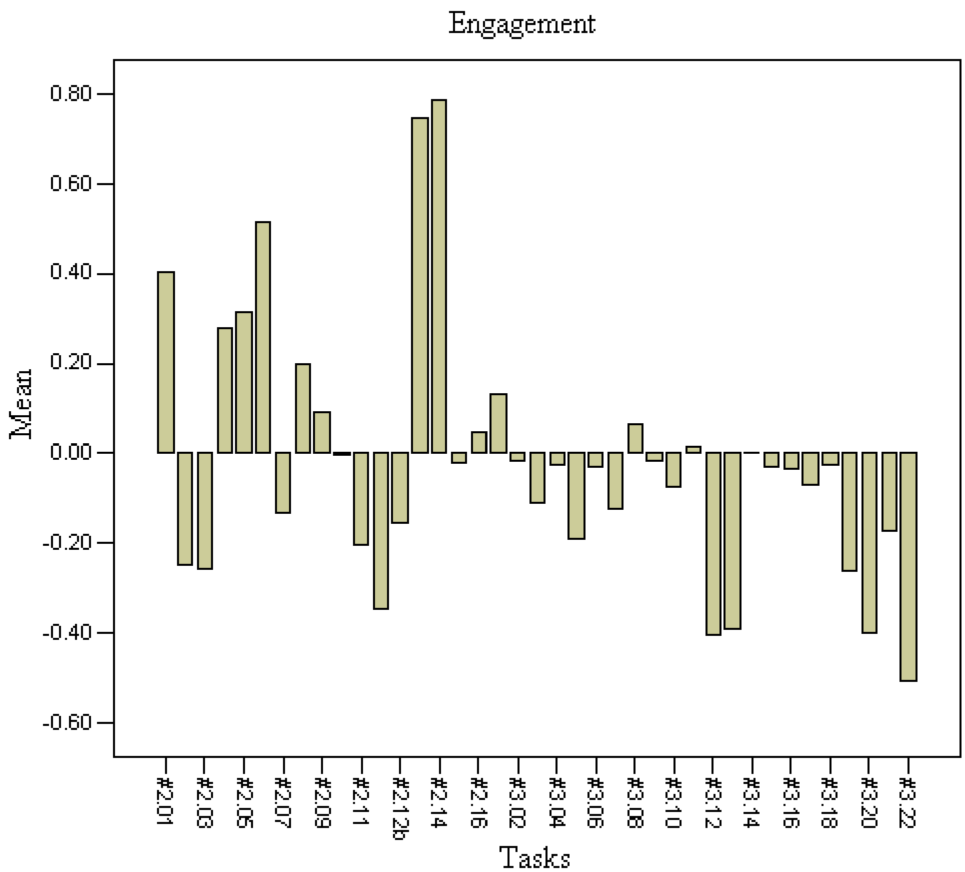

Figure G.4 – Mean z-scores for engagement by task

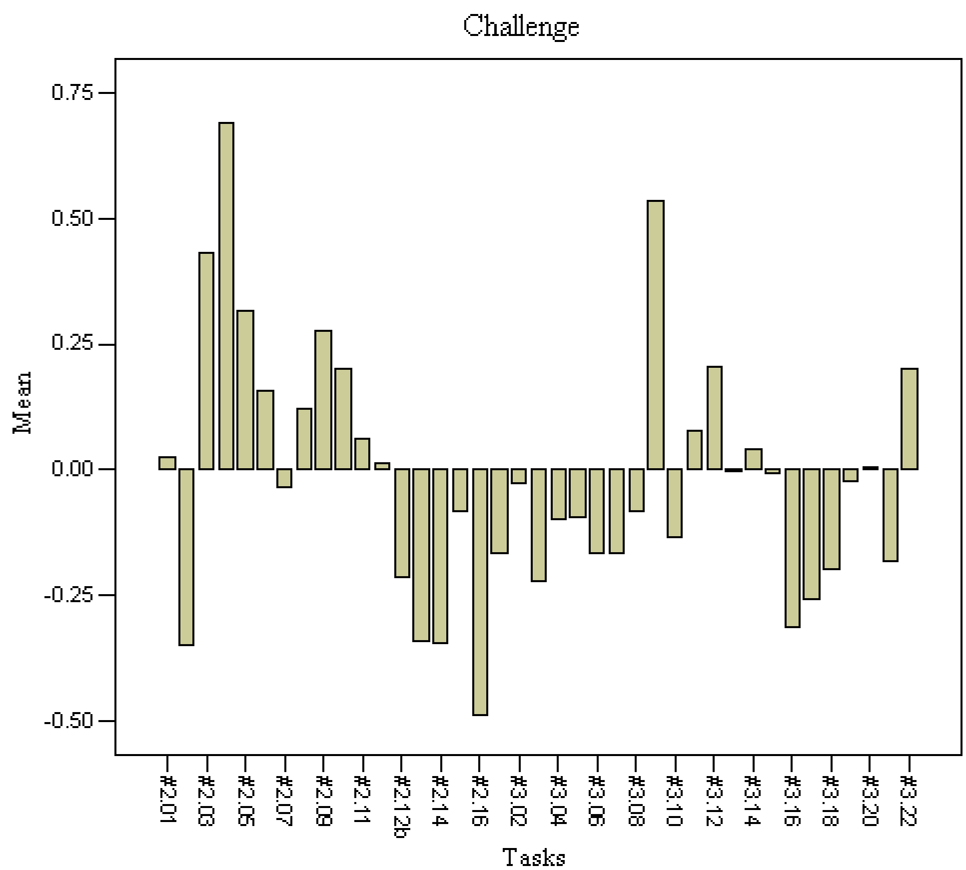

Figure G.5 – Mean z-scores for challenge by task

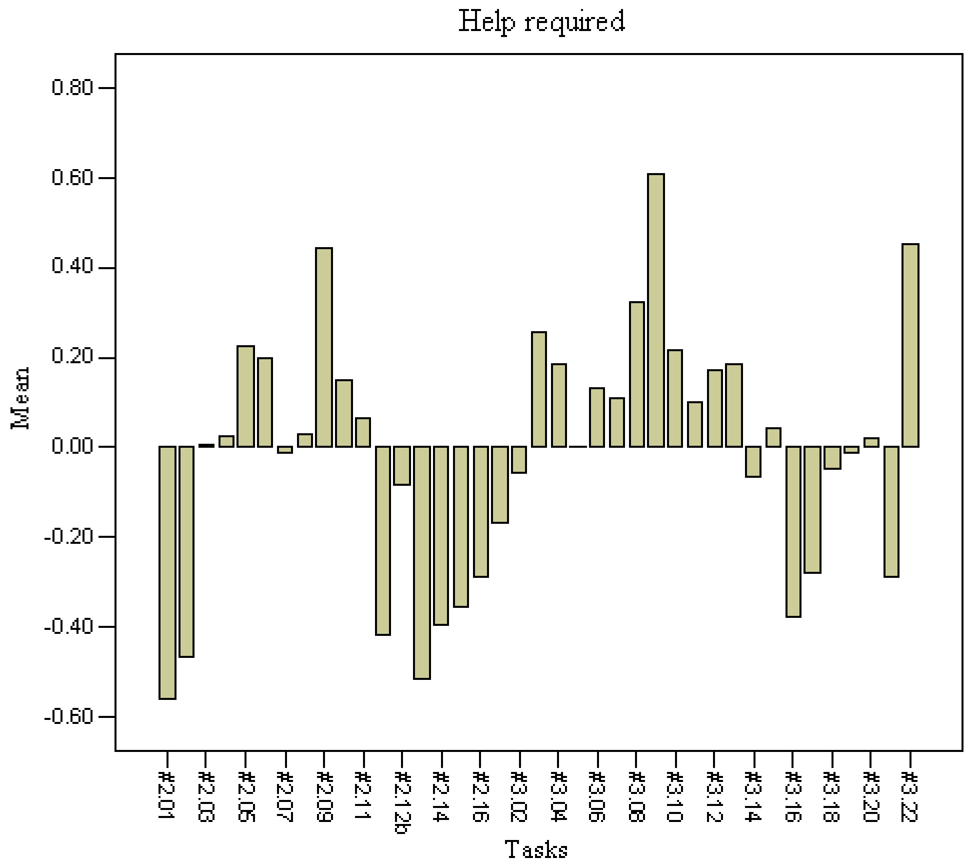

Figure G.6 – Mean z-scores for help required by task

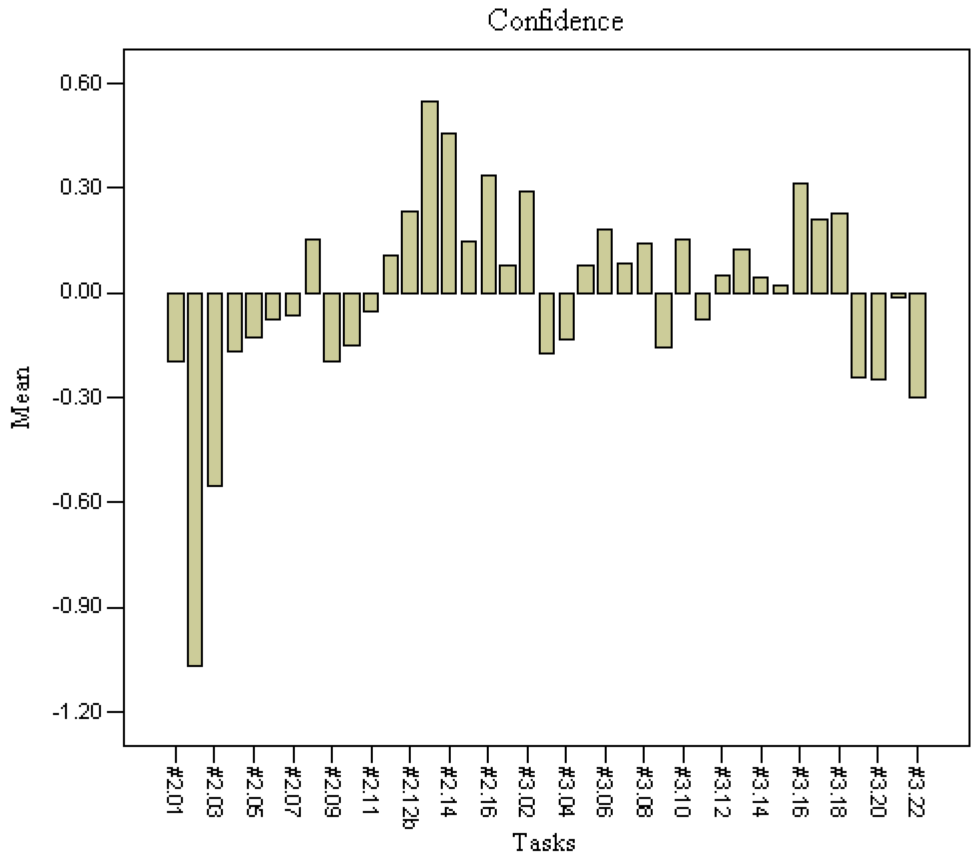

Figure G.7 – Mean z-scores for confidence by task

Table G.1

Tasks with means over 0.25 SD (+) and below 0.25 SD (–)

Task	Interest	Concen.	Enjoy	Engage	Chal.	Help	Confid.
2.01	+		+	+		–	
2.02					–	–	–
2.03	–		–	–	+		–
2.04		+			+		
2.05	+	+		+	+		
2.06	+		+	+			
2.08	+						
2.09					+	+	
2.11	–						
2.12a	–					–	
2.12b		–					
2.13	+	+	+	+	–	–	+
2.14	+	+	+	+	–	–	+
2.15						–	
2.16					–	–	+
3.02							+
3.03						+	
3.05	–						

Table G.1-continued

Task	Interest	Concen.	Enjoy	Engage	Chal.	Help	Confid.
3.08						+	
3.09					+	+	
3.12			–	–			
3.13	–		–	–			
3.16		+			–	–	+
3.17					–	–	
3.19		–		–			
3.20	–	–	–	–			–
3.21		–				–	
3.22	–	–		–		+	–

APPENDIX H

STUDENT COMMENTS

Task 2.01

