THE IMPACT OF COGNITIVE MONITORING LEARNING LOGS ON COLLEGE STUDENTS' DEVELOPMENTAL MATHEMATICS COURSE SUCCESS, PROBLEM-SOLVING PERFORMANCE, AND ATTITUDES

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by

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ABSTRACT

THE IMPACT OF COGNITIVE MONITORING LEARNING LOGS
ON COLLEGE STUDENTS' DEVELOPMENTAL MATHEMATICS COURSE
SUCCESS, PROBLEM-SOLVING PERFORMANCE AND ATTITUDES

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The purpose of this study was to determine the impact of the cognitive monitoring learning log (CMLL), as a metacognitive strategy, on college students’ developmental mathematics course success, problem-solving performance, and attitude toward mathematics and the CMLL.

Using a pretest-posttest control group design that employed mixed research methodologies, the researcher examined data collected from four sections of a pre-algebra course; two of which received the CMLL intervention. Data sources included testing, surveys, student self-report, and interviews. Data analysis using analysis of variance (ANOVA), independent and paired samples t-tests were utilized, along with appropriate case analysis.
Important findings that emerged from this study are as follows: the CMLL strategy can have some bearing on specific student outcomes (such as course grades); it can positively impact students’ attitudes towards math, but not their problem-solving performance or attitudes towards CMLL. The case study analysis based on interviews and logs written by students provided additional insight into their thoughts and perceptions, supplementing the story gathered from the quantitative data. Eighty-eight percent (88%) of those interviewed reported benefits of the CMLL strategy.

While findings from this study are inconclusive as to the impact of learning logs in the cognitive aspects, it was not shown to be a detriment either. Efforts should be made to determine how best to intertwine the CMLL strategy with other methods of instruction that will benefit college students in developmental mathematics courses the most. Recommendations for further study and future research considerations are included.
ACKNOWLEDGEMENTS & DEDICATION

This dissertation is a testament to God’s faithfulness and grace so I dedicate this to Him and to my family (my husband, Andrew; my son, Timothy; my mom, Miriam; as well as my brothers, Daniel and Paul, and their families).

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CHAPTER 1
INTRODUCTION

Background

One of the most profound advocates of interactive education was John Dewey. In his book, *The School and Society*, he spoke of education as "methods of living and learning" (1907, p. 14). His discourse is more likely based upon his observation that students have a better appreciation for their education when it is made personally meaningful for them, when students ultimately take charge of their own learning, and are able to meet the challenges and changing demands of society through education.

Research has shown both methods and content make a course relevant. But, as educators begin to replace the lens of behaviorism (see positions of Pavlov, Watson, Thorndike, Skinner, & Hull as cited in Lefrancois, 1995) with a lens of cognitivism/constructivism (see theories of Bruner, Piaget, & Vygotsky as cited in Lefrancois, 1995) to view student learning in educational settings and as the students move to becoming active meaning constructors instead of passive knowledge recipients, the method of teaching through which content is “processed” has more prominent importance. So, how is learning processed? How does one know when a student has truly grasped the course
material or is having difficulty in grasping certain concepts? Why are certain concepts, processes, or skills difficult for some students? What do they do to resolve their difficulty or confusion?

One of the ways that this study addressed the aforementioned questions was by examining a form of reflective writing, identified here as cognitive monitoring learning log (CMLL), a metacognitive tool or strategy for students to reflect on their learning and thinking. Through the CMLL, students in this study were given opportunity to specifically communicate and explain their course difficulty or confusion and the way they resolve such issues; or to share their strategies or plan for success. Students engaging in a metacognitive exercise or strategy to process their learning (through writing) has a significant value in education, particularly in the area of mathematics. In fact, the National Council of Teachers of Mathematics (NCTM) states that “the very act of communicating clarifies thinking and forces students to engage in doing mathematics” (NCTM, 1989, p. 214). In its most recent publication, NCTM (2000) identifies communication as one of five process standards along with reasoning and proof, connections, problem solving, and representation. While the NCTM documents are geared
towards elementary and secondary education, they have implications for post-secondary education as well. Students pursuing post-secondary education will more likely pursue a major or course of study involving mathematics in the curriculum. A push for implementing the teaching principle of the NCTM is evident in higher education. Additionally, the American Mathematical Association of Two-Year Colleges (AMATYC) recognizes the importance of communicating mathematical concepts in writing among college students. Their *Crossroads in Mathematics: Standards for Introductory College Mathematics before Calculus* (1995) document establishes standards and recommendations for college mathematics faculty to “adopt instructional strategies that develop communication skills” (AMATYC, 1995). In a paper presented at an annual meeting of the Conference on English Education, Keith and Keith (1985) discussed the results of implementing writing as a learning tool in a pre-calculus course and said the following:

> Writing helps in the development of [a] deeper understanding [of math] by improving class participation, by creating ‘opportunities for conceptual growth’ for all students, by stimulating discussion, and by alleviating anxieties created by the feeling that math is a ‘special’ language removed from the ordinary world. (p. 11)

writing in mathematics as follows: “promote understanding, facilitate reasoning and problem solving, help generate meaning, reveal what was misunderstood, stimulate the posing of questions, promote independent learning, and help with retention of content” (p. 7).

Pape, Bell, and Yetkin (2003) point out that teaching students skills to be more self-regulated (through writing) has been shown to help improve their thinking and organizational skills. Additionally, Paris and Paris (2001) indicate that provoking students’ thought through journaling gives students opportunities for self-evaluation and independent problem solving.

Truly, if students are engaged in a meaningful learning environment that enables them to reflect on their learning and see its practical application, it results to what Dewey (1907) calls "the intimate connection between knowing and doing" (p. 106). This engagement in the learning process makes for a successful educational experience, especially for developmental college students who need to improve upon their mathematics and problem-solving skills. After all, even Vygotsky (1986) who is known for his theoretical framework on social interaction’s fundamental role in cognitive development, believed that writing and algebraic thought have a special connection
since both writing and mathematics involve conscious reflection, or what he calls the “spontaneous concepts” of speech and arithmetic.

Student engagement can be enhanced when teachers model or value patterns of thinking and behavior that enable students to think for themselves, to problem solve, and be aware of their thought processes. This process of “thinking about thinking” or analyzing one’s own thought process is known as metacognition (Flavell, 1979). Metacognition, according to Newton (1992) is a loosely defined word that “refers to the understanding and control that students have over their learning strategies” (p. 172). It is said to be an important characteristic involved in problem solving (Wineburg, 1998), as it enables one to monitor his/her current level of understanding and decide when it is not adequate (Bransford et al., 2000).

Unfortunately, Bruning (1994), McGregor (1993), and Schoenfeld (1983, 1985) observed that college students were unaware of their thinking and learning processes. These students were unable to direct their learning in productive ways and would, thus, benefit from being instructed on ways to facilitate their thinking and learning (Bruning, 1994; Schoenfeld, 1987). Weinstein (1982) argues that under-prepared students do not even know how to acquire and
process information; thus, they need instruction or
guidance to monitor their comprehension and to think
strategically about learning. They need to take an active
role in their education to be more competent and capable as
learners (Zimmerman, 1990).

For developmental or remedial students to experience
success in their educational endeavors, they need to learn
to recognize when they are not able to comprehend or
understand course concepts and then be able to think
through strategies or means to do so. It, therefore,
behooves an educator to help these students understand
themselves as learners who know their capabilities
(resources) and limitations and can monitor their learning
or level of understanding, as well as evaluate their test-
readiness and performance (Bransford et al., 2000). These
students need to be able to problem solve and apply
critical thinking skills necessary for more advanced or
complex learning.

The value of problem solving in learning and
instruction has motivated many educators and researchers to
study its nature. Research on various instructional
strategies to develop students' problem-solving skills
seems ongoing. Likewise, the motivation for this study was
the need to explore effective instructional strategies that
would positively affect students' problem-solving performance, mathematics course success, and attitudes.

Statement of the Problem

What kind of impact would infusing cognitive monitoring learning logs, as a metacognitive strategy, in a developmental mathematics classroom have on college students' mathematics course success and problem-solving performance? Would such strategy have any bearing on student attitudes toward mathematics and problem solving?

Many educators, community leaders, and various organizations and associations, recognize the need to develop competence in problem solving as a necessity in this modern world. They see problem solving as an important topic in need of continuing research, particularly, to explore areas that have to do with students' problem-solving performance. Because of considerable interest in comparing the mathematics achievement of U.S. students with those from other countries, it is also imperative that various means to assess and look into what and how students learn and understand take center stage.

Educators believe that the specific integration of writing, especially as a metacognitive strategy, in the
mathematics classroom gets students engaged in the course and helps them in learning and understanding mathematics (Countryman, 1992; Crannell, 1994; UPS, 2006). The benefits extend to the teachers as well as it helps recognize and diagnose the nature of students' conceptual problems (Drake & Amspaugh, 1994; Elliott, 1996). Quinn and Wilson (1997) find that "teachers gain important information from students' writing that can inform their instruction" (p. 14). Countryman (1992) contends that "the use of writing exercises in math classes leads to both a better understanding of the material and heightened math communication skills" (p. 1). In her book, Writing to Learn Mathematics, Countryman (1992) further comments:

Knowing mathematics is doing mathematics. We need to create situations where students can be active, creative, and responsive to the physical world. I believe that to learn mathematics, students must construct it for themselves. They can only do that by exploring, justifying, representing, discussing, using, describing, investigating, predicting, in short by being active in the world. Writing is an ideal activity for such processes. (p. 2)

However, as much as metacognition, and using writing in particular as a metacognitive tool, is widely known to have influenced many curricular areas, the strategy has only recently been applied to the teaching of mathematics; moreover, such practice (of journaling) is limited to pre-college classrooms. Substantial anecdotal accounts are
available on the internet, mathematics journals, and forums that indicate writing helps with communication between teachers and students, offers additional insights into the student learning or subject difficulty comprehension, and the like; but they are also most often limited to the elementary and secondary classrooms. A two-year college math forum has limited discussion on incorporating writing assignments in mathematics. Moreover, very few formal research studies exist to support such beliefs.

Obviously, the benefits of writing as a metacognitive strategy has implications for post-secondary classrooms and need to be made explicit and promoted to assist developmental college students, especially in the area of mathematics and the problem-solving performance where traditional methods have failed them. Developmental college students easily accept their weakness in mathematics (Wilkinson, 2002), but educators have the responsibility to challenge them and enable them to experience mathematics success. It is known that their past failures or negative experiences contribute to their negative attitude towards mathematics. Therefore, it is important to offset or counter this negative attitude (or at worst, anxiety) with a psychological boost by experiencing success in mathematics (National Research
Council, 1989). The integration of CMLL, as a metacognitive strategy, is one way to get students to play a more active role in their learning.

Purpose of the Study

The importance of integrating a metacognitive strategy through writing in a mathematics course brings forth a challenge. The purpose of this study was to determine if the implementation of such strategy would indeed result in students’ developmental mathematics course success, enhanced problem-solving performance, and improved attitude toward mathematics.

The attributes of metacognition (monitoring and evaluation) were fostered through a form of reflective writing referred to in this study as “cognitive monitoring learning log” (CMLL). The researcher investigated college students’ participation in CMLL, as a metacognitive strategy, and the extent to which it influenced their developmental mathematics course success, problem-solving performance, and attitudes. Concomitantly, the extent to which their attitudes towards mathematics and CMLL influence their mathematics course success and problem-solving performance were investigated as well, along with student-perceived benefits of CMLL.
Writing and reflecting about mathematical learning through this study offered students the opportunity to develop a deeper understanding of the mathematics they are learning and to extend their thinking (Shield & Galbraith, 1998). The learning logs provided an avenue for students to write and reflect on the difficulty they experience in the course or confusion with course concepts/materials. They were used as a gateway into the students’ minds to inform the instructor. Additionally, students were asked to state how they plan to resolve their difficulty or confusion. The types of response students provided for this question or prompt also informed the instructor and researcher as to whether or not students need guidance in learning the strategies or having the resources they need to address their perceived dilemma or problem. Although it did not happen in this study, the researcher was hoping that some students would further comment on concepts learned in class that they can relate to or were able to apply in the real world -- for when students connect mathematical concepts to an experience that they have had, they will better understand that concept (Jones, Rich, & Day, 1996; Stillman & Galbraith, 1998).

The logs were predicted to reveal that students have resolved their difficulty or confusion, truly learned a
process or a skill, and understood the concepts that would enable them to work on a problem-solving task successfully. It is known that students survive a math course by memorizing what they perceive is a fixed body of knowledge rather than learning to think for themselves (Yusof & Tall, 1999). Hiebert (1999) points out that it is difficult for students to go back and understand procedures later if they have memorized and practiced them a lot. The metacognitive strategy, CMLL, as investigated in this study was intended to address this dilemma since students were engaged in a strategy that supposedly would help them clarify their thinking and process their learning.

Research Questions

The following research questions were used to help in this investigation of the impact of the independent variable, cognitive monitoring learning log (CMLL) strategy, on the dependent variables -- mathematics course success, problem-solving performance, and attitudes towards mathematics and CMLL:

1. What differences in mathematics course success exist between those students who participate in the CMLL intervention and those who do not participate in the intervention?
2. What differences in problem-solving performance exist between those students who participate in the CMLL intervention and those who do not participate in the intervention?

3. What differential changes in attitudes towards mathematics exist between those students who participate in the CMLL intervention and those who do not participate in the intervention?

4. What differential changes in attitudes towards CMLL are reported by students who participate in the CMLL intervention?

5. What were the students’ perceptions of the CMLL strategy in the developmental mathematics course?

Theoretical Perspective

Vygotsky viewed the classroom as the ideal place for observing student learning and development (Moll, 1990). He also saw the higher mental functions of students as the goal of development and that their active participation or involvement is critical in instructional programs. This research study examined student learning and development in the area of mathematics and problem-solving (higher mental function) from four similar sections of a community college’s developmental mathematics course offered in a
classroom setting. It also attempted to determine the impact of their engagement in a strategy on their course success and attitudes.

Various research theories considered the catalyst for research in areas of cognitive learning and constructivism, metacognition, and problem solving are mentioned here to understand the basis for this research. The latter two, metacognition and problem solving, are considered more closely (see Chapter 2) through the identification of a metacognitive strategy – the cognitive monitoring learning log (CMLL) – and the extent to which it influences students’ mathematics course success, problem-solving performance, and attitudes toward mathematics and CMLL writing.

Perspectives on Learning and Cognition

Student growth and development is always a part of an educational institution’s mission. The college experience is especially a time when important changes take place in the ways students learn and think (Jewler & Gardner, 1993; Osterlind, 1997; Pascarella, 1989; Pascarella et al., 1996). Historically, an orientation to explain behavior and learning based on instincts and emotion had influenced much of the psychological and learning theories in the early 1900s. A
shift from behaviorism to cognitivism, however, has since taken place as some (like the Gestalt theorists) who shared the behaviorist perspective also delved into the cognitivist view with their use of “more mentalistic concepts” (Lefrancois, 1995, p. 21). Behaviorism, with proponents such as Skinner (operant conditioning), Watson (classical conditioning), Pavlov, and Thorndike (see Lefrancois, 1995; Wood & Wood, 2000), holds that stimuli and responses are the only observable aspects of behavior. Meanwhile, cognitivism (with proponents such as Bruner and Piaget as cited in Lefrancois, 1995) deals with a more comprehensive view of learning and ‘higher mental functions’ that involve perception, memory, language, thinking, problem solving, and decision making (Lefrancois, 1995; Wood & Wood, 2000). The cognitive view resulted in more emphasis on human research, instead of just animal research, particularly that which affects learning, and more focus on brain research (Lefrancois, 1995). As can be observed from research, the cognitivists’ interest in mental processes sparked a growing interest in instructional strategies that facilitate thinking processes.

_Perspectives on Constructivism_

Trends in education reflect a shift from a traditional teacher-centered approach to teaching and learning to one
that is student-centered and constructivist in approach (Burns, 2000; Case & Gunstone, 2002). This trend is observed as teachers adopt practical models of teaching, such as constructivism (Burns, 2000; Johnson, Johnson, & Smith, 1998), and are expected to accommodate the varying needs and learning styles of students and to focus on developing students’ metacognitive awareness (Case & Gunstone, 2002).

Constructivism is “a theory of learning that allows students to develop and construct their own understanding of the material based upon their own knowledge and beliefs and experiences in concert with new knowledge presented in the classroom” (Miller, 2000, p. 2). According to Lefrancois (1995), psychologists such as Bruner and Piaget claim that “the world [knowledge] is not found or discovered; rather, it is constructed… resulting to a model of the learner as a builder of knowledge” (p. 322). Vygotsky (as cited in Orlich et al., 1998) asserts that constructivism, as a subset of the cognitive perspective, holds that cognition is an outcome of social processes, and that knowledge or meaning results from individuals’ interpretations of their experience in particular contexts. While a learner constructs knowledge, it is then equally
important for that learner to interact socially, to engage in some form of communication that will shape his/her mind.

From a constructivist perspective, knowledge or meaning is in the mind of the learner. George Booker (1996) points out that “an essential feature of this view is that existing conceptions, whether gained from everyday experiences or previous learning, guide the understanding and interpretation of any new information or situation that is met” (p. 381). Moreover, this thinking includes some of the following notions (Anderson et al., 1994):

- Learning is dependent on the prior conceptions the learner brings to the experience (p. 23)
- The learner must construct his or her own meaning (p. 23)
- Learning is dependent on the shared understandings learners negotiate with others (p. 24)
- Greater emphasis should be placed on “learning how to learn” rather than on accumulating facts (p. 32).

Driver (1989) notes that, in constructivist classrooms where students are encouraged to make meaning, students are generally involved in developing and restructuring patterns of knowledge through experiences with phenomena, through exploratory talk, and through teacher intervention. Burns (2000) comments:
Because mathematical concepts and relationships are constructed by people and exist only in their minds, to learn mathematics, children must construct these concepts and relationships in their own minds. Learning mathematics requires that children create and re-create mathematical relationships in their own minds. (p. 24)

So, from a constructivist perspective, it is worthwhile to point out what Stigler, Fernandez and Yoshida (1996) observe: “[L]earning mathematics results from the students’ thinking, not from the training of behaviors” (p. 150). Teachers must then create the conditions with which students can form meaning from the course material, ‘process’ it, and have a better understanding of it for further processing. It needs to be said that an aspect of Vygotsky’s theory, “learning has a social quality” (as cited in Orlich et al., 1998, p. 46), indicates the role of social interaction that is important for teachers to consider as well. Based on Vygotsky’s theory, as students listen to class discussion, they can think along and eventually internalize the material that can then be worked out individually. In other words, students must engage in active learning (like journal or log writing), while the teacher takes on a facilitative role.

Indeed, student learning and cognitive development can be influenced not only by teacher/instructional behaviors (Feldman, 1997), but also by instructional approaches that
are constructivist in nature (Driver, 1989). In fact, some studies point out students who learn in a constructivist classroom had a statistically significant advantage over students who learn in a traditional format in course-content mastery (Hofer, 1998; Lord, 1997) and problem-solving performance (Schumow, 1999).

Obviously, mathematics (as a subject of study) and problem solving (as a mental process) are viewed from a perspective unlike the traditional learning theories. Constructivism is associated with the active nature of student involvement or "active learning" that seems strongly held among mathematics educators recently. Teaching mathematics and problem solving has been contrasted with traditional expository methods and reflects the constructivist model of teaching (Burns, 2000).

_Perspectives on Metacognition_

In psychology and education research, cognition ("acquired knowledge") and metacognition ("one's awareness and understanding of that knowledge") are often referred to as "two related but separate intellectual processes" (Vadhan & Stander, 1993, p. 307) that are both important to analyze learning (Flavell & Wellman, 1977). According to O’Malley and Chamot (1990), cognitive and metacognitive
strategies are often used together, supporting each other. In education, then, the goal should be to develop both cognition (thinking) and metacognition (thinking about thinking) among students to affect learning. Vadhan and Stander (1993) indicate that while teachers would like for students to acquire specific knowledge, said teachers also desire that students become more efficient and effective learners. Vadhan and Stander (1993) point out “metacognitive abilities help students to understand what they are supposed to learn and to become aware of whether or not they have actually achieved the goal” (p. 307).

For clarification, Rickey and Stacy (2000) note: “[M]etacognition is a more specific term than reflection [and its] object of reflection is always one’s personal knowledge or thinking” (p. 915). To distinguish metacognition from cognitive processes, they offer the following statements made by chemistry students engaged in problem solving:

Statement 1: ‘Cause pressure is just the number of molecules. It’s not like the size of them.
Statement 2: But I don’t see how we use partial pressures to find out the reaction. Do you know what I am saying? The stoichiometry? (Rickey & Stacy, 2000, p. 915)

Rickey and Stacy (2000) point out that “statement 1 shows more evidence of cognition relating to the idea of partial pressures, [while] statement 2 is more
metacognitive, as it indicates the student’s awareness of her own thoughts and her attempt to regulate the direction taken in the problem-solving process" (p. 915). Certainly, similar situations arise in the mathematics classroom especially when students are given a problem-solving task and draw upon previous knowledge or understanding to do so (assuming metacognitive awareness). Similarly, Flavell (1976) observes “asking yourself questions about the chapter might function either to improve your knowledge (a cognitive function) or to monitor it (a metacognitive function)” (p. 231). This monitoring aspect of metacognition is central to this study. It is important to examine this monitoring aspect or this metacognitive strategy as it is also an essential task in problem solving in that while it contributes to effective learning, students either find it difficult to do or will not take the time to do it.

**Perspectives on Problem Solving**

This study examined problem solving which is rooted in the work of George Polya (1966) who thought of problem solving as the “‘[m]athematical activity nearest to the center of everyday thinking’ (p. 125). Polya’s (1973) popular problem-solving framework includes the processes of (a) understanding the problem (problem representation), (b)
devising a plan, (c) carrying out the plan, and (d) looking back (monitoring and evaluation). Another framework proposed by Schoenfeld (1985a) asserts that students’ abilities to solve problems are functions of how well they employ and regulate relevant cognitive and affective characteristics. Schoenfeld (1985a) identifies resources, heuristics, metacognitive control, and belief systems as four components of knowledge and performance fundamental to the problem-solving process.

The National Council of Teachers of Mathematics (NCTM, 2000) view problem solving as an “integral part of all mathematics learning” and defines it as:

engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings. (p. 52)

This definition obviously espouses the learner-focused, constructivist approach. CMLL, as a metacognitive strategy, was certainly appropriate for this approach since it intended to encourage students to make sense of their learning. There is little doubt as to the value of metacognition to enhance learning. Through a metacognitive strategy such as CMLL, students would be more engaged in the course and in their learning. Consequently, students would discover mathematical relationships (including
concepts, process, and skills) that would serve as a basis for understanding more, if not higher, forms of such mathematical relationships.

Definition of Terms

In this research study, the following terms are defined as stated:

1. **Algebra Assessment** – “the process of collecting information about students’ algebra knowledge at the end of the semester that will prove invaluable in understanding the teaching/learning process” (Bright & Joyner, 1998, p. 122).

2. **Attitude** – “affective (emotional) reactions that can generally be described as positive or negative and that have important motivational qualities” (Lefrancois, 1995, p. 318) as indicated by students’ responses to the mathematics and cognitive monitoring learning log attitude inventory/survey; “an acquired internal state that influences the choice of personal action (Gagne & Driscoll, 1988, p. 58).

3. **Behaviorism** – “general term for approaches to theories of learning concerned primarily with the observable components of behavior (such as stimuli and responses)” (Lefrancois, 1995, p. 331).
4. Benefits – a likely advantage from student participation in the CMLL intervention; students’ perceptions on the impact of cognitive monitoring learning log on their mathematics course success, problem solving performance, and attitudes.

5. Community College – a two-year institution of higher learning, or the equivalent.

6. Cognitive monitoring learning log (CMLL) – a strategy by which reflective writing is utilized and through which students are encouraged to think, to question, and to evaluate their own understanding of concepts, processes, or skills discussed and learned in class to facilitate their learning by way of monitoring their growth or skill development; the use of “learning log” is adapted from the concept of “journal writing for the purpose of stimulating metacognitive awareness of college students and which call for reflections on specific cognitive aspects of learning” (Commander and Smith, 1996, p. 447).

7. Cognitivism – “general term for approaches to theories of learning concerned with such intellectual events as problem solving, information processing, thinking, and imagining” (Lefrancois, 1995, p. 332).
8. Constructivism – “model (illustrated in the theories of Piaget and Bruner) that views the learner as actively inventing and building representations of reality rather than as simply discovering what is already out there” (Lefrancois, 1995, p. 333).

9. Mathematics Course Success – indicated by students’ completion of the Math010 (pre-algebra) course with a letter grade of B or better; also determined by passing the course’s final examination.

10. Metacognition – analyzing one’s own thought process (Flavell, 1976) which involves “the active monitoring and consequent regulation and orchestration of cognitive processes to achieve cognitive goals” (p. 252); metacognition also “refers to the understanding and control that students have over their learning strategies” (Newton, 1992, p. 172).

11. Meaningful learning – valuable education in which students can make sense out of and make connection to new learning or knowledge; “learning is an active process in which meaning is developed on the basis of experience” (Duffy & Jonassen, 1992, p. 21).

12. Metacognitive strategy – approach employed in this study to develop or enhance metacognition,
specifically through the cognitive monitoring learning log (CMLL).

13. **Problem Solving** – a process involved in engaging in a task or determining a solution to a problem for which the solution method is not known in advance; and by which one uses previously acquired skills and understanding (knowledge) to satisfy the conditions of an unfamiliar or novel situation and, often, to develop new mathematical understanding (NCTM, 2000; Polya, 1973).

14. **Problem-solving performance** – indicated by students’ capacity to solve problems and find successful resolution of problems provided on the Mathematics Problem Solving Test (MPST); the MPST was given as a pre-test and post-test with a net gain on the post-test score construed as enhanced or improved problem-solving performance.

**Significance of the Study**

The central tenets of problem solving have been explored for over fifty years as researchers and educators express concern over students’ inability to do problem solving or their lack of fundamental skills to do so (Cameron, 2002; Ford, 1994; Gabel & Sherwood, 1984; Gabel,
As a dynamic method of instruction that requires more active student participation and thinking, problem solving has recently become the focus of mathematics teaching. The National Council of Teachers of Mathematics (NCTM, 2000) regards problem solving as "not only a major goal of learning mathematics but also a major means of doing so" (p. 52). But, as Smith (2000) points out, students in the U.S. perceive mathematics as a fixed set of rules to be followed. This perception was identified as one factor that impedes U.S. students' success in mathematical thinking, particularly problem solving (Smith, 2000).

Obviously, efforts need to be made in exploring strategies that will enhance students' mathematics engagement, success, and problem-solving performance. It is true that research in education has produced a number of insights to add to a teacher's repertoire of instructional strategies. Even if the resulting application or use in the classroom setting is uneven and unpredictable (Schoenfeld, 1999), the investigation of additional strategies to improve mathematics instruction should continue since no one knows what may work for certain group of students. The identification of the cognitive
monitoring learning log as a metacognitive strategy and an instructional tool to enhance mathematics understanding and learning is an important step in this process.

Also, while “algebra is an area in which significant educational research has already been conducted” (Ball, 2003, p. 48), such research is limited to the pre-college classroom. Because most studies have focused on algebra at the high school level, little is known about college students’ learning of algebraic ideas and skills, even problem solving. Some type of algebra assessment (Bright & Joyner, 1988) could prove useful in knowing more about the teaching and learning process in post-secondary education.

Further, ‘fostering metacognitive growth in learning’ is an area that needs to be addressed. It appeared as one of the recommendations in Rosen’s (1988) discussion of ‘new wave’ instructional theory and approaches. As Rosen (1988) noted, teaching and learning in higher education needs to keep up with technology and with the “application of futuristic thinking” (p. 1). Over a decade later, Rickey and Stacy (2000) framed similar recommendation to foster metacognitive growth as one of the issues for future research in education. These researchers asked, “How can metacognition best be promoted in chemistry courses?” (p.
919). An analogous question could certainly be made in mathematics courses.

This research study endeavored to extend the concept of journal writing at the college level and to fill a gap in the literature concerning the specific use of learning logs as a metacognitive tool to enhance students’ mathematics course success and problem-solving performance. The goal of this study was to determine the impact of CMLL, a metacognitive strategy, on college students' developmental mathematics course success, problem-solving performance, and attitudes towards mathematics and CMLL. Hence, it was hoped that this study would inform teachers of additional means to enhance mathematics understanding, and learning, which may also enhance student metacognitive ability that can carry over to other courses. The results of this study provided additional evidence to substantiate the many claims that the learning log (writing) is beneficial in the mathematics classroom.

Summary

An important component of good teaching is flexibility to meet the demands of educational reform to enhance the education of today’s students. It is important for educators to consider strategies to add to their repertoire
in an effort to reach all students. The researcher has presented within this introduction the potential impact of the cognitive monitoring learning log in a developmental mathematics classroom, which may have implications for other college-level mathematics and other non-mathematics courses. Integrating writing through CMLL is a strategy that makes sense and one way that educators can engage students in their courses in a meaningful learning experience. It is further hoped that this research would prove valuable in technical fields that rarely employ writing, such as mathematics and the sciences, especially at the college level.
CHAPTER 2

REVIEW OF THE LITERATURE

Background

Student learning and understanding is ultimately a major goal of education. Society values an education that produces a literate populace and through which students learn to think for themselves and learn to problem solve. As such, educators have shown interest in mental or cognitive processes and in developing instructional strategies that facilitate thinking processes.

Despite the educators’ best efforts, however, reports continue to show students’ limited thinking and problem-solving skills. These skills are developed or enhanced through mathematics and science learning so that increased support in educating students in these areas is evident. In fact, millions are being invested in the classrooms to help students struggling with math and science (see Ammons, 2006, and The Sum of Math editorial in Seattle Times). Research studies also have shown the difficulty students have in mathematics and problem solving, let alone in analyzing their own learning or thinking.

In an attempt to look at the impact of cognitive monitoring learning log (as a metacognitive strategy) on students’ mathematics course success, problem-solving
performance, and attitudes, this chapter provides background information on the following: (1) metacognition and cognitive monitoring, (2) the relationship of metacognition and mathematics problem solving, (3) the relationship of metacognition and writing, (4) writing and cognitive monitoring learning log, (5) the relationship of writing and mathematics, (6) mathematics and problem solving in education, and (7) student attitudes toward mathematics and writing.

Metacognition and Cognitive Monitoring

Since the mid-1970s, metacognition is a term that has been used in psychology and education research literature. While initially thought of as a “loose and fuzzy construct” (Whitehurst, 1981, p. 62), metacognition is also known as the process of ‘thinking about thinking’ (Anderson, 2002; Jacobs & Paris, 1987) or analyzing one’s own thought processes (Flavell, 1976). Flavell’s (1976) broad definition of metacognition is as follows: “knowledge concerning one’s own cognitive processes and products or anything related to them” (p. 232), which involves “the active monitoring and consequent regulation and orchestration of cognitive processes to achieve cognitive goals” (p. 252).
Metacognition includes knowledge of cognition and regulation of cognition (Brown, 1987; Brown & Palinscar, 1982; Cross & Paris, 1988) or knowledge about cognition and strategy use (Pressley & McCormick, 1987). Knowledge about one's cognition includes information about one's own abilities and aptitudes, including limitations, and awareness of any challenges or difficulties as they arise during learning so that, hopefully, remedial action may be taken. Strategy use is about knowledge of when and where to use acquired strategies, which includes knowledge about the task and situations for which particular goal-specific strategies are appropriate. Strategy use or the regulation of cognition includes aspects of planning, evaluation and monitoring (Jacobs & Paris, 1987). Jacobs and Paris (1987) describe the three components of planning, evaluation, and monitoring in regulation of cognition as follows: (a) planning consists of setting goals, activating relevant resources, and selecting appropriate strategies, (b) evaluation involves determining one's level of understanding, and (c) monitoring involves checking one's progress and selecting appropriate repair strategies when originally-selected strategies are not working. Simply stated then and as pointed out by Sanacore (1984), metacognition is ‘knowing what you know,’ ‘knowing what you
need to know,’ and ‘knowing the utility of active intervention.’

Flavell and Wellman (1977), and Flavell (1979) include interpretation of ongoing experience, or simply making judgments about what one knows or does not know to accomplish a task, as other features of metacognition. White (1988) identified the following four facets of metacognition: (i) propositional knowledge about cognition (e.g., knowledge of the factors that affect ability to memorize something), (ii) awareness of one’s own thoughts (e.g., monitoring one’s own understanding during a lecture), (iii) ability to regulate thinking (e.g., deciding what path to take while attempting to solve a difficult problem), and (iv) readiness/propensity to apply the ability to regulate thinking.

Metacognition has been demonstrated to play an important role in increased student motivation in the learning process (Vojnovich, 1997). In her research project, the author targeted high school students with low participation problems, off-task behavior, and inadequate processing skills. Her solution strategies included the introduction of a variety of critical thinking tasks, the use of cooperative learning techniques, and the practice of writing reflective journal entries to enhance metacognition.
Anderson (2002) notes that metacognition can lead to higher learning and better performance. He advocates for second language learners to develop this essential skill, which certainly has implication for other types of learners as well, by asking teachers to help students to “think about what happens during the language learning process” (p. 1). Similarly, Graham (1997) believes metacognition to have the most central role to play in improvement of learning as he investigates the learning strategies utilized by successful and less successful language learners. He examines strategies utilized in think-aloud tasks by effective learners and discusses how they can be taught to others.

A component of metacognition that this study investigated is what Flavell (1976) calls cognitive monitoring. Skills of metacognition include “predicting the consequences of an action or event, monitoring one’s ongoing activity, and a variety of other behaviors for coordinating and controlling deliberate attempts to learn to solve problems” (Brown & DeLoache, 1978, pp. 14-15). Cognitive monitoring in essence is metacognition as it involves the awareness and regulation of one’s thinking.

Cognitive monitoring seemed only appropriate to employ with students in a developmental mathematics course and as
they engage in problem solving. A study by Flavell, Friedrich, and Hoyt (1970) found that a person with good metacognitive skills predicted one’s performance on a task accurately. Their study is cited often with predicting one’s memory span in which individuals are asked to recall a list of materials to be learned. In their study, kindergarten children are said to be overly optimistic about their readiness for a test and have low levels of recall after they say they are ready for a test. Meanwhile, elementary school children were found to be considerably more accurate; their accuracy was attributed to their greater self-testing during study.

Swanson (1990), who investigated the influence of metacognitive strategies and aptitude on problem solving found that students with high metacognitive knowledge and low aptitude outperformed those with high aptitude and low metacognitive knowledge. He concluded that high metacognitive skills can compensate for overall ability by providing certain knowledge about cognition.

Vadhan and Stander (1993), who studied college students’ metacognitive ability and test performance, found that students with higher metacognitive ability have better academic performance. They then concluded that helping students increase their metacognitive awareness (such as
simply asking them to predict their grades for the class) would help them become better learners (Vadhan & Stander, 1993).

In a research study that McGregor (1993) conducted to examine information use and cognitive processes of high school students, she observed the thinking processes that students engaged in while writing research papers and strategies they employed in the process. She observed that students seemed to be unaware of their cognitive processes and noted a characteristic of thinking that can be carried out intuitively without awareness of the processes involved. This lack of awareness on the part of the students certainly calls for incorporating instructional strategy that will enhance their metacognition, particularly in a mathematics course.

Schoenfeld (1985b, 1987) has encouraged teachers to act as a coach, asking questions and providing hints as they deem necessary when students solve problems. He particularly warns his students that he reserves the right to ask the following questions at anytime: “What are you doing?” “Why are you doing it?” “How does it help you?” (Schoenfeld, 1987, p. 206). He indicates that students have difficulty answering these questions at first. Over time, however, students begin asking themselves these
questions and preparing answers. This activity helps them monitor, regulate, and assess their level of understanding and actions. Similar activity was proposed in this study so that students were asked repeatedly every week to respond to the following questions for their cognitive monitoring learning log (CMLL): What is difficult for you right now in this mathematics class? Why is it challenging or difficult? How do you plan to resolve this difficulty or what are you going to do about it?

Metacognition & Mathematics Problem Solving Relationship

Feltovich et al. (1996) report that students’ difficulties in problem solving are in part due to misconceptions or shallow conceptions of domain knowledge. Unless students have a grasp of foundational concepts and skills in mathematics, they will more likely have difficulty dealing with situations requiring such understanding, especially when it comes to application problems. In any class that requires writing of some sort, a student needs to have a vocabulary and good grammar skills to build on or draw upon to produce an essay that makes sense. Mathematics has its own set of vocabulary and foundational concepts and skills without which successful resolution to a problem situation can be achieved.
But Brown (1987) noted that these difficulties in problem solving are, to a great extent, due to a lack of metacognitive knowledge. Schoenfeld (1985b) has characterized metacognitive skills as "aspects of mathematical understanding that extend beyond the mastery of routine facts and procedures" (p. 361). He noted that these skills do not usually develop in mathematics instruction because of the focus on factual and procedural knowledge (Schoenfeld, 1985b). He then presents examples of students’ lack of monitoring or lack of managing their actions during problem solving (Schoenfeld, 1985a, 1985b). Yet, to monitor the problem solving process the use of metacognitive skills is essentially inherent or inevitable for reflecting upon one’s approach/strategy use and solution process; otherwise it results in a pursuit of "wild mathematical geese." Kluwe and Friedrichsen (1985) note the need of problem solvers to monitor their own cognitive efforts, the effects of these efforts, the progress and the success of solution activity, as well as keeping track of the solution activity and conflicts between different goals, especially when problems represent states of uncertainty.

Polya (1973) identified the phase of ‘looking back’ (a metacognitive skill) with admonitions to examine the
solution by such activities as: checking the result; checking the argument; deriving the result differently; using the result, or the method, for some other problem; reinterpreting the problem; interpreting the result; or stating a new problem to solve. While regarded as possibly the most important part of problem solving since it provides opportunity for students to learn from the problem, ‘looking back’ is a difficult task for students to do as pointed out earlier. Kantowski (1977) and Schoenfeld (1992) found little evidence among students of looking back even though the instruction had stressed it.

Metacognition is of interest to chemical educators because the “good monitoring and regulation of thinking” is said to improve success in problem solving (Rickey & Stacy, 2000, p. 916). Without a doubt, mathematics educators should be of the same mind. Schoenfeld (1992), a big proponent of using metacognition in the mathematics classroom, found that monitoring and control (metacognition) were successful components to problem solving. The NCTM Standards (2000), in describing good problem solvers, state that they “tend naturally to analyze situations carefully in mathematical terms and to pose problems based on situations they see” (p. 52). Meanwhile, “[e]ffective problem solvers constantly monitor and adjust
what they are doing... plan frequently... and stop to consider alternatives” (NCTM, 2000, p. 54). The monitoring and regulation of one’s thinking, which are aspects of metacognition, are essential in successful problem solving.