Tanner:

The experiment was a lot of fun to do. #2 might not have been much fun.

I though this activity was very hands on and enjoyable.

It was pretty fun!

No.

I think that the task was easy only because the data was a very easily recognizable pattern.

It was difficult to compare everyone's results because we had different coins.

The question seemed vague to me.

No.

Doing hands on activities are more fun than just looking at a table.

Baker:

None in my group doesn't listen and its annoying me.

Find a way that will make me want to learn!

None.

The a and b questions are the same.

More hands on experiments.

Task 2.02

Baker:

Make it more interesting to people, like me and my math group.

Task 2.03

Tanner:

Our discussion about population was very interesting, the work, not quite as much.

I liked this task because we got to learn something about populations and we also go to do math along with it.

Not really.

No.

It was an interesting subject.

The reasons I didn't really care for this activity was because it wasn't really hands on.

Baker:

Make it interesting for people to get it done.

None.

No.

Task 2.04

Tanner:

No.

I was very confused but now I'm not.

Baker:

Make math interesting to students.

Task 2.05

Tanner:

I understood how to do the equation.

Baker:

Make it fun to do!

Task 2.06

Tanner:

I think this was pretty fun.

Baker:

Make it kind of fun!

Try to make it fun.

Task 2.07

Baker:

Make work seem more worthwhile.

Can you make in enjoyable?

Pretty easy.

Task 2.08

Tanner:

None.

The solutions are easy once you understand how to do them…

Baker:

This was very not worthwhile.

Can you try to make this class a little enjoyable for people to do it.

Task 2.09

Baker:

Did not have calculator. Did it by hand.

Task 2.10

Tanner:

I feel like this investigation was unnecessary. I think we've spent enough time on this material.

Task 2.11

Baker:

Boring!

Task 3.12

Tanner:

It was very long – took over an hour to do.

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