Although investigations of the influence or effects of metacognitive process on mathematics achievement or problem solving have been established for elementary students (Evans, 1984; Millican, 1994), middle school & secondary students (Bell & Bell, 1985; Frenkel, 2004; Human, 1993; Pape & Wang, 2003; Shepard, 1993; Stewart, 1993), little inquiry has been conducted on the influence or effects of writing as a metacognitive strategy on mathematics problem solving, especially among college students.

Metacognition and Writing Relationship

One way educators can help students develop strong metacognitive skills is to incorporate the use of writing in the curriculum. Indeed, educators have incorporated writing in their classes to enhance strategy training or metacognition (Buehl, 1996; Commander & Smith, 1996). Nelson (2001) asserts that writing allows students to make connections, reflect on, and synthesize learning while also engaging in authentic practices of the discipline. The basic concept of writing enables students to put their
thoughts in written words that can then be seen and analyzed; it is a process that allows students to reflect on their learning; and thus, make it more meaningful for them. Newton (1992) indicates that the “journal is one way of helping students develop their metacognitive potential” (p. 174) as they “chronicle their meaning-making processes” (p. 175).

Tynjala (2001) makes the distinction between ‘knowledge telling’ writing tasks and ‘knowledge transforming’ writing tasks, asserting that the ‘knowledge telling’ tasks fit more comfortably within the transmission framework, and ‘knowledge transforming’ tasks fit within the constructivist framework. Writing as a transforming task is, therefore, seen as a process through which students actively develop their ideas and connecting it with other or previous forms of learning. Boscolo and Mason (2001) maintain that “writing can improve students’ learning by promoting active knowledge construction, requiring them to be involved in transforming rather than a process of reproducing” (p. 85). Kirby, Nist, and Simpson (1986) hold that writing in a journal helps students “develop a sense of control and independence” (p. 17).

Educators draw on Vygotsky’s Zone of Proximal Development theory to individualize curricula that are
constructivist in nature for students by providing assistance necessary for their success. Vygotsky’s theory also supposes incorporating metacognitive strategy in instruction through “leading questions,” for example, that enables students to think. He believes that through the use of everyday concepts, children have been able to understand the concepts taught in school (Moll, 1990). His belief has implications for college students in that as they reflect on their learning, it results in familiarity and understanding and further learning. In this study, the structure of the learning log as earlier described was used to encourage students’ responses pertaining to their experiences and conceptual understanding of mathematics.

Writing and Cognitive Monitoring Learning Log (CMLL)

Bazerman et al. (2005) point out that writing-to-learn programs (formerly known as ‘Writing Across the Curriculum’) were developed in the 1970s. Writing-to-learn is “based on the observation that students’ thought and understanding can grow and clarify through the process of writing” (p. 57). Tynjala (2001) notes that the writing-to-learn program promotes an understanding that writing could be a tool for learning and thinking as well as a means of recording and expressing. As students put their
thoughts into visual form of words (through writing), they are better able to analyze, critique, and revise their thinking patterns or their understanding of concepts and processes.

The writing-to-learn program seemed to have emerged alongside the increasing popularity of the constructivist view or approach to learning and has promoted the integration of writing in various subject areas including mathematics (Pugalee, 2001). Langer and Applebee (1987) offer a substantial contribution to the research on writing-to-learn through their book, *How Writing Shapes Thinking*. They looked into the contribution that written language has to intellectual development and offered some of the following conclusions:

1. Writing activities promote learning better than activities involving only studying or reading.

2. Different kinds of writing activities lead students to focus on different kinds of information.

3. In contrast to short-answer responses, which turn information into discrete small pieces, analytic writing promotes more complex and

Unfortunately, as Johnson, Johnson, and Smith (1998) point out, students often do not spend enough time reflecting on what they are learning and how it relates in a personal way to their lives. Or even if students may have the time, many simply do not have the experience to monitor their academic progress, engage in self-regulation of learning, and share their thoughts (Commander & Smith, 1996). Commander and Smith (1996) find that “students need opportunities to explore their own thinking and to evaluate their own progress in using the skills and strategies typically deemed necessary for college success” (p. 446).

Various studies have examined how journals were incorporated in the classroom (Audet, Hickman & Dobrynina, 1996; Cannon, 1990; Cowles, Strickland, & Rodgers, 2001; Selfe & Arbabi, 1983 & 1986). In statistics, Sgoutas-Emch and Johnson (1998) explored the relationship between journal writing and student anxiety toward statistics. They found that those who kept journals had decreased anxiety towards the course. Burns and Silby (2001) present their suggestions to help elementary school teachers incorporate journal writing in math class. They believe such a strategy is useful to keep track of students’
thinking. Chapman (1996) discussed the value of journal assignments for diagnosing and trouble-shooting misconceptions. She further asserted that they are useful as an avenue for students to express their uncertainties and are “pathways that lead students to the world of thought - their own” (p. 589).

While English (2001) raised ethical concerns about students being required to disclose and blend their professional and personal lives in the pages of mandatory journals, Myers (2001) and Wolf (1983) supported the validity, reliability and accuracy of journal writing techniques as important learning tools (as cited in Laysears-Smith, 2005). Ryan (2000) notes that journal writing provides students significant opportunities and support for the development of complex understanding. Writing, be it through a journal or learning log, is simply an ideal tool to encourage learners to reflect and communicate their learning, including their successes and frustration or difficulty with a task, for further understanding of the course content and processes.

According to Johnson, et al. (1998),

Logs tend to emphasize short entries concerning the subject matter being studied. Journals tend to emphasize more narrative entries concerning personal observations, feelings, and opinions in response to readings, events, and experiences. (p. 8:19)
Due to their belief in the power of writing, Commander and Smith (1996) “adapted the concept of journal writing into a series of learning logs for the purpose of stimulating metacognitive awareness of college students” (p. 447). They continued, “as opposed to traditional journal writing assignments that engage in an ongoing dialogue of feeling and personal reflections, the learning log assignments call for reflections on specific cognitive aspects of learning” (p. 447).

The learning log assignment for this study took on a similar approach that was given on a weekly basis that Commander and Smith (1996) had discussed in their article, *Learning Logs: A Tool for Cognitive Monitoring*, and designed for a history class. While the concept is similar, the cognitive monitoring learning log (CMLL) for this study was given towards the end of class, not as homework assignment proposed by Commander and Smith (1996) as such assigned homework may entice a student to have someone else work on it. Moreover, the CMLL focused on one question or topic each week, not ten different topics, so that the researcher can truly determine whether or not students have actually corrected or replaced prior difficulties they indicated in the log with more useful strategies for solving problems. Commander and Smith
(1996) shared that the primary goal of the learning log is “to give learners the opportunity to write about and thus know about their own learning” (p. 452). In addition to said goal, this study tracked the students’ successful resolution, if any, of their perceived problems.

Writing and Mathematics Problem Solving Relationship

Kenyon (1988) and Pugalee (2005) point out that writing, as an integral part of the thought process, is a significant method for solving problems. While this is the case, they also argue that this method is not widely supported in the mathematics community.

As noted earlier, monitoring is a critical component of mathematics problem solving. This monitoring activity can be done through reflective journal writing or by keeping logs -- one of the ways, in addition to group work, cooperative learning, and writing reports, that Human (1993) and Stewart (1993) say would clarify one’s thinking. Clark and Yinger (1985) note that the process of writing itself promotes self-reflection. Dewey (1944) claimed students learn best through action and reflection, both of which are central practices to problem solving pedagogy.

Some early mathematicians thought that writing could greatly help students grasp the reasoning and meaning
behind mathematics. A University website (UWS, 2006) quoted Jerome Bruner as saying that there is no better way to learn mathematics than "to catch its complexities in the constraining structure of words." Simply said, one’s learning and thinking processes truly could be best understood or explained once they are put into writing.

The NCTM recognizes the role of writing assignments in its *Curriculum and Standards* (1989) document suggesting that mathematics education should make such use to help students gain a better understanding of mathematical concepts. Although the NCTM standards are more directed to K-12 education, they have implications for the post-secondary curriculum.

Pugalee’s (2001) investigation on whether students’ writing showed evidence of metacognitive framework underscored the importance of implementing writing as an integral part of the mathematics curriculum. Through writing, one can reflect on and change ideas, as well as explore and clarify one’s thinking. A popular saying by E. M. Forster, “How can I know what I think until I see what I say” (BrainyQuote, 2006) attests to the purpose of writing and portrays the essence of writing-to-learn programs. According to Connolly (1989) and Countryman (1992), writing-to-learn helps explore students’ attitudes toward
math and math learning, and allows students to reflect on their understanding, log their learning process, and solve specific mathematical problems. Abbey (1996), Dodd (1992), and Thurlow (1995) suggested journal writing as an intervention for improving students' attitudes and behavior towards mathematics. These studies used dialogue and response journals and dealt with improving or investigating structured personal journal writing to self-esteem.

In describing his experience of incorporating a writing component in his number theory course and claiming that a quarter of its students became 'reasonable' writers after a term, Price (1989) proposes requiring all math students to write in their courses. Davison and Pearce (1988) believe "most aspects of students' mathematical development, from concept acquisition through problem solving abilities can be facilitated through integration of writing activities" (p. 494). Abel and Abel (1988) note that writing helps students see new relationships, invent new ideas, and communicate better. Similarly, Stempien and Borasi (1985) note that writing helps students understand, organize, and become more active in the learning process. Azzolino (1988) asserts that writing assignments are useful diagnostic tools as well as an aid to student comprehension of mathematics. While Borasi and Rose (1989) note the
potential benefits of journal writing, they caution educators as to the type of writing activities utilized.

In an experimental research study conducted with college students in a developmental mathematics course, Ganguli (1989) shared that the experimental group given short in-class writing assignments performed better on the final examination compared to the group without writing activities beyond ordinary note taking. This has supported Watson’s (1980) assertion that integrating writing into mathematics class helps students improve their grades.

Meanwhile, Grossman, Smith and Miller (1993) report strong relationships between writing ability, conceptual understanding, and problem solving. They suggest that the ability to comprehend and apply mathematical concepts is related to the ability to explain concepts in writing (p.4).

In essence, both students and teachers benefit from the use of journals (Vukovich, 1985). Burns (1988) adds that they help develop student abilities to think about and understand content and provides teachers with a better understanding of students’ cognitive processes. Nahrgang and Petersen (1986) claim that in-class journal writing is an effective method of using writing to help students learn mathematics. Thus, this study also proposed the use of
cognitive monitoring learning log to be completed in class and not assigned for take-home work.

Mathematics & Problem Solving in Education

Within the last fifteen years, there has been a major shift in the teaching of mathematics, particularly with respect to problem solving. Problem solving is at the focus of mathematics teaching and of all the National Council of Teachers of Mathematics (NCTM) standards documents (Curriculum and Evaluation Standards for School Mathematics, 1989; Professional Standards for Teaching Mathematics, 1991; Assessment Standards for School Mathematics, 1995; and Principles and Standards for School Mathematics, 2000). The NCTM developed its Standards in response to a recognized need for change in the teaching, learning, and assessment of mathematics. Similarly, the American Mathematical Association of Two-Year Colleges (AMATYC) just released its standards document, Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College; it builds on its first standards document, Crossroads in Mathematics, released in 1995. This document presents a renewed vision for mathematics courses offered in the first two years of college and “is intended to stimulate faculty, departments, and
institutions to examine, assess, and improve every component of mathematics education” (Wood, Bragg, Mahler & Blair, 2006, par 1). Additionally, it reiterates the opportunity for students to improve their problem-solving ability through taking mathematics courses.

Even the National Science Education Standards (NRC, 1996) takes on problem solving as an important component in promoting scientific literacy that is of increasing importance in the workplace. “More and more jobs demand advanced skills, requiring that people be able to learn, reason, think creatively, make decisions, and solve problems” (NRC, 1996, p. 1). These skills are a part of the NSES vision for a scientifically literate populace.

What is Problem Solving?

Problem solving in general is described in Encyclopaedia Britannica (2006) as a “process involved in finding a solution to a problem” and “may be characterized as a systematic search through a range of possible actions in order to reach some predefined goal or solution” (par 1). Considered the most complex of all intellectual functions, problem solving has also been defined as a higher-order cognitive process that requires the modulation
and control of more routine or fundamental skills (McCarthy & Worthington, 1990).

Many definitions of problem solving appear in the literature. Lajoie (1992) defines mathematical problem solving as: “modeling the problem and formulating and verifying hypotheses by collecting and interpreting data, using pattern analysis, graphing, or computers and calculators.” The National Center for Education Statistics (2006) defines it as “one’s capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution is not immediately obvious.” The Northwest Regional Educational Laboratory (2002) defines it as the process of moving towards a goal when the path to that goal is obstructed or unclear. The National Council of Teachers of Mathematics (NCTM, 2000), seeing it as an “integral part of all mathematics learning”, defines problem solving as follows:

engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings. Solving problems is not only a major goal of learning mathematics but is also a major means of doing so. (p. 52)

For the purposes of this study, problem solving is looked at within the confines of mathematics education and one that is rooted in the work of George Polya. Polya
(1966) thought of problem solving as the "[m]athematical activity nearest to the center of everyday thinking" (p. 125). He popularized the notion of problem solving and explained it as follows: "Solving a problem means finding a way out of a difficulty, a way around an obstacle, attaining an aim which was not immediately attainable" (1962, p. v.). Others expanded on this definition by referring to it as a process by which a student uses previously acquired skills and understanding to satisfy the conditions of an unfamiliar situation or when no solution method is obvious (Gagne & Medsker, 1996; Krulik & Rudnik, 1987; Mayer & Wittrock, 1996; Schoenfeld, 1989).

The NCTM (1989) Standards state:

Problem-solving should be the central focus of the mathematics curriculum. As such, it is a primary goal of all mathematics instruction and an integral part of all mathematical activity. Problem solving is not a distinct topic, but a process that should permeate the entire program and provide the context in which concepts and skills can be learned. (p. 23)

As a process, problem solving is, indeed, regarded as a higher order or complex level of thinking that is not only desirable, but is necessary.

Finally, this study used Gagne and Medsker’s (1996) broad definition of problem solving as: "a higher level cognitive ability, either novel or routine, that requires previous learning of various types and that may result in
new learning” (p. 124). Its key features, according to Gagne and Medsker (1996) are as follows:

1. the task requires a solution or sets a performance goal, but the solution process may not be a defined procedure, and there may be a variety of correct solutions;
2. some degree of search takes place in the performer’s thinking process;
3. the performer uses previously learned rules, verbal information, and cognitive strategies to reach a solution or achieve the goal; and
4. in the process of solving the problem, the performer may learn a higher order rule or cognitive strategy that will help solve similar problems in the future. (pp. 124-125)

Evidently, Schoenfeld (1987) places more emphasis on the importance of metacognition and the cultural components of learning mathematics (i.e., belief systems) in his analysis of students solving problems.

**Routine versus Non-Routine Problems**

In determining problems to solve, Polya classified them as either routine or non-routine. A routine problem, according to Polya (1973), is one that “can be solved by substituting special data into a formerly solved general problem, or by following step by step, without any trace of originality, some well-worn conspicuous example” (p. 171). In short, it is merely an exercise that does not contribute much to any mental or cognitive activity. Meanwhile, a non-routine problem encourages creativity and originality.
for a problem solver (Polya, 1966). The Pentathlon Institute website distinguishes routine problem solving as using sets of known or prescribed procedures (algorithms) to solve problems, while a non-routine problem uses heuristics, which do not guarantee a solution to a problem but provide a more highly probable method for solving problems (Gilfeather & del Regato, 2004). Fortunately, while non-routine problems are perceived as challenging and unfamiliar, it is not insurmountable (Becker & Shimada, 1997). For the purpose of this study, the definition of non-routine problems was based on IEA’s TIMMS 2003 International Report on Achievement in the Mathematics Cognitive Domains definition as follows:

Non-routine problems are problems that are very likely to be unfamiliar to students. They make cognitive demands over and above those needed for solution of routine problems, even when the knowledge and skills required for their solution have been learned. (Mullis, Martin, & Foy, 2005, p. 69)

Problem Solving Framework and Heuristics

A framework to think about processes involved in mathematics, as introduced by Polya (1973), includes the following four stages: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back (pp. xvi-xvii). Krutetskii’s (1976) theory which maintains that there are stages in the solution of
mathematical problem solving—information gathering, information processing, and information retaining, correspond with Polya's list of heuristics. Schoenfeld (1985a) also has suggested frameworks for mathematical problem solving and pointed out that a student's ability to solve non-routine problems is a function of how well he or she employs and regulates relevant cognitive and affective characteristics. The four components of knowledge and performance identified as fundamental to the problem solving process are resources, heuristics, metacognitive control, and belief systems (Schoenfeld, 1985a).

Johnson, Herr, and Kysh (2004) offer the following strategies for problem solving that should prove useful in devising a plan: draw a diagram, make a systematic list, eliminate possibilities, look for a pattern, guess and check, identify sub-problems, analyze the units, solve an easier related problem, create a physical representation, work backwards, draw venn diagrams, convert to algebra, organize information, change focus, and visualize spatial relationships. Although it was not made evident through this study, the researcher hoped that students would somehow talk about these strategies in their logs or during the interview session.
Students Attitudes Concerning Mathematics Problem Solving and Writing

Students need a positive attitude to be successful in mathematics (Cornell, 1999; Fiore, 1999; Lester, Garofalo & Kroll, 1989; Neale, 1969; Silver, 1985). Ma (1997) believes that students who are determined to succeed and willing to put the best behind them generally do well. This seems to be an obvious fact but there still seems to be a good number of students who are simply terrified of being in a math classroom or could care less about the course.

According to Kroll and Miller (1993), “An important difference between successful and unsuccessful problem solvers lies in their beliefs about problem solving, about themselves as problem solvers, and about ways to approach solving problems” (in NCTM 2000, p. 259). To approach a problem, Beaver (1994), Burns (2000), and Krulik and Rudnik (1987) proposed taking into consideration certain attitudes and student characteristics that need to be identified and incorporated in problem solving efforts such as:

- have an ownership interest in problem solving
- have a desire for solution to the problem
- feel capable of solving the problem (help them build on small success)
- be willing to begin the problem solving process
• be willing to risk possible failures (being wrong at times) and repeated attempts to solve a problem
• have confidence to try various strategies
• be willing to persevere when solutions are not immediate, and
• understand the difference between not knowing the answer and not having it found it yet.

Indeed, one’s attitude in dealing with a perceived problem determines whether or not a successful resolution is explored and/or found. One may decide to take on a problem and persist, another may decide to take on a problem but give up eventually, while yet another may choose to avoid the problem all together and not care about finding any resolution.

As cited in the Mathematical Association of America’s website (2006): “DeBellis and Goldin [1997] view beliefs, attitudes, emotions and values – and their interplay with cognition as fundamental to problem solving; these provide information that can facilitate or hinder monitoring” (¶19). It is, therefore, important to empower students with a positive attitude (Tobias, 1993); equally important is to see where they are coming from or the source of their anxiety or attitude. Fiore (1999) found it helpful to have
his students write an essay about their past experiences in math. Drawing on three years of experience in a mathematics program with student journals, Vukovich (1985) notes that journals can act as a means of communication between teacher and students and help students examine their own reasoning processes. Consequently, students “develop a better understanding and appreciation of both mathematics and writing” (p. 20).

Abbey (1996), Dodd (1992), and Thurlow (1995) suggest journal writing as an intervention for improving students’ attitudes and behavior towards mathematics. These studies used dialogue and response journals and dealt with improving or investigating structured personal journal writing to self-esteem. Miller and England (1989) discuss a research project which investigated the effect of regular writing in algebra classes on students’ attitudes and skills in algebra and the effect of regular reading of student writing on teacher awareness of student difficulties in and attitudes toward algebra. They claim that results have shown improved attitudes of the students and the teachers toward each other about the teaching and learning of algebra.
Summary

Many educators and researchers contend that incorporating writing in the mathematics curriculum is sensible in light of the fact that writing promotes self-reflection, and self-reflection is critical in mathematics and the problem solving process. While studies on the relationship between writing and mathematics course success and/or problem-solving performance are limited, there is arguably an abundance of action research reports that lends credence to the intrinsic value of this relationship. Writing, particularly as a metacognitive strategy (referred to in this study as cognitive monitoring learning log) should be valued not only because it might help students in experiencing success in mathematics and problem solving, but because it can contribute to both classroom and student development.
Overview

This chapter is a description of the research design and the quantitative and qualitative research methodologies employed in this study, as well as the unit of analysis, role of the researcher, the procedure and details of the research design (including techniques for data collection and analyses), and issues of verification and validity for the study.

The purpose of this study was to investigate the impact of cognitive monitoring learning logs (CMLL) - a metacognitive strategy - on the college students’ pre-algebra course success, problem-solving performance, and attitudes toward mathematics and CMLL strategy. The researcher needs to remind the reader that CMLL writing is more structured and definite than personal journal writing in that students are encouraged to think, to question, and to evaluate their own understanding of concepts discussed or skills learned in class that will facilitate their learning by way of monitoring their growth or skill development. The questions for the logs in this study were designed to stimulate students’ metacognitive awareness similar to Commander and Smith’s (1996) approach. For this
study, the participants were asked to respond to specific questions or prompts directly related to the material covered in the course or pertaining to course difficulty.

To address the problem identified in this research, the researcher reviewed documents related to multiple sections of a mathematics course, in this case, the pre-algebra (Math 010) course. Other types of documents that were acquired were as follows: Course Form 335 (which includes catalog description, learning outcomes, and sequence of learning activities – see APPENDIX A), Course Outline/Syllabus (see Appendices B & C), and Course Competencies (see APPENDIX D). Notes and observations made during interviews and the course-related documents provided quantitative, qualitative, and/or both quantitative and qualitative data.

Research Questions

This study endeavored to explore the impact of cognitive monitoring learning log (CMLL) – a metacognitive strategy – on students’ mathematics course success, problem solving performance, and attitudes towards mathematics and CMLL. Specific questions that were addressed by this study are shown in Figure 1.1 below and are listed with their data source/s and analysis techniques:
### Figure 3.1 Summary of Data Sources for Research Questions

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Source/s</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What differences in mathematics course success exist between those students who participate in the CMLL intervention and those who do not participate in the intervention?</td>
<td>Final course grade</td>
<td>T-test for two independent samples, one-way ANOVA</td>
</tr>
<tr>
<td>2. What differences in problem-solving performance exist between those students who participate in the CMLL intervention and those who do not participate in the intervention?</td>
<td>Mathematics Problem Solving Test (MPST)</td>
<td>two-way ANOVA</td>
</tr>
<tr>
<td>3. What differential changes in attitudes towards mathematics exist between those students who participate in the CMLL intervention and those who do not participate in the intervention?</td>
<td>Modified Mathematics &amp; Science Attitude Inventory (MSAI), semi-structured interview</td>
<td>two-way ANOVA</td>
</tr>
<tr>
<td>4. What differential changes in attitudes towards CMLL are reported by students who participate in the CMLL intervention?</td>
<td>CMLL Attitude Survey (CMAS), semi-structured interview</td>
<td>Paired samples T-test</td>
</tr>
<tr>
<td>5. What were the students’ perceptions of the CMLL strategy in the developmental mathematics course?</td>
<td>semi-structured interview, CMLL entries</td>
<td>Case analysis</td>
</tr>
</tbody>
</table>
Rationale for Pre-test/Post-test Research Design

The research design most appropriately used for this study is a pre-test/post-test control group design dependent upon the application of quantitative and qualitative methodologies. There were four intact groups (four sections of the pre-algebra course); two groups were assigned to receive the CMLL intervention while the other two were assigned as control groups. Additionally, the two instructors who taught these groups each had a section assigned to a control group and an intervention group (see Figure 1.2 below). The rationale for the selection of this research design is explained here.

Figure 3.2 Pre-test/Post-test Control Group Design

<table>
<thead>
<tr>
<th>Instructor 1</th>
<th>Instructor 2</th>
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<tbody>
<tr>
<td><strong>Control group</strong></td>
<td><strong>Intervention group</strong></td>
</tr>
<tr>
<td><em>(NCML)</em></td>
<td><em>(CMLL)</em></td>
</tr>
<tr>
<td><strong>Control group</strong></td>
<td><strong>Intervention group</strong></td>
</tr>
<tr>
<td><em>(NCML)</em></td>
<td><em>(CMLL)</em></td>
</tr>
</tbody>
</table>
The research design for this study is best described by Gay, Mills and Airasian (2006) in their Educational Research text as follows:

pretest-posttest control group design requires at least two groups, each of which is formed by random assignment; both groups are administered a pre-test, each group received a different treatment, and both groups are post-tested at the end of the study. Post-test scores are compared to determine the effectiveness of the treatment. (p.254)

Moreover, as Gay et al. (2006) pointed out, all sources of internal validity are controlled in this type of design due to the “combination of random assignment and the presence of a pre-test and a control group” (p.254). They clarified this with the following assertion:

Random assignment controls for regression and selection factors; the pre-test controls for mortality; randomization and the control group control for maturation; and the control group controls for history, testing, and instrumentation. Testing is controlled because if pre-testing leads to higher post-test scores, the advantage should be equal for both the experimental and control groups. (Gay et al., 2006, p. 254)

The above assertion is also supported by Fraenkel and Warren (2000) indicating that a static-group pre-test/post-test design “provides better control over history, maturation, testing, and regression threats [including] better control of the subject characteristics threat” (p. 289).
Rationale for Quantitative and Qualitative Methodology

The research methods used in this study were mainly quantitative. The Community College’s recently developed and currently in use Mathematics Problem Solving Test (MPST) in Appendix E was used to ascertain the students’ mathematics problem-solving performance. Students’ mathematics course success was determined based on receipt of a course grade of B or better, due mostly to performance on the College-implemented final examination (see sample in Appendix F). The College had approved the researcher to give the instructors participating in the study the option (if needed) of incorporating all items in the Mathematics Problem Solving Test (as a post-test) in place of any problem-solving items originally embedded in the final exam. The College-approved modified Mathematics and Science Attitude Inventory (MSAI) in Appendix G was used to determine students’ attitudes towards mathematics, while a College-approved Cognitive Monitoring Learning Log Attitude Survey (CMAS) in Appendix H was used to determine students’ attitudes towards and past experience with log or journal writing, if any.

However, a small component of survey data employed a qualitative methodology: semi-structured interviews and student self-report from CMLL entries. Consequently, this
research does not fall into the traditional pre-test/post-test research design. In order to further examine students’ problem-solving performance and attitudes, the researcher examined other aspects that can be evaluated or other means to add validity to the study. After all, it was the recommendation of educational researchers (Huberman & Miles, 1994; Wandersee, Mintzes & Novak, 1994) to employ novel research designs and new methods to address complex issues as discussed in this study. Thus, a qualitative measure was incorporated into this study. To probe into students’ work, the researcher employed having an interview expert to ask open-ended questions because nuances of students’ mathematics course success and problem-solving performance were not expected to be solely revealed in the instruments used in this study. From what Huberman and Miles (1994) and Wandersee et al. (1994) recommended, this researcher integrated the pre-test/post-test control group design methodology and qualitative methodology.

Participants

The participants in this study were college students who were taking a developmental mathematics pre-algebra course (Math 010) at a community college in Pennsylvania’s southeastern region, and two instructors each assigned to
teach two of the four sections of the course. The particular campus of the community college targeted for this study is composed of a diverse student body with about 4,500 students; a little over 18,000 students attend college-wide (from all five campuses). The students for this study were enrolled in different sections of the same math course level. They were from four intact classes selected because they were taught by two experienced instructors each assigned to teach two or more sections of the course during the same semester. The students were expected to range in age from 18 to 60, distributed among the four sections. Moreover, the students in the study were placed in the course because of their performance on the College’s online Accuplacer mathematics placement test developed by the College Board™. If needed, other students may enroll in the pre-algebra course after successfully completing Math005 (Basic Mathematics) with a grade of C or better. All students who may need an algebra-based mathematics course (such as College Algebra, Statistics, Trigonometry, Math for Teachers) or need to show math proficiency at a certain level to meet curriculum or other program requirements are required to take the College’s placement test, unless they transfer in a college-level, algebra-based course that meets said criteria. For those
who do not have the necessary skill or level required by their program of study, the College then offers four levels of developmental math (Math 005-Basic Mathematics, Math 010-Pre-Algebra, Math 020-Beginning Algebra, and Math 051-Intermediate Algebra) that eventually prepares them for success in their pursuits. As pointed out in their 2006-2007 course catalog,

[The College] offers several courses designed for students who need assistance in sharpening their skills for college-level work. Students who would benefit from preparatory work are identified through [the College’s] Testing and Placement Program or through the optional CEEB or ACT test scores they present upon admission (p. 12).

Permission to release the participants’ course grades, along with any assessment results were solicited by ensuring confidentiality in such a way that the researcher did not know the students’ identity. Information was coded (example: section number, initials, student’s last four to six digits of college-assigned student number). Instructors’ permission was solicited as well and confidentially maintained.

The Role of the Researcher

The researcher is a faculty member of the community college where the research study was investigated. She is a tenured full-time professor of counseling, and an adjunct
faculty in the Mathematics, Science and Allied Health (MSAH) division and Adult Basic Education and Developmental Studies (ABEDS) division of the same college. She has over seventeen years of teaching and counseling experience, in addition to program development.

Pertaining to the research study, the researcher did not interact with the students or the instructors in any capacity during the teaching of any lesson inside the classroom. She took on a more passive role (Stake, 1995) to avoid any bias or ethical issue that may arise resulting from being a participant observer (Bogdan & Biklen, 2003). However, she did hold private discussions with the instructors to discuss general questions related to the research logistics such as CMLL question prompts and/or non-routine problems assigned to students who were in the group receiving the CMLL intervention, to discuss class progress for students in all four sections, and to ensure that all sections had the same pace or lecture topic.

Research Setting

The pre-algebra (Math 010) course that was investigated for this study is a developmental mathematics course “designed to review the basic operations of arithmetic and introduce algebraic representation and
application” (as stated in the College’s online course description). As said earlier, four of the eight course sections offered at the College’s local campus were selected because they were taught by two similarly-experienced and full-time instructors who were each assigned two sections of the course for the semester when this study was conducted. (See also Math 010 course competencies and sample course syllabus in Appendices C & D). The instructors conducted each meeting using a lecture/discussion format. Prealgebra, 4th ed., by K. Elayn Martin-Gay (Prentice Hall) was the textbook used for all sections. All sections met for 15 weeks during a regular semester. Each section of the course was expected to have a maximum of 20 students. The four sections were then assigned as follows: two to the cognitive monitoring learning log (CMLL) strategy groups (intervention group) and two to the no cognitive monitoring learning log (NCML) strategy group (control group). The sample consisted of participants who self-enrolled to be in any one of (or distributed over) the four sections of varying class size (or with a maximum of 20 students).

Participants in all groups were given a College-developed and implemented Mathematics Problem Solving Test (MPST) used as both pre-test and post-test (see Appendix
E), a College mandated final exam (see Appendix F), a College-approved Modified Mathematics and Science Attitude Inventory (MSAI) – see Appendix G, and a College-approved CMLL Attitude Survey (CMAS) – see Appendix H. Students in the intervention group responded to weekly CMLL question/prompt (see Appendix I). Some of the participants from the intervention group (randomly selected from a pool of volunteers from each class roster) were then interviewed on a voluntary basis to ascertain their attitude towards mathematics and towards the cognitive monitoring learning log (CMLL) and perceived benefits of the CMLL.

As mentioned previously, there were four intact groups for this study; two groups participated in the CMLL intervention. The groups receiving the intervention were introduced to and engaged in cognitive monitoring learning log strategy (metacognitive). Before completing any inventories and assessments, all participants signed informed consent forms (see Appendices J & K), with approval from the College where the study was conducted (see Appendix L), and approved by Temple University’s Institutional Review Board, which also approved conducting the study.
Variables

The independent variable, CMLL intervention, has two levels: cognitive monitoring learning log strategy (CMLL) and no cognitive monitoring learning log-writing strategy (NCML). The CMLL intervention was a weekly writing in response to learning prompts. Each prompt solicited from students was a short written response to a specific set of questions or instructions. Participants in the CMLL group were assigned to respond to the prompts or questions on a weekly basis during weeks 4-12 of the semester in addition to any homework assignment or assigned exercises from their textbook. In class, they were given a limited amount of class time (5 to 10 minutes at the end of each class period) for reading the prompt, making sure they understood what was being asked, and formulating and writing their responses. They handed in their response the same day, but they also got a copy of similar question/prompt to take home in case they want to elaborate on what they had written out. The NCML condition consisted of exercises selected from the student textbook to minimize the use of writing. The same amount of class time (5 to 10 minutes) was allocated for this activity at the end of each class period.

Dependent variables were as follows: mathematics course success, based on receipt of a course grade of B or
better during the period of study, and problem-solving performance as measured by the results on the Mathematics Problem Solving Test (MPST) given as pre-test and post-test during the period of study. Additional dependent variables were attitude towards mathematics, obtained through responses on the Modified Mathematics and Science Attitude Inventory (MSAI), attitude towards cognitive monitoring learning log strategy, obtained through responses on the CMLL Attitude Survey (CMAS), and perceived benefits of CMLL. Additional insights on student attitudes (for both mathematics and CMLL) and perceived benefits were obtained through interviews.

The instructor variable was controlled by having all students in the study taught by two similarly-experienced (each with ten or more years of teaching experience) and full-time instructors using the same textbook. Moreover, the course content covered during the study was identical for both CMLL and NCML conditions.

Instrumentation and Materials

Instrumentation refers to the process of data collection in a research investigation, which ultimately leads to the conclusions of the study so that decisions can be made about the research problem at hand (Wiersma, 2000).
The instrumentation used in this study was a Mathematics Problem Solving Test (MPST), mathematics course success assessment based on the College-implemented course final examination, modified Mathematics and Science Attitude Inventory (MSAI), CMLL Attitude Survey (CMAS), cognitive monitoring learning log (CMLL) entries, and interviews to survey attitudes towards the CMLL strategy, success in mathematics and problem solving. Overall, Fraenkel and Wallen (2000) warn investigators that the choice of instrumentation affects validity and reliability.

Description of the Mathematics Problem Solving Test (MPST)

The Mathematics Problem Solving Test (MPST) in Appendix E is a College-utilized seven-item mathematics problem set. It was developed from an initial body of fourteen problems collected from the course textbook, *Prealgebra* (Martin-Gay, 2004), as well from a supplemental book on problem solving, *Problem Solving Strategies: Crossing the River with Dogs* (Johnson, Herr, & Kysh, 2004). The test covers course topics/areas on equations, fractions, ratio and proportion, percent, introduction to statistics, geometry, and measurement. The seven problems were selected by a panel of six experts in mathematics education (course instructor, two adjunct mathematics
faculty each with over 25 years of experience in mathematics instruction, 2 full-time mathematics faculty, and Dean of the Community College's math, science, and allied health division), with the goal of identifying items representative of concepts expected of students to learn at the completion of the course.

A rubric to assess mathematics problem solving (see Figure 3.1) was selected from among three popular ones reviewed by the panel of experts mentioned above. Because the College’s division dean, math discipline faculty, and campus coordinator have approved the use of the Analytic Scale for Problem Solving by Szetela and Nicol (1992), this scoring rubric was initially elected for use by the researcher to evaluate the participants’ responses to the Mathematics Problem Solving Test (MPST) used in this study. However, upon review of students’ responses to the problem-solving task, it became obvious that there was some type of bias present in terms of test administration that resulted in varying score improvement for students from pre to post. Some students seemed to have followed the instructions carefully in terms of showing their thought process to arrive at their problem solution; some did not. This may be due to different verbal instructions given during the administration of the pre-MPST and post-MPST. Therefore,
after scoring was done, the researcher opted to only rely on the 2-point score for correct solution (see Figure 3) in answering the problem (Scale III); scores for understanding (Scale I) and solving (Scale II) the problem were not considered. For future consideration of replicating this study, the rubric originally considered for use as a scoring guide is retained here.

In terms of scoring the tests, nineteen mathematics education majors in a secondary math methods class from a local university were trained for two days on grading according to the rubric. Each math education student graded no more than one question per test; piles of tests were rotated to a new grader after each question was graded. Also the pre-tests and the post-tests were mixed in the piles, ensuring that participant names were not on the test. Therefore, graders for the tests were unbiased outsiders (considered “early professionals” in the math education profession); neither instructors nor the researcher were involved in grading.

Description of Rubric to Evaluate Problem Solving

The Analytic Scale for Problem Solving, modified by Szetela and Nicol (1992) based on a Math Problem Solving rubric devised by Charles, Lester, and O’Daffer (1987) was
the rubric utilized for this study (see Figure 3.3). According to the authors and rubric designers (Szetela & Nicol, 1992), the Analytic Scale for Problem solving has “increased emphasis given to the understanding and solving stages” (p. 43) in problem solving. Problem solving involves complex interactions between cognitive and metacognitive processes. Szetela and Nicol (1992) break the problem solving process down into three stages: (a) understanding the problem; (b) solving the problem, and (c) answering the question, and they score performance on each one separately. Their rubric presents a more detailed picture of students' abilities rather than a simplistic approach such as measuring only correct and incorrect outcomes. Additionally, they identify the following typical sequence of actions for successful problem solving (p. 42):

1. Obtain appropriate representation of the problem situation.
2. Consider potentially appropriate strategies.
3. Select and implement a promising solution strategy.
4. Monitor the implementation with respect to problem conditions and goals.
5. Obtain and communicate the desired goals.
6. Evaluate the adequacy and reasonableness of the solution.
7. If the solution is judged faulty or inadequate, refine the problem representation and proceed with a new strategy or search for procedural or conceptual errors.

Figure 3.3 Analytic Scale for Problem Solving

<table>
<thead>
<tr>
<th>Scale I</th>
<th>Understanding the Problem</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Complete understanding of the problem</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Misinterprets minor part of the problem</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Misinterprets major part of the problem</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Completely misinterprets the problem</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>No attempt</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale II</th>
<th>Solving the Problem</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>A plan that could lead to a correct solution with no arithmetic errors</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Substantially correct procedure with minor omission or procedural error</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Partially correct procedure but with major fault</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Totally inappropriate plan</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>No attempt</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale III</th>
<th>Answering the Problem</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Correct solution</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Copying error; computational error, partial answer for problem with multiple answers; no answer statement; answer labeled incorrectly</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>No answer or wrong answer based upon an inappropriate plan</td>
<td></td>
</tr>
</tbody>
</table>


Description of Mathematics Course Success Assessment (Course Examination)

A College-implemented final examination was utilized to measure students’ mathematics achievement or course
success. The final exam is typically a 65-item comprehensive exam covering areas/topics on whole numbers, signed numbers, linear equations in one variable, fractions, decimals, ratio and proportion, percent, introduction to statistics, geometry, and measurement. The faculty, however, is given the option to modify the test as they see fit. See Appendix F for a sample test. For this study, the final exam for the four classes identified may include all the items from MPST (as post-test) in place of other problem-solving questions embedded in the original exam. The researcher discussed this option with the instructors and determined that it was not necessary to do so because they have chosen to give the MPST before the week of final exam.

**Description of Modified Mathematics and Science Attitude Inventory (MSAI)**

A College-utilized Modified Mathematics and Science Attitude Inventory (MSAI), adapted from a 62-item Mathematics and Science Attitude Inventory developed by Project EDGE at Rochester Institute of Technology, was used for the study (see Appendix G) with permission from National Science Foundation (NSF)-funded Online Evaluation Resource Library. The modified MSAI is a 31-item, closed-ended, four-point Likert scale (ranging from strongly
disagree to strongly agree) inventory with four demographic questions. With questions pertaining to science removed from the original inventory, it measures students’ attitudes toward mathematics and covers topics on academic habits, academic preferences, attitudes and beliefs, and self-assessment. Cronbach’s alpha for this instrument is 0.9 which is slightly above the acceptable level of 0.8.

*Description of the Cognitive Monitoring Learning Log Attitude Survey (CMAS)*

A College-approved *Cognitive Monitoring Learning Log Attitude Survey (CMAS)* in Appendix H was used for the study to measure student attitude towards cognitive monitoring learning log (CMLL) and determine past experiences with such strategy, if any. It was given to participants as a pre-test and post-test, with some questions therein utilized for the interview. The CMAS was adapted from a *Journaling Attitude Survey (JAS)* developed with permission from Laysears-Smith (2005). Laysears-Smith (2005) developed her survey from student attitude surveys developed by Eastman (1997), Forlizzi and Askov (1993), Greenberg (1997) and Stemper (2002). She then used the relevant literature base to formulate additional statements for gathering information about students’ attitudes concerning structured personal journaling.
The CMAS consists of 20 statements, which were modifications of statements that Laysears-Smith (2005) developed through analysis of the literature on topics related to students' knowledge of journal writing, perceptions of journal writing, and attitude about journal writing. The students' attitudes toward CMLL were ascertained from a five-point Likert scale ranging from strongly disagree to strongly agree. According to Laysears-Smith (2005), items 7 and 8 of the survey are revised statements of the Student Attitude Survey from Forlizzi and Askov (1993). Items 3 and 13 through 15 are revised statements of the Student Attitude Survey from Stemper (2003). Items 6, 10, and 12 are revised statements of the Student Attitude Survey from Greenberg (1997). Items 4, 5, and 9 through 11 were developed from the Guidelines to the Personal Journal (see similar guidelines in Appendix M). The remaining items of the CMAS, 1, 2, and 16-20 were developed by Laysears-Smith (2005) from the existing literature and her personal experience to obtain additional information concerning students' attitudes and feelings about personal journal writing. Cronbach's alpha for this instrument is 0.9 which is slightly above the acceptable level of 0.8.
The College-reviewed CMLL guidelines (see Appendix M) was also adapted from the Journal Writing Guidelines with permission from Laysears-Smith (2005). It was given as a handout and explained to the students by their instructor. These guidelines consisted of statements that have been shown to promote successful outcomes (Eastman, 1997) as cited in Laysears-Smith (2005).

Description of the Cognitive Monitoring Learning Log (CMLL) Entries

Much like personal journal writing or reflective writing, a cognitive monitoring learning log (CMLL) enabled students to put into writing their thoughts, observations, reactions, questions, ideas, concerns, even doubts and fears. It was an avenue for students to express and to reflect upon their thoughts and strategies used, even the successes, challenges and difficulties faced in dealing with mathematics problems, new concepts or lessons learned and other issues pertaining to their mathematics course. Through the CMLL, students were encouraged to think, to question, and evaluate their own understanding of concepts discussed or skills learned in class, in addition to responding to specific question prompts or special problems, that would facilitate their learning by way of monitoring their growth or skill development. This
strategy should exhibit one's growth in learning and understanding (or lack thereof) of the mathematics concepts and skill in mathematics and problem solving, along with attitudes towards learning mathematics and towards the writing strategy itself. Questions posed include:

- Based on a recent test, what problem or question was difficult or challenging for you?
- Why was it challenging or difficult?
- What do you plan to do about it or how would you resolve your difficulty?
- If you have already overcome the difficulty or challenge, how did you do it? Otherwise, what do you think you need to do to overcome it?"

All student logs were provided to the students by the researcher through their instructor. This ensured that all logs were the same. Students were required to write their initials and last four digits of their college-assigned student number on the log for differentiation. The CMLL questions were to guide the students and encourage them to provide responses about their learning and their experiences based on the prompt or question. Student log entries were limited on their content and response and consisted of two sentences or longer.
Description of the Interviews

The interviews that were used for this study were semi-structured, and followed a process outlined by Gay, Mills and Airasian (2006). The semi-structured interview consisted of three types of questions to ascertain their course experience, perceived educational benefits of learning logs, and attitudes about mathematics, in general, and cognitive monitoring learning log use, in particular.

Questions on the Modified Mathematics and Science Attitude Inventory (MSAI) and CMLL Attitude Survey (CMAS) were used as a guide for ascertaining the students' attitudes. The interviewer was supposed to follow up on responses that may seem unclear or incomplete to gain more information about the students' attitudes obtained from the modified MSAI (for math attitude) and CMLL attitude inventory completed at the beginning and near the end of the course. The traditional use of the survey would not afford the instructor the opportunity for further probing on students' answers.

There are advantages and disadvantages with conducting an interview for research purposes. Although interviews can "produce in-depth data not possible with a questionnaire, it is expensive and time consuming" (Gay et al., 2006, p. 173). In addition, the students may respond
with "biased answers that are affected by [their] reaction to the interviewer, especially if [they have] not known the interviewer for a long time" (Gay et al., 2006, p. 173).

Data Collection Procedure and Protocol

Data Collection Strategies

For the purpose of this study, the data collection strategies utilized were testing (problem-solving test and course final exam), interviews (attitude towards CMLL and mathematics), surveys (mathematics attitude and CMLL attitude surveys), and student self-report through learning logs (CMLL entries).

Testing (Mathematics Exam)

“Achievement or ability tests measure an individual’s knowledge or skills in a given area or subject” (Frankel & Wallen, 2000, p. 145). For this study, a Mathematics Problem Solving Test (MPST) was administered by the instructor both as a pre-test and post-test to measure students’ problem-solving performance (see protocol in Appendix N). Students’ mathematics course success was measured based on receipt of final grade of B or better.

The Mathematics Problem Solving Test (MPST) was provided as a pre-test. The post-test, with similar
questions/items included on the MPST, was administered prior to the final exam as a separate test. This study did not set a specific score as a goal for the post-test. However, it was expected that each student would show improvement on the MPST post-test and, more so, with the intervention strategy (CMLL). See Appendix N for the protocol.

Interviews

As described earlier, the interviews that were used for this study were semi-structured, and followed a process outlined by Gay, Mills and Airasian (2006). The interviewer was given a copy of the post-test and noted the item perceived as most difficult or hard by the majority of students. During the time of the interview, the interviewer asked each student individually to describe the process that he/she used to solve a specific type of problem and to explain why the problem was perceived as difficult. Since problem-solving performance will not be identical for all students, the interviewer can "follow up on incomplete or unclear responses by asking additional probing questions" (p. 173).

In conducting the face-to-face interview, the interview expert used the questions on the Modified
Mathematics and Science Attitude Inventory (MSAI) and CMLL Attitude Survey (CMAS)) as a guide for ascertaining the students’ attitudes. The interviewer followed up on responses that seemed unclear or incomplete to gain more information about the students' attitudes obtained from the MSAI and CMLL attitude inventory completed towards the end of the course.

The interviews were conducted by an interview expert and not by this researcher. This individual has experience as a mathematics/science educator and in the interview process. The interviews were held in an appropriate place and at a convenient time for the respondents. With permission from all the participants, the interviews were audio-taped and then transcribed. The interviewer also took notes as appropriate. See Appendix O for the protocol. A copy of the interview questions appears in Appendix P.

Surveys

Much like questionnaires, attitude scales are also subject-completed instruments. “The basic assumption that underlies all attitude scales,” according to Fraenkel and Wallen (2000), “is that it is possible to discover attitudes by asking individuals to respond to a series of
statements of preference” (p. 144). Use of questionnaires and attitude measurements (self-report inventories) “assumes that individuals are both willing and able to report accurately” (Linn & Gronlund, 1995, p. 284).

For the study, student attitudes toward mathematics and CMLL were obtained through College-utilized Modified Mathematics and Science Attitude Inventory (MSAI) and Cognitive Monitoring Learning Log Attitude Survey (CMAS). (See Appendix N for the protocol.)

CMLL Entries (Student Self-Report)

For this study, student-generated self-report through their CMLL entries or responses were utilized to examine students’ ability to reflect on their thinking and learning. While essay questions are normally used to measure “knowledge of factual information,” questions utilized for student learning logs “measure learning outcomes that are not readily measured by objective test items” (Linn & Gronlund, 1995, p. 220). As Linn and Gronlund (1995) suggest, the question prompts for the learning logs for this study were similar to “restricted-response essay questions” (p. 220), in which the log entries were limited on their content and response. Because the questions were more structured, they were “most
useful for measuring learning outcomes requiring the interpretation and application of data in a specific area” (p. 221).

Procedure for Data Collection

As a participant in this research, the instructors were asked to lead their students in their participation of the study. The instructors administered a Mathematics Problem Solving Test (MPST), a Modified Mathematics and Science Attitude Inventory (MSAI), and CMLL Attitude Survey (CMAS) and completed by students, emphasizing the importance of honesty when completing them. These instruments that were used for data collection were given during the first two to three weeks of classes (when class rosters were finalized or more established); the CMAS was given a week prior to the CMLL intervention. The test to measure mathematics course success was also an instructor-administered test (final exam) given according to the schedule on the course syllabus (see Appendix C).

The researcher met with the course instructors prior to the beginning of classes to discuss the administration and scoring of the Mathematics Problem Solving Test (MPST). The instructors were asked to make a commitment to following the directions provided by the researcher by
signing an instructor agreement and consent form (see Appendix K).

The researcher further met with the course instructors prior to the CMLL intervention to go over the CMLL guidelines that were provided to the students as a handout. The instructors were prepared by the researcher with the specifics concerning introducing the CMLL to the students and the explanation of the guidelines of which both are to be handed out and clearly explained to students. Meanwhile, all student log forms were provided to the students by the researcher through the instructor. This ensured that all logs would be the same. Students were required to write their initials and last four digits of their college-assigned student number on the log for differentiation. The instructor was the only one to distribute and collect the logs, which are then returned to the students. Copies of student log entries were kept in a locked file cabinet in the instructors’ offices and were handled only by the instructors.

The students who had a signed consent form to participate in the study and were selected to be in the CMLL intervention group were then expected to write once a week for nine weeks. The instructors then asked students to again complete the attitude inventories, one week after
the CMLL intervention ended. Students in the control group were not given the CMAS. Students in the intervention group were given both attitude inventories (MSAI and CMAS) as post-tests. The students from the intervention group were also interviewed during finals’ week to ascertain their feelings about mathematics and log writing. The Mathematics Problem Solving Test (MPST) was administered separately a week before the scheduled final exam.

Over a nine-week period (weeks 4-13), the four groups were exposed to problem solving – both as a concept and process. The groups receiving the CMLL intervention were asked to respond to question prompts for their CMLL writing strategy and/or note their reaction/plan on a problem-solving task. They were given 5-10 minutes towards the end of the class period to write their responses on their logs. The other group simply did additional textbook exercises. The written responses were collected individually on a weekly basis and returned to students the following week for a period of nine weeks (weeks 4-12).

The log entries in response to a specific question/prompt were analyzed for identification of common challenges or difficulties indicated by students, as well as to identify similarities and differences in the approach students took to solve the challenge or difficulty. The
researcher and another trained rater each reviewed the data and categorized the responses, looking for problems (procedural, conceptual, academic, personal) and identifying the strategies or approach to resolve the problems or difficulty (such as “ask instructor for help,” “go for tutoring,” “review/check solution,” “slow down,” “attend test anxiety workshop,” etc.). If given, the log entries for a problem-solving task can be analyzed for identification of error patterns and solution strategies, as well as to identify similarities and differences in the approach students took to solve the problem/s. The researcher and another trained rater can each review the data and categorize the responses, looking for errors (procedural, computational, and algebraic) and identifying the strategies used to solve the problems (diagrams, tables, lists, guess-and-check, working backwards, searching for patterns, and so on). The researcher and rater can then agree on the error or problem categorizations and on the strategies used, with any discrepancies resolved through further dialogue.
Quantitative and Qualitative Data

Summary of Data Sources

The aforementioned data sources for this study are summarized as shown in Figure 3.4:

Figure 3.4 Summary of Quantitative & Qualitative Data Sources

<table>
<thead>
<tr>
<th>DATA SOURCE</th>
<th>APPENDIX</th>
<th># of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUANTITATIVE DATA SOURCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics Problem Solving Test (MPST)</td>
<td>E</td>
<td>7</td>
</tr>
<tr>
<td>Mathematics Course Success Assessment (final exam)</td>
<td>F</td>
<td>65</td>
</tr>
<tr>
<td>Modified Mathematics &amp; Science Attitude Inventory</td>
<td>G</td>
<td>31</td>
</tr>
<tr>
<td>CMLL Attitude Survey (CMAS)</td>
<td>H</td>
<td>20</td>
</tr>
<tr>
<td>QUALITATIVE DATA SOURCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMLL entries (weekly for 9 weeks)</td>
<td>I</td>
<td>9</td>
</tr>
<tr>
<td>Semi-Structured Interviews</td>
<td>P</td>
<td>6</td>
</tr>
</tbody>
</table>

Quantitative Component

At the discretion of this researcher, data that were clearly quantitative in nature were treated as such. Descriptive statistics were utilized to summarize the data; measures of central tendency (e.g. mean, mode, median), as well as standard deviations, were determined. Analysis of variance and t-tests were carried out as well. However, data that were deemed qualitative in nature required additional, if not careful, analysis.
Bogdan and Biklen (2003), Huberman and Miles (1994), Creswell (1998), and Stake (1995) offer general strategies for analyzing qualitative data. These strategies adequately accommodated the qualitative and quantitative components of data analysis critical to a pre-test/post-test control group research design.

In discussing a strategy for analyzing qualitative data, Bogdan and Biklen (2003) suggest:

the pervasive nature of quantification in educational organizations calls us to study counting and its ramifications from a qualitative perspective, one that moves us from a point of taking it for granted to one of studying it in context. (p. 155)

As advanced by Huberman and Miles, cited in Yin (1994), there are six analytic techniques upon which a researcher could rely to organize data prior to the actual analysis. These include the following:

1. Putting information into different arrays;
2. Making a matrix of categories and placing the evidence within such categories;
3. Creating data displays - flowcharts and other devices - for examining the data;
4. Tabulating the frequency of different events;
(5) Examining the complexity of such tabulations and their relationships by calculating second-order numbers such as means and variances; and

(6) Putting information in chronological order or using some other temporal scheme. (p. 103)

After organizing the data in a manner recommended by Huberman and Miles (1994), this researcher obtained a better understanding of precisely how to proceed with the analysis.

Case Study Method

Yin (2003) recommends the case study method in doing social science research. He pointed out:

[C]ase studies are the preferred strategy when ‘how’ or ‘why’ questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context. (Yin, 2003, p. 1)

Patton (1990) supports case study research, “where one needs to understand some special people, particular problem, or unique situation in great depth” (p. 54). Patton (1990) notes that qualitative methods “typically produce a wealth of detailed information about a much smaller number of people and cases” (p. 14). Because the sample size for this study is small, the information gathered from the weekly logs and interview responses sheds
additional light on the results discussed and provides possible reasons for these results.

Students for this case study were selected on the basis of their target mathematics course performance (successful versus not successful), which was determined by their final grades in the course. They were selected from a voluntary sample of 18 students who took part in the intervention and signed up to be interviewed. Instructors were asked to determine which students were expected to achieve a high level of course success (A/B grade) and low level of course success (C or below grade). Names were placed in two groups representing high success level (A/B grades) or low success level / unsuccessful (C grades or below); four names were drawn from among the high achievers, and another four were drawn from among the low achievers. These students were then contacted and scheduled for a semi-formal interview with an interview expert. A total of 8 students were interviewed, representing a range of viewpoints on their overall experience with the math course and with the CMLL strategy, their perception of the benefits associated with the CMLL strategy, and its impact on their course success and attitude towards math.
The researcher handled multiple tasks simultaneously as data were collected, sorted, tallied, and understood during the data analysis phase. Yin (2003) describes this process as “pattern-matching” when the data are related to some theoretical proposition (p. 26). He then adds that “a reasonable approach is to corroborate interview data with information from other sources” (p. 92). This is because “any finding or conclusion in a case study is likely to be much more convincing and accurate if it is based on several different sources of information, following a corroboratory mode” (Yin, 2003, p. 98).

The case study analysis provides a rich description, through the use of direct quotes from participants, on how the CMLL strategy had impacted them personally, their mathematics course success, their attitude towards mathematics, and perceived benefits of the CMLL.

Furthermore, as Huberman and Miles (1994) suggest, this researcher generated meaning from the qualitative data obtained from the aforementioned documents by noting either patterns and themes, seeing plausibility, clustering, making metaphors, counting, making contrasts/comparisons, partitioning variables, subsuming particulars into general, factoring, noting relations between and among variables, finding intervening variables, building a logical chain of
evidence, and/or making conceptual/theoretical coherence. From this analysis, this researcher answered the research questions when making and interpreting findings at different levels of inference. The qualitative data were not summarized with the descriptive statistics, and where statistical significance was found as appropriate.

The primary data collected for this qualitative portion of the data were the participants’ responses to the weekly log during the nine-week intervention and their responses to the interview questions. Interviewer notes and transcripts were all verified from the taped interviews transcribed by a trained clerical staff. Support from a colleague (trained in clerical matters) was solicited for the data entry and coding. One of the dissertation committee member and a colleague also provided support and additional perspective in sorting the data and organizing the final codes.

Miles and Huberman (1994) offer a three-piece definition of data analysis, with each part running concurrent with the others: data reduction, data display, and conclusion drawing/verification (p. 10). This study employed data coding by hand, supplemented by an impartial coding of the data by a colleague not involved with the study and whose help was solicited for this purpose.
The interview lasted 15-20 minutes for each student. Students were asked to further explicate their attitudes toward mathematics, attitudes toward the CMLL strategy, and perception of benefits of the strategy. The interviews, conducted by an interview expert, were informal conversations which provided students with opportunities to explain their written answers as well as to orally express their feelings about how the CMLL writing affected their mathematics course success and attitudes.

Data Analyses

Document Analysis

For the study, this researcher attempted to answer the associated research questions with a combination of analyses applied to a variety of document and interview data sources. For each of the research questions, this researcher has provided the sources of data, the nature of the data, and the methods of data analyses that were utilized as an attempt to respond to or address the research questions as previously referred to in Figure 3.1 (Summary of Data Sources for Research Questions) and Figure 3.4 (Summary of Quantitative & Qualitative Data Sources).
Interview Analysis

Completed routine and non-routine problems, if given, can be analyzed with the scoring rubric (analytic scale for problem solving) described earlier. When appropriate, descriptive statistics of frequency, percentages, means, and standard deviations can be used to summarize the data. The students' descriptions of solving the problems and their attitude data were analyzed via the method of analyzing qualitative data described earlier in this proposal by Huberman and Miles (1994). An appropriate case analysis was applied noting patterns and common themes from student responses. Again, descriptive statistics of frequency, percentages, means, and standard deviations were used to summarize the quantitative data. Finally, an appropriate statistical test was made as appropriate.

Methods of Verification

"All research is concerned with producing valid and reliable knowledge in an ethical manner" (Merriam, 1998, p. 198). Since this study was founded upon both qualitative and quantitative methodologies, it is critical that these issues be addressed. Moreover, both reliability and validity are essential to any research procedure design and measurements. For this reason, the researcher attempted to
discuss the validity and reliability issues pertinent to
the design of this research and instrumentation/materials
utilized for data collection.

Validity and reliability are known to be essential to
measurements and research procedure designs. These two
concepts are distinct yet related. As clarified on the
University of Wisconsin-Stout’s website (2006, para. 1):

While high reliability does not warrant validity, a
study cannot achieve validity without reliability. Validity refers to how close to the truth are the
conclusions made based on the measurement while
reliability refers to the consistency of the measurement
or instrument used.

Construct Validity

Multiple sources of evidence were collected on site
(documents, interviews) and provided the sources for both
triangulation and construct validity. Construct validity
is the recognition of ideas or constructs that exist rather
than imposing theories or ideas on informants (Lather,
1986). Whenever possible, the researcher provided the
respondents with an opportunity to review the final
document (face validity and construct validity), which also
allowed an opportunity for the respondents to make
additional comments on the work (catalytic validity).
Catalytic validity refers to the degree to which the
research process "re-orients, focuses, and energizes
participants to know reality in order to better transform it" (Lather, 1986, p. 67). This is important if the research is to affect change in practice since it is the participants who were the catalysts for such change. Specifically, when respondents participate in the study and examine their own thinking as evidenced in their answers to questions, their comments and reactions will provide catalytic validity. This technique is called members check, and is considered to be "the most critical technique for establishing credibility" (Lather, 1986, p. 314).

Construct validity refers to the extent that a case study as utilized in this investigation "can be shown to measure a particular hypothetical construct" (Gall, Gall, & Borg, 1999). Yin (1994) advises that a researcher must establish "correct operational measures for the concepts being studied" (p. 33). What this means is that the researcher must clearly identify and articulate those phenomena intended for investigation during the research. For this study, the concepts to be investigated were the mathematics course success, problem-solving performance, and attitudes toward mathematics and CMLL. These were derived from the following instruments: course final grade, CMAS, CMLL entries, MPST, MSAI, and semi-structured interviews. This researcher relied on multiple data
collection techniques and triangulation of data to heighten the case study’s construct validity.

Internal Validity

"Internal validity deals with the question of how research findings match reality" (Merriam, 1998, p. 201). Merriam (1998) offers several strategies that will enhance the internal validity of a descriptive case study. Triangulation requires the use of "multiple investigators, multiple sources of data, or multiple methods to confirm the emerging findings" (p. 204). "Triangulation has been generally considered a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation" (Stake, 2000). The study relied on multiple sources of data and multiple methods to confirm the findings. Internal validity was enhanced by combining a traditional pre-test/post-test research design with qualitative methodology.

External Validity

This study was a description of a specific group of individuals (i.e., two instructors and four separate classrooms/sections of students) at a particular point in time. Thus, the generalizability is limited in that the
results that were generated from this study are valid for the group of individuals that were described in the immediate study.

Reliability

"Reliability is the degree to which the results of a measurement accurately represent the true "magnitude" or "quality" of a construct" (Tashakkori & Teddlie, 1998, p. 82). Tashakkori and Teddlie (1998) identified two assumptions that underpin the reliability of a measurement. First, "if a measurement is accurate, it should be repeatable over time or obtainable with an identical method of measurement (e.g., a parallel test, a second observer)" (p. 83). This, they added, is "simply a type of triangulation of measurement simultaneously with two or more identical methods in the same group or situation, or with the same method on more than one occasion" (p. 3). The reliability of the data collected during this study was assured through the triangulation of a variety of data sources whenever possible. In addition, there was no interaction between this researcher and the instructors or their students for the duration of the course. Moreover, Cronbach’s Alpha was used to assess the reliability of instruments (MSAI and CMAS) utilized in this study.
Ethical Considerations

Researchers are always faced with a challenge when doing a study where human subjects are concerned. As Lincoln and Guba (1985) pointed out, "difficulties in protecting anonymity and confidentiality will continue to plague the writer" (p. 369). Moreover, "Ethics has to do with how one treats those individuals with whom one interacts and is involved, and how the relationships formed may depart from some conception of the ideal" (Smith, 1990, p. 260). Smith (1990) continued, "At a common sense level, caring, fairness, openness, and truth seem to be the important values undergirding the relationships and the activities of inquiry" (p. 260).

To ensure that such concerns were addressed, all participants were asked to take part in this study voluntarily. Each student for this study was given an explanation of the purpose of the study and what was expected of them; approximate amount of time that was required of them; possible ways that their input were used, and possible risks involved in the research. They were also afforded the opportunity to ask questions that addressed any of their concerns more fully. It was
explained that pseudonyms or initials were used in place of real names and for the college.

Because the researcher already has a personal and a collegial relationship with the mathematics instructors who were involved in the study, the researcher faced a dilemma, i.e. being careful not to antagonize nor favor anyone. The researcher did attempt to "create and maintain an atmosphere in which the respondent felt that he [or she] is fully understood and in which it is safe to communicate fully without fear of being judged, criticized, or subsequently identified and disadvantaged" (Cannell & Kahn, 1969, p. 581). It was, therefore, important that the research study did not jeopardize collegial relationships already in place.

Summary

The techniques that were utilized for this study were designed to determine the impact of cognitive monitoring learning log on college students’ developmental mathematics course success, problem-solving performance, and attitudes.

Using a pre-test/post-test control group design for the study, the researcher endeavored to examine data that were collected from four sections of a pre-algebra course; two of which were assigned to receive the CMLL
intervention. Data sources included testing, surveys, student self-report, and interviews. Descriptive statistics of frequency, percentages, means, and standard deviations were used to summarize the data. Data analysis using analysis of variance (ANOVA) and t-tests for two independent samples or paired samples were utilized, along with appropriate case analysis.
CHAPTER 4

RESULTS

Overview

This chapter presents the results of the study based on the statistical analyses performed on the data collected in this study as well as additional case study analysis. Multi-source data were gathered at various times during the nine-week intervention. The data sources included final grades as a measure of mathematics course success or achievement, post-intervention interviews, weekly cognitive-monitoring learning log (CMLL) responses, and pre- and post-responses from the following: Mathematics Problem Solving Test (MPST), the modified Mathematics and Science Attitude Inventory (MSAI), and the Cognitive Monitoring Learning Log Attitude Survey (CMAS). The statistical analyses used to answer the first four research questions in this study are a combination of or one of the following: descriptive statistics, independent / paired samples t-tests, and two-way analysis of variance (ANOVA). All statistical analyses in this study used a significance level of 0.05. The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 16.0. Insights from these results will be utilized to explore and understand issues related to the fifth research
Research Questions

The purpose of this study was to examine the impact of the cognitive-monitoring learning log (CMLL) strategy on students’ mathematics course success, problem-solving performance, and attitudes towards mathematics and CMLL. The research questions used to guide this investigation were as follows:

1. What differences in mathematics course success exist between those students who participate in the CMLL intervention and those who do not participate in the intervention?

2. What differences in problem-solving performance exist between those students who participate in the CMLL intervention and those who do not participate in the intervention?

3. What differential changes in attitudes towards mathematics exist between those students who participate in the CMLL intervention and those who do not participate in the intervention?
4. What differential changes in attitudes towards CMLL are reported by students who participate in the CMLL intervention?

5. What were the students’ perceptions of the CMLL strategy in the developmental mathematics course?

Limitations and Delimitations

Various factors may very well have placed limitations on the design of this study (called threats to internal validity). Wiersma (2000) enumerated several threats to validity in his book, Research Methods in Education, some of which are included here and are as follows:

1. Testing (Mathematics Exam and Surveys) -- the content of the pre-MPST and pre-attitude surveys may have given students an indication that the same, if not similar, type will be given for the post-MPST and post-attitude surveys. Also, a single session is desirable to administer each individual instrument. However, this was not made possible since students were from various sections of the course that met at various times so that differences in testing conditions may have been encountered. One-time test administration is a limitation as students do not have the opportunity to show improvement from special circumstances that may have affected their responses at the
time the tests and surveys were taken. Moreover, as with any surveys or self-reports, one can only assume that students responded honestly to the questions posed in the MSAI and CMAS surveys. Accuracy of student responses had not been validated.

2. Instrumentation -- two instructors administered the tests and surveys; one can only hope that they both have given the same set of instructions and procedures, along with the same amount of time for completion of the tests and surveys. Also, the instruments used for this study do not test all of mathematics problem solving at a specific developmental level. The surveys utilized focused on the areas deemed appropriate for this study.

3. Attrition -- there were students who may have taken the pre-measures, but only some or not any of the post-measures, or vice-versa; these students may have been different from those who stayed throughout in terms of persistence or motivation (or lack thereof), but the same can be said of the other students who have chosen not to take the course at the time the study was undertaken. Nevertheless, the missing data may have impacted the power of statistical analysis for this study.

4. Selection-maturation interaction -- students self-selected the course section offered at the College at the
time the study was undertaken; their age ranged from 18-50 years; there was no strict random assignment of participants to control or intervention groups.

5. Selection effect – the eight students interviewed for this study were selected from a voluntary sample of eighteen students who took part in the intervention and signed up to be interviewed; as such, they may represent members of a polarized group, such as those who are more highly motivated or who have a personal agenda in doing so.

The generalizability (delimitations) of the study is also impacted by external validity issues that include the following:

1. This study was conducted among college students taking one of the four levels of developmental mathematics courses (pre-algebra) offered at a community college in the northeastern part of the United States during the spring term of 2007. The participants neither represent students in any other level of developmental math nor do they represent those in the upper level or college level math.

2. The students who chose to participate in the study likely differ from non-participants, in that they may be reacting to the intervention because of its innovation or uniqueness and not as a resolve (intervention) to help them...
in improve their performance in the course; thus, this limits the conclusion that can be drawn from this study.

Demographic Information

There were 78 college student participants in this study, and two instructors each assigned to teach two of the four sections of a developmental mathematics course (pre-algebra). Each instructor was randomly assigned a section as the control group, and another as the intervention group. Instructor 1 had 16 students for the control group (T1-C), 19 for the intervention group (T1-I). Instructor 2 had 20 students for the control group (T2-C), 23 for the intervention group (T2-I). Upon review of the data collected, it was found that some participants did not have pre- and/or post-scores for various measures; some only have the pre-MPST scores, for example, while others only have the post-MPST scores (see Table 4.1).

Rationale for Combining Groups

For more statistical power, this researcher decided to see if results for the two control groups and the two intervention groups could be combined. A two-way analysis of variance (ANOVA) was carried out to see if there was a difference in course grades between the two control groups,
between the two intervention groups, or whether or not either of the differences depended on the other factor.

Table 4.1 Frequency Count and Percentage of Participants with Pre-Post Scores

<table>
<thead>
<tr>
<th>Groups</th>
<th># with pre and post measures</th>
<th>Percent</th>
<th># with missing pre or post measures</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-I (n=19)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MPST</td>
<td>12</td>
<td>63.16</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>MSAI</td>
<td>14</td>
<td>73.68</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>CMAS</td>
<td>13</td>
<td>68.42</td>
<td>6</td>
</tr>
<tr>
<td>T2-I (n=23)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MPST</td>
<td>11</td>
<td>47.83</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>MSAI</td>
<td>15</td>
<td>65.22</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>CMAS</td>
<td>13</td>
<td>56.52</td>
<td>10</td>
</tr>
<tr>
<td>T1-C (n=16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MPST</td>
<td>10</td>
<td>62.50</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>MSAI</td>
<td>10</td>
<td>62.50</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>CMAS</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>T2-C (n=20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MPST</td>
<td>12</td>
<td>60.00</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>MSAI</td>
<td>8</td>
<td>40.00</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>CMAS</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

* Participants in the control group were not given the post-CMAS measure

The first independent variable, instructor, has two levels: Instructor 1 and Instructor 2. The second independent variable, CMLL participation, also has two levels: Intervention and Control Group. Course final grades are referred to in this study as mathematics course success, which ranged from 0.0 (F/W grade) to 4.0 (A grade) on a 4.0-scale. Table 4.2 displays means, standard deviations, and sample sizes of the data collected for all participants in terms of math success. Table 4.3 displays a summary of
significance for the variables of instructor and CMLL participation for the analysis of variance.

Table 4.2 Means, Standard Deviations, and Sample Size for Instructor’s and CMLL Intervention Groups’ Final Grades (Course Success)

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention Group (T1-I)</td>
<td>2.474</td>
<td>1.467</td>
<td>19</td>
</tr>
<tr>
<td>Control Group (T1-C)</td>
<td>2.062</td>
<td>1.389</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>2.286</td>
<td>1.426</td>
<td>35</td>
</tr>
<tr>
<td>Instructor 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention Group (T2-I)</td>
<td>2.044</td>
<td>1.665</td>
<td>23</td>
</tr>
<tr>
<td>Control Group (T2-C)</td>
<td>1.500</td>
<td>1.357</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>1.791</td>
<td>1.536</td>
<td>43</td>
</tr>
<tr>
<td>Total</td>
<td>2.238</td>
<td>1.574</td>
<td>42</td>
</tr>
<tr>
<td>Intervention Group</td>
<td>1.750</td>
<td>1.381</td>
<td>36</td>
</tr>
<tr>
<td>Control Group</td>
<td>2.013</td>
<td>1.499</td>
<td>78</td>
</tr>
</tbody>
</table>

Table 4.3 Analysis of Variance Summary for Course Success Based on Final Grades for Instructor and Participation in CMLL Intervention

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>4.724</td>
<td>1</td>
<td>4.724</td>
<td>2.136</td>
<td>.148</td>
<td>.028</td>
</tr>
<tr>
<td>I-C Group</td>
<td>4.369</td>
<td>1</td>
<td>4.369</td>
<td>1.976</td>
<td>.164</td>
<td>.026</td>
</tr>
<tr>
<td>Instructor x I-C Group</td>
<td>.084</td>
<td>1</td>
<td>.084</td>
<td>.038</td>
<td>.846</td>
<td>.001</td>
</tr>
<tr>
<td>Error</td>
<td>163.631</td>
<td>74</td>
<td>2.211</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From Table 4.3, it is evident that there is no significant main effect for instructor with p = .148, no significant main effect for CMLL participation (intervention vs. control) with p = .164, and no significant interaction with p = .846. Since the ANOVA results...
are not significant, there is reason to believe that the
groups are not different (at least, not different enough to
produce a significant effect in this analysis). Therefore,
scores for the two sections of intervention groups were
combined to create one intervention group for further
statistical analyses and scores for the two sections of
control groups were combined to create one control group
for further statistical analyses. Moreover, and as
presented in Chapter 3, reasons for combining the groups
include both instructors’ status as full-time tenure-track
faculty, each with over ten years of teaching experience;
adherence to similar course syllabi and books utilized for
the course; and assignment to teach two or more sections of
the course level investigated in this study.

Reliability of Surveys

The revised mathematics and science attitude inventory
(MSAI) and cognitive-monitoring learning log attitude
survey (CMAS) were tested for reliability (internal
consistency) on each of the two administrations of the
surveys using Cronbach’s alpha (Cronbach, 1951).
Cronbach’s alpha was found to be .903 for the pre-MSAI and
.911 for the post-MSAI. It was .911 for the combined MSAI
pre- and post-measures. Cronbach’s alpha was found to be
.856 for the pre-CMAS and .915 for the post-CMAS. It was .876 for the combined CMAS pre-post measures. A Cronbach’s alpha level of, at least, .8 is considered to be the lowest acceptable level; anything higher indicates a high degree of internal consistency for group analyses.

Data Results Ensuing from the Research Questions

Results will be presented by enumerating each of the research questions and the data analysis that follows. Research questions one through four will be presented under the heading, “Quantitative Analysis,” while research question 5 will be addressed under “Qualitative Analysis.”

Quantitative Analysis

Quantitative data results ensuing from the research questions as indicated are as follows:

1. What differences in mathematics course success exist between those students who participated in the CMLL intervention and those who did not participate in the intervention?

An independent samples t-test was carried out to see if there was a difference in mathematics course success (based on final grades) between the grouping variables, intervention and control groups. The test variable was final grades (referred to in this study as mathematics course success or achievement, which ranged from 0.0 to
4.0, with quality points assigned to grades as follows: F/W=0, D=1.0, C=2.0, B=3.0, A=4.0).

Table 4.4 displays means, standard deviations, and sample sizes of the data collected for all participants in terms of mathematics course success (based on final grades). Table 4.5 displays a summary of significance for the variable of mathematics course success (final grades), based on CMLL participation (intervention versus control).

The mean for the intervention group’s final grades ($M=2.238$, $SD=1.574$) is notably higher than that of the control group’s final grades ($M=1.750$, $SD=1.381$) (see Table 4.4). However, the t-test result for math success [$t(76) = 1.444, \ p = .153$ (two-tailed), $p = .076$ (one-tailed)] indicate differences among the intervention and control groups are not statistically significant ($p > .05$). Thus, no significance in terms of mathematics course success was found between those in the intervention group and the control group among all participants’ final course grades.

Table 4.4 Means, Standard Deviations, and Sample Sizes for Course Success (Final Grades) of All Participants (Intervention vs. Control)

<table>
<thead>
<tr>
<th>Final Grade</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention Group</td>
<td>2.238</td>
<td>1.574</td>
<td>42</td>
</tr>
<tr>
<td>Control Group</td>
<td>1.750</td>
<td>1.381</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>2.013</td>
<td>1.499</td>
<td>78</td>
</tr>
</tbody>
</table>
Table 4.5 Independent Samples Summary for Course Success (Final Grades) for All Participants (Intervention vs. Control), n=78

<table>
<thead>
<tr>
<th>Source</th>
<th>F</th>
<th>Sig.</th>
<th>T</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Grade</td>
<td>1.183</td>
<td>.280</td>
<td>1.444</td>
<td>76</td>
<td>.153</td>
<td>.48810</td>
<td>.33806</td>
</tr>
</tbody>
</table>

Since it is reasonable to assume that the intervention group will score higher based on final grades than the control group (making the case for a directional hypothesis/one-tailed evaluation versus non-directional hypothesis/two-tailed evaluation), half the value for the significance level obtained (from two-tailed test) in Table 4.5 is taken (from p=.153), resulting to p = .076, a marginally significant difference based on grades. Because of this or the fact that the main effect of CMLL participation (intervention vs. control) was marginally close to being significant, this researcher decided to do a focused analysis by analyzing the benefit of the CMLL intervention. In addition to comparing the intervention versus control group, a comparison was made on the number of logs that were written and submitted by participants.

It was decided to introduce another grouping variable; i.e., those who responded and submitted five to nine (5-9) weekly logs versus those who responded and submitted four (4) weekly logs or less or none at all. A one-way ANOVA
was conducted to determine the main effect of log writing by looking at the difference in mathematics course success between the grouping variable, 5-9 CMLLs and 0-4 CMLLs groups. The results are shown in Tables 4.6 and 4.7. The test variable again is final grades (referred to in this study as course success or achievement).

Table 4.6 displays means, standard deviations, and sample sizes of the data collected for all participants in terms of mathematics course success. Table 4.7 displays a summary of significance on final grades, based on CMLL logs written and submitted (5-9 CMLLs versus 0-4 CMLLs).

Those who wrote and submitted 5-9 weekly logs outperformed those who wrote and submitted 0-4 logs. The mean for the 5-9 CMLLs group’s final grades (M=2.818, SD=1.259) was notably higher than that of the 0-4 CMLLs group’s final grades (M=1.696, SD=1.476). The ANOVA result indicates that the main effect of log writing, F(1, 41) = 7.225, p = .010 is significant, p < .05. Thus, significant difference in terms of mathematics course success was found between those who had 5-9 weekly logs (and engaged in the CMLL strategy) and those who had 0-4 weekly logs (or rarely engaged in the CMLL strategy) during the nine-week intervention.
Table 4.6 Means, Standard Deviations, and Sample Sizes for Course Success (Final Grades) for All Participants (5-9 CMLLs vs. 0-4 CMLLs)

<table>
<thead>
<tr>
<th>Groups</th>
<th># CMLLs</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-9 CMLLs</td>
<td></td>
<td>2.818</td>
<td>1.259</td>
<td>22</td>
</tr>
<tr>
<td>0-4 CMLLs</td>
<td></td>
<td>1.600</td>
<td>1.667</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2.238</td>
<td>1.574</td>
<td>42</td>
</tr>
<tr>
<td>Control Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-4 CMLLs</td>
<td></td>
<td>1.750</td>
<td>1.381</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1.750</td>
<td>1.381</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-9 CMLLs</td>
<td></td>
<td>2.818</td>
<td>1.259</td>
<td>22</td>
</tr>
<tr>
<td>0-4 CMLLs</td>
<td></td>
<td>1.696</td>
<td>1.476</td>
<td>56</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2.013</td>
<td>1.499</td>
<td>78</td>
</tr>
</tbody>
</table>

Table 4.7 One-Way ANOVA Summary for Final Grades for Participants in the Intervention Group (5-9 CMLLs vs. 0-4 CMLLs), n=42

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>15.546</td>
<td>1</td>
<td>15.546</td>
<td>7.225</td>
<td>.010</td>
<td>.011</td>
</tr>
<tr>
<td>Within Groups</td>
<td>86.073</td>
<td>40</td>
<td>2.152</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>101.619</td>
<td>41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Upon further analysis, a two-way ANOVA was conducted to (1) replicate the effect and (2) to determine if the effect might depend on which instructor was involved. As shown in Table 4.8, the instructor did not make a difference since the main effect yields \( p = .365 \) \( (p > .05) \), and the interaction effect also yields \( p = .757 \) \( (p > .05) \). Moreover, with this analysis the main effect of control versus intervention yields \( p = .004 \), with eta squared = .11. This suggests that the improvement in predicting a
student’s final grade based on knowing which group he or she belonged to would be about 11%.

Table 4.8 Analysis of Variance Summary for Course Success for Instructor and Participation in CMLL Intervention (5-9 CMLLs vs. 0-4 CMLLs)

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>1.684</td>
<td>1</td>
<td>1.684</td>
<td>.830</td>
<td>.365</td>
<td>.011</td>
</tr>
<tr>
<td>CMLL Interv (5-9 vs. 0-4)</td>
<td>17.895</td>
<td>1</td>
<td>17.895</td>
<td>8.815</td>
<td>.004</td>
<td>.106</td>
</tr>
<tr>
<td>Instructor x CMLL Interv</td>
<td>.196</td>
<td>1</td>
<td>.196</td>
<td>.097</td>
<td>.757</td>
<td>.001</td>
</tr>
<tr>
<td>Error</td>
<td>150.216</td>
<td>74</td>
<td>2.030</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results, however, are inconclusive. Despite the various analyses noting statistical significant difference between those who wrote more logs versus those who wrote less in terms of mathematics course success, no statistical significant difference was found between those who participated in the intervention and those who did not.

2. What differences in problem solving performance exist between those students who participated in the CMLL intervention and those who did not participate in the intervention?

Problem-solving performance was measured using the Mathematics Problem Solving Test (MPST). MPST scores ranged from a low of 0 to a high of 12. Out of 78 participants, 63 completed the pre-MPST, 48 completed the post-MPST, and 45 completed both the pre and post tests (see Table 4.9, upper).
Based on a two-way ANOVA (repeated measures) for those with both pre-MPST and post-MPST scores (see Table 4.9—lower part, and Table 4.10), the intervention group’s scores increased from $M = 4.04$ (pre-test) to $M = 8.00$ (post-test). The control group’s scores increased from $M = 2.73$ (pre-test) to $M = 7.55$ (post-test). This suggests that the intervention group started out somewhat higher than the control group, and they stayed somewhat higher than the control group at the end. However, the gap between the two groups narrowed a bit. The main effect of phase (pre versus post) was significant, $F(1,43) = 98.427$, $p = .001$, eta squared = .70. This means that, overall, the two groups improved from pre to post, with about 70% improvement in predicting a student’s result if one knows which phase is being considered (pre versus post). Furthermore, the probability that this is a chance occurrence is < .001. Second, the overall difference between the control and intervention groups was not significant, $F(1,43) = 1.574$, $p = .216$. Third, the significant improvement from pre- to post-measure did not depend on which group one is considering, since the interaction between these two factors is also not significant, $F(1,43) = .949$, $p = .335$. Therefore, both groups (control and intervention) improved in basically the
same way. Therefore, no statistical significance in terms of mathematics problem solving performance was found between those in the intervention and the control group.

Table 4.9 Means, Standard Deviations, and Sample Size for Participants with Pre-Post Mathematics Problem Solving Test (MPST) Scores

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-MPST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention Group</td>
<td>3.6765</td>
<td>2.42113</td>
<td>34</td>
</tr>
<tr>
<td>Control Group</td>
<td>2.7241</td>
<td>2.64435</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>3.2381</td>
<td>2.55087</td>
<td>63</td>
</tr>
<tr>
<td>Post-MPST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention Group</td>
<td>7.7600</td>
<td>2.57034</td>
<td>25</td>
</tr>
<tr>
<td>Control Group</td>
<td>7.6957</td>
<td>3.08125</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>7.7292</td>
<td>2.79619</td>
<td>48</td>
</tr>
<tr>
<td>Net MPST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention Group</td>
<td>3.9565</td>
<td>2.38324</td>
<td>23</td>
</tr>
<tr>
<td>Control Group</td>
<td>4.8182</td>
<td>3.47284</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>4.3778</td>
<td>2.96409</td>
<td>45</td>
</tr>
</tbody>
</table>

| With pre and post    |        |                    |             |
| Pre-MPST             |        |                    |             |
| Intervention Group   | 4.0435 | 2.70485            | 22          |
| Control Group        | 2.7273 | 2.84825            | 23          |
| Total                | 3.4000 | 2.82360            | 45          |
| Post-MPST            |        |                    |             |
| Intervention Group   | 8.0000 | 2.54058            | 22          |
| Control Group        | 7.5455 | 3.06637            | 23          |
| Total                | 7.7778 | 2.78706            | 45          |

Table 4.10 Two-Way ANOVA Repeated Measures Summary for Pre- and Post-MPST for Participants (Intervention vs. Control), n=45

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase (pre-post)</td>
<td>432.885</td>
<td>1</td>
<td>432.885</td>
<td>98.427</td>
<td>.000</td>
<td>.696</td>
</tr>
<tr>
<td>I-C Groups</td>
<td>17.629</td>
<td>1</td>
<td>17.629</td>
<td>1.574</td>
<td>.216</td>
<td>.035</td>
</tr>
<tr>
<td>Phase x I-C Group</td>
<td>4.174</td>
<td>1</td>
<td>4.174</td>
<td>.949</td>
<td>.335</td>
<td>.159</td>
</tr>
<tr>
<td>Error</td>
<td>189.115</td>
<td>43</td>
<td>4.398</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. What differential changes in student attitudes towards mathematics exist between those students who participated in the CMLL intervention and those who did not participate in the intervention?

Mathematics attitude scores were measured using the modified *Mathematics and Science Attitude Inventory* (MSAI). Attitude scores for the MSAI ranged from a low of 15 to a high of 105 for the pre-MSAI, a low of 43 to a high of 106 for the post-MSAI, and from a loss of 38 to a gain of 18 for the net MSAI score (obtained by subtracting the pre-score from the post-score). Out of 78 participants, 62 completed the pre-MSAI, 50 completed the post-MSAI, and 46 completed both the pre- and post-MSAI (see Table 4.11). Higher score in the MSAI indicates a more positive or favorable attitude towards math.

Based on a two-way ANOVA (repeated measures) for those with both pre-MSAI and post-MSAI scores (see Table 4.11-lower part, and Table 4.12), the intervention group’s score actually increased, from $M = 79.42$ (pre-test) to $M = 81.21$ (post-test). However, the control group’s score decreased from $M = 84.33$ (pre-test) to $M = 71.28$ (post-test). This suggests an interaction between the two factors since improvement depended on which group is being considered. The interaction is significant as seen in Table 4.12.
Table 4.11 Means, Standard Deviations, and Sample Size for Participants with Pre-Post Mathematics Attitude Inventory (MSAI) Scores

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-MSAI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>77.800</td>
<td>16.7293</td>
<td>35</td>
</tr>
<tr>
<td>Control</td>
<td>81.296</td>
<td>13.0054</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>79.323</td>
<td>16.7293</td>
<td>62</td>
</tr>
<tr>
<td><strong>Post-MSAI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>82.467</td>
<td>13.6375</td>
<td>30</td>
</tr>
<tr>
<td>Control</td>
<td>73.300</td>
<td>12.4059</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>78.800</td>
<td>13.7959</td>
<td>50</td>
</tr>
<tr>
<td><strong>Net MSAI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>5.103</td>
<td>20.0541</td>
<td>29</td>
</tr>
<tr>
<td>Control</td>
<td>-13.056</td>
<td>14.8065</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>-1.851</td>
<td>20.1354</td>
<td>47</td>
</tr>
</tbody>
</table>

With pre and post

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-MSAI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention Group</td>
<td>79.4286</td>
<td>12.64451</td>
<td>29</td>
</tr>
<tr>
<td>Control Group</td>
<td>84.333</td>
<td>12.06843</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>81.3478</td>
<td>12.52237</td>
<td>47</td>
</tr>
<tr>
<td><strong>Post-MSAI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention Group</td>
<td>81.2143</td>
<td>13.23116</td>
<td>29</td>
</tr>
<tr>
<td>Control Group</td>
<td>71.2778</td>
<td>10.19692</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>77.3261</td>
<td>12.97528</td>
<td>47</td>
</tr>
</tbody>
</table>

Table 4.12 Two-Way ANOVA Repeated Measures Summary for Pre- and Post-MSAI for Participants (Intervention vs. Control), n=46

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
<th>Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase (pre-post)</td>
<td>695.790</td>
<td>1</td>
<td>695.790</td>
<td>10.121</td>
<td>.003</td>
<td>.187</td>
</tr>
<tr>
<td>I-C Groups</td>
<td>138.701</td>
<td>1</td>
<td>138.701</td>
<td>.595</td>
<td>.445</td>
<td>.013</td>
</tr>
<tr>
<td>Phase x I-C Group</td>
<td>1206.660</td>
<td>1</td>
<td>1206.660</td>
<td>17.552</td>
<td>.000</td>
<td>.285</td>
</tr>
<tr>
<td>Error</td>
<td>3024.829</td>
<td>45</td>
<td>68.746</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

First, the main effect of the intervention phase (pre versus post) is significant, F(1,45) = 10.12, p = .003, eta squared = .19, with about 19% improvement in predicting a student's result depending on the phase being considered.
(pre versus post). Second, the main effect of group (control versus intervention) is not significant, \( F(1,45) = .595, p = .445 \). The control group averaged about 78 for the 2 phases and the intervention group averaged about 80 for the 2 phases. Thus, the resulting effect is not significant. However, there is a significant interaction between the two factors, \( F(1,45) = 17.55, p = .001 \), \( \eta^2 \) squared = .29. This means that whether or not a group improved from pre to post depended on which group is being considered. The control group’s score went down and the intervention group’s score went up.

The significant difference in the scores in terms of students’ attitudes towards math clearly shows that the change in attitudes was statistically different for the two groups. Students in the intervention group scored significantly greater than students in the control group on the MSAI post-measure and their net scores.

4. What differential changes in attitudes towards CMLL are reported by students who participated in the CMLL intervention?

Cognitive monitoring learning log (CMLL) attitude scores were measured using the CMLL attitude survey (CMAS). Attitude scores ranged from a low of 33 to a high of 86 for the pre-CMAS, a low of 27 to a high of 83 for the post-CMAS,
and from a loss of 33 to a gain of 20 for the net CMAS score (obtained by subtracting the pre-score from the post-score). Out of 78 participants, 56 completed the pre-CMAS. The post-CMAS scores for the control group cannot be obtained as this group was not given the post measure; 30 participants from the intervention group completed the post-CMAS, and 26 completed both the pre-post measures (see Table 4.13).

Based on a paired samples t-test conducted to compare the pre-CMAS scores with that of the post-CMAS scores (n = 26), the intervention group did not improve on their CMLL attitudes from pre-CMAS $M = 59.615$ ($SD = 11.229$) to post-CMAS $M = 58.923$ ($SD = 12.923$), and the difference was not significant, $t(25) = -.295$, $p = .771$ (see Table 4.14). Therefore, no statistically significant change in attitude towards CMLL can be reported.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-CMAS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>59.467</td>
<td>10.8365</td>
<td>30</td>
</tr>
<tr>
<td>Control</td>
<td>62.115</td>
<td>10.3318</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>60.696</td>
<td>10.5932</td>
<td>56</td>
</tr>
<tr>
<td><strong>Post-CMAS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>59.867</td>
<td>12.902</td>
<td>30</td>
</tr>
<tr>
<td>Control</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>59.867</td>
<td>12.902</td>
<td>30</td>
</tr>
<tr>
<td><strong>Net CMAS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>-.693</td>
<td>11.986</td>
<td>26</td>
</tr>
<tr>
<td>Control</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>-.693</td>
<td>11.986</td>
<td>26</td>
</tr>
</tbody>
</table>
Table 4.14 Paired Samples Test Summary for Net CMLL Scores
(Intervention only), n=26

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>SEM</th>
<th>T</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-CMAS</td>
<td>58.923</td>
<td>12.9242</td>
<td>2.53464</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-CMAS</td>
<td>59.615</td>
<td>11.2288</td>
<td>2.20215</td>
<td>-.295</td>
<td>25</td>
<td>.771</td>
</tr>
<tr>
<td>Net CMAS</td>
<td>-.6923</td>
<td>11.9859</td>
<td>2.35063</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Case Study Analysis

A case analysis was also conducted to determine what students thought of the CMLL intervention. While the intervention group's net CMAS mean score in terms of their attitude was evidently negative (Mean=-.693, SD=11.986), a closer look at student responses from those interviewed reveal that a majority benefited from and found the CMLL strategy useful.

Commander and Smith (1996) point out that the primary goal of the learning log is “to give learners the opportunity to write about, and thus, know about their own learning” (p. 452). In addition, and as presented earlier, statistical significance was found on the difference between those who engaged in the CMLL strategy (by writing more logs) and those who did not, favoring the first in terms of mathematical course success (based on final grades) and better attitudes towards mathematics.
This part of the results section focuses on the case analysis used for this study. A general method of constant comparative analysis originally described by Glaser and Strauss (1967) and advocated by Huberman and Miles (1994) and Yin (2003) with sorting, coding, and determining patterns and common themes from student responses were used to ascertain their perceived benefits of the CMLL strategy.

A total of 8 students were interviewed, representing a range of viewpoints on their overall experience with the math course and with the CMLL strategy, their perception of the benefits associated with the CMLL strategy, and its impact on their course success and attitude towards math. Also to be noted are students’ responses on the weekly log indicating the difficulty, if any, experienced in the math course and what they did about it. Students were clustered together in terms of mathematics course success, those with A/B grades versus those with C grades or less.

The case study analysis provides a rich description, through the use of direct quotes from participants, how the CMLL strategy had impacted them personally, their mathematics course success, and attitude towards mathematics (see Table 4.15). Their weekly CMLL responses are also included here (see Table 4.16). The data essentially tell three basic stories: first, the challenges or difficulty faced by
students in their math course; second, their strategies or approach to resolving said difficulty or challenge; and, third, their perceived benefits of the CMLL strategy. Results are presented using direct quotes focusing on students’ perceptions of the CMLL strategy. Their responses to the weekly log are included as appropriate.

**Qualitative Analysis**

5. What were the students’ perceptions of the CMLL strategy in the developmental mathematics course?

Seven of the eight students interviewed (all except EK – see Table 4.16) had written 5 logs or more. In expressing their experience with the learning log (see Table 4.17), four (KF, JA, DR, AK) noted the strategy as helpful in providing the motivation to do more practice work and get help if needed. Two of these students (KF and JA) belong to the high achievers group (received A/B grades in the course), the other two (DR and AK) belong to the low achievers group (received C grade or less). JA used the strategy for another course (sociology) she found challenging or “wasn’t really too crazy about,” DR thought it helped her “realize her weakness,” while still another (AK) simply stated how she “looked forward to it.”

Two (CZ, JT) did not give an indication as to whether or not it was a positive experience, but one of them (CZ), also belonging to the high achiever group, mentioned that
it helped her “put things in perspective” and “used it more for thinking about more so in other classes” that she struggled with (like philosophy). JT, who is among the low achievers, simply did what she had to do noting she “tried to answer it as best as [she] could and being like honest and everything.” Two (DP, EK) found the experience “pointless” or “not worth the time,” admitting that they were either “not a journal person” or “not really into writing.” EK, who is among the low achievers and said it was “pointless” did note, however, that he found the strategy “in some ways helpful and in other ways it wasn’t.” Meanwhile, DP (in high achievers group) is like JT (in low achievers group) who simply “filled out [the] log” with a “game plan of basically [studying] until I know it.”

Interestingly, when it comes to these students’ perception of the benefits of the strategy (regardless of how they may feel about the writing process), seven of the eight participants interviewed noted the CMLL strategy as beneficial. The strategy was perceived as helpful to either identify the problem or areas where they felt thwarted or frustrated, in taking steps to resolve their problem, and in their thinking process or self-reflection.

Excerpts (verbatim) from participant responses to interview questions are as follows (student initials were used for anonymity; H-high achievers, L-low achievers):
CZ (H1,8 logs written) - “It definitely helps you think about your process a lot. Well, and I’m always one to, that I think, if you have anxiety or whatever, it’s good to kind of write it out.”

KF (H2,9) – “When it asked what is difficult for you right now? I had to stop and think, ok, well I am having a problem with this so what am I going to do? Am I going to do more practice, am I going to ask for more help? [It] helped me to take steps to resolve the problem.”

DP (H3,6) – “For the younger people it would keep it in the forefront. [Y]ou really need to make sure that you understand [math] and that there is a way to understand it and to get it.”

JA (H4,9) – “It helped me identify the problem. [I]t pushed me to get the help that I needed.”

DR (L1,8)– “It just made me realize that I’ve got to study harder if I want to be able to understand [math]. Keep me focused and help me realize my weaknesses and help me to realize that if I want to be able to understand better the problem I was having with complex fractions and equations that I had to either study harder, get tutoring.”

AK (L2,5)– “I think it would have been a little more difficult for me without the log. The benefit was getting the response. The process of writing helped. Another benefit was that if I didn’t understand it and I got the response and still didn’t understand it, I could go to an instructor and show her exactly what was going on and what exactly I needed help with.”

JT (L3,5) – “It made me step back and evaluate myself instead of just going in there, taking a test and then leaving. It was more like seeing, did I understand what I was doing or do I understand what’s going on in class, that type of thing and how to solve it.”

EK (L4,3) – “I used it to show me what parts I need to hit on, like what parts of math were difficult for me so I knew what to study and all that.” (Student also said that he would use these questions and that would tell him where he had to focus his time later on in the evening.)
<table>
<thead>
<tr>
<th>St #</th>
<th>Overall Experience with Math Course</th>
<th>Learning Log Experience</th>
<th>Perceived Benefits of CMLL</th>
<th>CMLL impact on Math Achievement</th>
<th>CMLL impact on Math Attitude</th>
<th>Pre-Eval Score</th>
<th>Post-Eval Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>Oh, it was good. A lot of it I had learned before - I had algebra 1, 2, geometry in high school but I didn't remember any of it. The math teacher was good. She explained things the way the book explained it. In high school I hated algebra. I come here and I think it has a lot to do with being the non-traditional student, but I found it fascinating this time. My interest was peaked.</td>
<td>I don't know that the learning log really helped me understand but it did put it in perspective that what are the things that I'm doing? ... it helped me think about the fact that you know, I'm not doing so bad. My tests are coming back great, I'm doing the homework, I'm doing the reading material. So in that perspective it was good because I was like 'oh this is really easier than I thought it would be.' The [log] questions repeated themselves and other people in the class thought that too ... I used it more for thinking about more so in my other classes. Like philosophy I had and I struggled with that class. I kept thinking about ok, put my effort that I am putting into this math what could I be doing differently? So that did help me a little bit and see like, that was more a class that I was struggling in versus this math. But the philosophy was completely different - it didn't click with me like that.</td>
<td>It definitely helps you think about your process a lot. Well, and I'm always one to, that I think, if you have anxiety or whatever, it's good to kind of write it out. I'm not always a journal user, but I have in many instances and in many cases, like, written letters about frustrating situations. I just always thought about my philosophy and that you know you have to take it one thing at a time, don't look at the whole picture, take it one step at a time and eventually it will sink in.</td>
<td>I don't think [it helped with math.] Just because like I said, the math seemed to zone so much easier for me. There wasn't really any effort into it because I was doing the assignments and things like that. [It helped] with the thinking process of like I said, a reminder to myself of why I'm here, why I need to do the hard work, why it's important for me to go back and look at those problems that I didn't necessarily catch in class. Those were the things that were kind of in my mind as I wrote that. It may not flow but that's because I have the goal of wanting to do well, doing my homework, reviewing the books and test information. The learning logs don't really seem to fit in with the math for me. I don't know to be honest with you.</td>
<td>In a good way. Because, like I said, it helped. For me, it was a little bit of a self-praise. Because I was like, I'm doing good, it's easy and I find that ... like I said, coming into school this year was a very huge adjustment for me, so I was really scared starting classes and to even see the writing that it wasn't as bad as I thought it was going to be and I'm actually doing ok and most of these were easy problems ...</td>
<td>MPST-10</td>
<td>MSAL-83</td>
</tr>
<tr>
<td>C</td>
<td>I've never been a math person. I hate math; however, when I did go to college earlier in my life, it was for accounting. So that kind of numbers I'm fine with but you give me numbers and letters together and my brain goes &quot;nope, can't do it.&quot; But my instructor was very good ... made me feel very relaxed, very comfortable.</td>
<td>[Initially thought] a big waste of my time. But as I had to sit down and really read the question and think, I began to take steps to correct the problem. [provided motivation to practice more or get help]</td>
<td>When it asked what is difficult for you right now? I had to stop and think ok, well I am having a problem with this so what am I going to do? Am I going to do more practice, am I going to ask for more help? ... helped me to take steps to resolve the problem. It's helpful to have to write things down because it helps you to focus on how you're going to solve your problem.</td>
<td>I had to take the time and look at the fact that yeah I do have [difficulty] ... because sometimes like if the teacher asks if anyone has a question, I'm like, no, I'm fine with this, but then when I had to read this and go ok, well is there something I'm having a problem with? And then it was like, yeah, then I could define the problem. We should be able to list how this helped us so that then we would be able to see that &quot;oh, that really wasn't a waste of my time because look what I learned from it.&quot;</td>
<td>I learned that I don't have to be afraid of numbers with letters beside them. I learned that just because it might be more challenging for people like me that it doesn't mean I can't do it. I just have to sit down and figure out a plan for me to learn it. There's a solution to every problem.</td>
<td>MSAL-89</td>
<td>CMAS-59</td>
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<td>Z</td>
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<td>Final - A</td>
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<td>H 3</td>
<td>It was very positive. My teacher was very good. I was very apprehensive when she said she was a high school teacher because I was like, oh no, you know the old high school, scary teacher ... but she had an excellent way of describing simple concepts to the class without making them feel stupid... math is a subject I've been terrified of [but because of her] I'm much less apprehensive to go into my next math class.</td>
<td>I'm not much of a journal person so it really wasn't worth my time to do a learning log. I filled out this log but you kind of feel like you're sending out the same answers. I mean, my game plan was always the same. I would basically study until I knew it, if I don't know it, I'd keep studying.</td>
<td>I think like for the younger people it would keep it in the forefront of... you really need to make sure that you understand it and that there is a way to understand it and to get it... that the college actually cares about the fact that you get it. So, I think for the younger people, because I know these 2 girls who got in like the 70% and they were happy with that and I said, &quot;if you're not getting it, you might want to try reading the book.&quot; My older brain was saying well that's why you're getting 70%... it's probably good for the younger people to keep it, the fact that they need to put some effort into it. I think it's easier for the younger people not to put the effort into it because they don't see the big picture.</td>
<td>It didn't [help with math]. Because my personality is such that I wouldn't be taking that math class if I didn't want to understand math. So, whether I had that log or not it wouldn't have changed anything about the way I accomplished anything. [recommend IF!] there was some way to ask different questions, because it gets redundant. I would say, &quot;is there anything difficult&quot; instead of &quot;what&quot;.</td>
<td>The log shaped my attitude towards the college because I thought that was nice that the college was trying to at least do something to help because the country in general is low in mathematics. [Personally] I had already decided that I have to make good grades, I have to do this if I want to... So there's nothing that that log would have done or not done to dissuade me.</td>
<td>MPST-7</td>
<td>Final - A</td>
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<td>J 4</td>
<td>I found it easier than last semester... I had been out of school for so long it's like I really didn't grasp it and I was like really struggling at first.</td>
<td>I think they're very helpful. I mean, they let you know... I think it's better in writing, you see where you're at so it's like writing like what was the difficulty and what wasn't. It helped me see like in what I needed help and so I was able to get tutoring in. I got into the habit of doing it. I even took it like for my sociology class because that was another class that I wasn't really too crazy about. I wasn't doing bad in it but I really wasn't too crazy about it so I just started writing what I understood and then I would go back and ask my teacher about the things that I didn't understand. I got into a habit of writing things down.</td>
<td>It helped me identify the problem. Well that, I mean it pushed me to get the help that I needed... I used to get tutoring and I made my husband help me and I used to ask more questions when I felt more comfortable asking questions. Because I was able to write my problems down and I guess seeing it in writing, coming from me, I could see where I needed help. So that was helpful.</td>
<td>Because of the questions that it asked, I could see in what area I was lacking and I needed a little more help in.</td>
<td>The log shaped my attitude towards the college because I thought that was nice that the college was trying to at least do something to help because the country in general is low in mathematics. [Personally] I had already decided that I have to make good grades, I have to do this if I want to... So there's nothing that that log would have done or not done to dissuade me.</td>
<td>MSAI-79</td>
<td>CMAS-57</td>
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<td>J 4</td>
<td>I found it easier than last semester... I had been out of school for so long it's like I really didn't grasp it and I was like really struggling at first.</td>
<td>I think they're very helpful. I mean, they let you know... I think it's better in writing, you see where you're at so it's like writing like what was the difficulty and what wasn't. It helped me see like in what I needed help and so I was able to get tutoring in. I got into the habit of doing it. I even took it like for my sociology class because that was another class that I wasn't really too crazy about. I wasn't doing bad in it but I really wasn't too crazy about it so I just started writing what I understood and then I would go back and ask my teacher about the things that I didn't understand. I got into a habit of writing things down.</td>
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<td>Because of the questions that it asked, I could see in what area I was lacking and I needed a little more help in.</td>
<td>The log shaped my attitude towards the college because I thought that was nice that the college was trying to at least do something to help because the country in general is low in mathematics. [Personally] I had already decided that I have to make good grades, I have to do this if I want to... So there's nothing that that log would have done or not done to dissuade me.</td>
<td>MSAI-92</td>
<td>CMAS-86</td>
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<tr>
<td>J 4</td>
<td>I found it easier than last semester... I had been out of school for so long it's like I really didn't grasp it and I was like really struggling at first.</td>
<td>I think they're very helpful. I mean, they let you know... I think it's better in writing, you see where you're at so it's like writing like what was the difficulty and what wasn't. It helped me see like in what I needed help and so I was able to get tutoring in. I got into the habit of doing it. I even took it like for my sociology class because that was another class that I wasn't really too crazy about. I wasn't doing bad in it but I really wasn't too crazy about it so I just started writing what I understood and then I would go back and ask my teacher about the things that I didn't understand. I got into a habit of writing things down.</td>
<td>It helped me identify the problem. Well that, I mean it pushed me to get the help that I needed... I used to get tutoring and I made my husband help me and I used to ask more questions when I felt more comfortable asking questions. Because I was able to write my problems down and I guess seeing it in writing, coming from me, I could see where I needed help. So that was helpful.</td>
<td>Because of the questions that it asked, I could see in what area I was lacking and I needed a little more help in.</td>
<td>The log shaped my attitude towards the college because I thought that was nice that the college was trying to at least do something to help because the country in general is low in mathematics. [Personally] I had already decided that I have to make good grades, I have to do this if I want to... So there's nothing that that log would have done or not done to dissuade me.</td>
<td>MPST-3</td>
<td>Final - A</td>
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<td>J 4</td>
<td>I found it easier than last semester... I had been out of school for so long it's like I really didn't grasp it and I was like really struggling at first.</td>
<td>I think they're very helpful. I mean, they let you know... I think it's better in writing, you see where you're at so it's like writing like what was the difficulty and what wasn't. It helped me see like in what I needed help and so I was able to get tutoring in. I got into the habit of doing it. I even took it like for my sociology class because that was another class that I wasn't really too crazy about. I wasn't doing bad in it but I really wasn't too crazy about it so I just started writing what I understood and then I would go back and ask my teacher about the things that I didn't understand. I got into a habit of writing things down.</td>
<td>It helped me identify the problem. Well that, I mean it pushed me to get the help that I needed... I used to get tutoring and I made my husband help me and I used to ask more questions when I felt more comfortable asking questions. Because I was able to write my problems down and I guess seeing it in writing, coming from me, I could see where I needed help. So that was helpful.</td>
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<td>The log shaped my attitude towards the college because I thought that was nice that the college was trying to at least do something to help because the country in general is low in mathematics. [Personally] I had already decided that I have to make good grades, I have to do this if I want to... So there's nothing that that log would have done or not done to dissuade me.</td>
<td>MSAI-101</td>
<td>CMAS-77</td>
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<td>L 1</td>
<td>The first part of the semester, it was too sad. The first couple of chapters of what we were doing, but after chapter 3 we got to complex fractions and equations and stuff and that's what got a little bit difficult for me, a little bit.</td>
<td>This helped me to realize my weaknesses, where I was in my math, you know what I mean... which was equations and complex fractions.</td>
<td>It just made me realize that I've got to study harder if I want to be able to understand it. Keep me focused and help me realize my weaknesses and help me to realize that if I want to be able to understand better the problem I was having with complex fractions and equations that I had to either study harder, get tutoring. It helped me, encouraged me to work a little bit harder, study a little harder.</td>
<td>It has helped me study better, keep me focused.</td>
<td>It definitely helped me to be more encouraged and appreciate math a little bit more. Math was never my best subject, I always dreaded math and specifically that I had a learning disability in math since I was a little kid so kind of helped me, I can't say enjoy math better, but it made it less stressful.</td>
<td>Final - C</td>
<td>MPST-7</td>
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<td>L 2</td>
<td>It was a little difficult. I was here last semester and I was in a bad car accident and I had to withdraw because I was in a coma for awhile so I couldn't go to school obviously... I think the most difficult was not knowing how to do it, think it was remembering all the steps - how to do it, the rules of it, where to do that and where to do this. I couldn't really remember the rules as much as anything else.</td>
<td>I felt like I looked forward to it because then I could write down my frustrations and what I didn't learn or what I needed help with and I got a response back from it and I liked that because the response helped me try different strategies or different ways to remember the information.</td>
<td>I think it would have been a little more difficult for me without the log. The benefit was getting the response. The process of writing helped. Another benefit was that if I didn't understand it and I got the response and still didn't understand it, I could go to an instructor and show her exactly what was going on and what exactly I needed help with without trying to explain to her what is the problem since it was already on the paper and she could look at it... It helped build confidence and focus on the positive, that you need to look at things a little differently and allow things to come to you.</td>
<td>Like I said, the tips - to help identify useful things I need to do, how to do things and then it would work a lot better for me and I would get it more. I would suggest maybe that the instructor would go over it, like ask the students if they still didn't get something, what she or he could do to help them and then do it on the blackboard in front of everybody because I'm sure that just because they had a problem with it doesn't mean nobody else did.</td>
<td>I'm not so negative anymore. Before, I would get tested and be so negative like &quot;I'm going to fail&quot; or &quot;this isn't right&quot; or I'd change my mind all the time but this log taught me how to be positive a little more than negative like; &quot;oh, I can do this&quot;, it just made a little more confidence in myself that this is the right answer.</td>
<td>Final - W</td>
<td>MPST-0</td>
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<td>L 3</td>
<td>A lot easier to understand because the teacher I had made it a lot more understandable for someone like me who didn't really grasp math or anything like that. (I had) less distractions and it was more about focusing on doing the class work and actually learning.</td>
<td>Usually we had them at the end of tests that we look at them and then it would be asking us like, how do we think we are doing on the class or what is it difficult for us at that time and, I don't know, sometimes it was just like, I wanted to get out because I had a class right after that and that was just kind of like, I don't know if I really want to do this right now, but I tried to answer it as best as I could and being like honest and everything.</td>
<td>It made me step back and evaluate myself instead of just going in there, taking a test and then leaving. It was more like seeing. I didn't understand what I was doing or do I understand what's going on in class, that type of thing and how to solve it. It was beneficial towards improvement... Like evaluating your self. So then, it's not just you're going into class and just getting grades, you're also evaluating yourself on what you need to improve and help yourself instead of having the teacher always help you.</td>
<td>Like I said before, just stepping back and like seeing what my mistakes were and like how I could fix it and so then if I do have one of those logs at the end, I can just do it myself instead of just going in there blindly and winging it I guess.</td>
<td>Well, I think it was more a result of just paying attention and not being as distracted as far as the class goes but the log helped a little bit as far as focusing on what I need to change and what I need to improve on.</td>
<td>Final - C</td>
<td>MPST-5</td>
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<td>J 4</td>
<td>Less difficult. It was a lot easier to follow along with the lessons.</td>
<td>Usually I'd have a lot of trouble understanding the concepts and having the log really helped me to break it down and understand what was going on.</td>
<td>It helped me to see where I needed to improve and what areas I needed more practice in.</td>
<td>It definitely helped me to be more encouraged and appreciate math a little bit more. Math was never my best subject, I always dreaded math and specifically that I had a learning disability in math since I was a little kid so kind of helped me, I can't say enjoy math better, but it made it less stressful.</td>
<td>I'm not so negative anymore. Before, I would get tested and be so negative like &quot;I'm going to fail&quot; or &quot;this isn't right&quot; or I'd change my mind all the time but this log taught me how to be positive a little more than negative like; &quot;oh, I can do this&quot;, it just made a little more confidence in myself that this is the right answer.</td>
<td>Final - W</td>
<td>MPST-0</td>
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<td>140</td>
<td>At first it was pretty easy for me, then it got challenging towards the middle and like easy towards the end again. I thought it was a really good math class.</td>
<td>I honestly thought they were pointless. I didn't really learn anything or get anything out of it. I'm not really into writing in logs. I did (the CMLL) in the beginning but towards the end, I really didn't so I wasn't writing in the notebook. I used it as helpful to a point but sometimes I thought it was a waste of time and I could use that time for other homework or something, so... I guess in some ways it was helpful and in other ways it wasn't.</td>
<td>There was stuff that I was having more difficulties on at the time. ... Yeah, it helped me hit on like what the difficult parts and towards the end everything was easy because I worked all the bugs out in the middle. [I recommend] I just to make sure it got done and it would be beneficial to the teacher.</td>
<td>Well, just like what I said before, as far as it showed me what was easy for me and what was hard for me, so I knew not really to waste my time on easy stuff but to work on the more difficult stuff.</td>
<td>I knew it was a class I had to do good in so I had to pay attention and I really didn't have a bad attitude towards it but some of the math teachers before I had bad attitudes towards them.</td>
<td>MPST-4</td>
<td>MPST-9</td>
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In terms of their overall experience with the math course (see Table 4.17), five (CZ, DP, JA, JT, EK) of the interviewed participants have directly noted it as “good” or “very positive” and two (DR, AK) indicated that the course “became difficult” or “was difficult.” The one student (KF) who mentioned that “[she has] never been a math person and hate[s] math” expressed, however, that her teacher made her feel relaxed and comfortable in the course.

Five (KF, JA, DR, AK, JT) of the participants noted the strategy’s positive impact on their mathematics course success. Three students (CZ, DP, EK) did not see the strategy as helpful, with two of them (CZ, EK) exhibiting ambiguity in their responses since they either said that “it helped with the thinking process” or “showed what was easy or hard so as not to waste time on the easy stuff.”

Six (CZ, KF, JA, DR, AK, JT) of the participants thought that the strategy impacted their attitude towards math in a good way, affirming their math confidence, helping them appreciate math, or helping them focus on making needed change for improvement. One student (EK) did not really give a response. Another participant (DP) did not think that it had any impact on her personally but more so for others, but said that it did “shape [her] attitude towards the College.”
Meanwhile, challenges or difficulty encountered by students in this study in their math course that are academic or personal in nature include the following:

ACADEMIC - Conceptual/Procedural

- Word problems (CZ, AK)
- Changing decimal to percent (KF)
- “silly mistakes” in multiplication (DP)
- Factor tree and determining LCD (KF)
- Cumulative property (JA)
- Dividing fractions (JA)
- Proportions (JA)
- Linear equations (JT) involving absolute value (DR)
- Combining like terms (DR)
- Complex fractions (DR)
- Equations containing decimals or fractions (DR, JT)
- Division (JT)
- Percent, interest (JT)

PERSONAL

- Remembering concepts learned in the past (CZ, AK)
- Self (DP noted, “I am my biggest obstacle,” while DR claimed she has math learning disability)
- Time constraint (DP)
Table 4.16: Weekly Log Entries - Verbatim (H-high level of course success, A/B grades; L-low level of course success, C or below)
(Weekly questions / prompts asked for difficulty experienced in the course, if any, why it was difficult/challenging, and how it was resolved.)

<table>
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<tr>
<th>Student</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
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<th>Week 9</th>
<th>Pre-Eval Score</th>
<th>Post-Eval Score</th>
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<tr>
<td>H1CZ</td>
<td>I did well on the test. The thing that was more difficult was the stuff that wasn't the freshest in my mind. A simple review of the information made it easier.</td>
<td>I continue to do all assigned homework and I do the practice tests from each chapter. I strongly believe this has helped with my success in this class.</td>
<td>I continue to do my homework and review the sections we discuss in class. As we get deeper into the textbook, I am finding I need to focus more and spend more time on it to fully make sure I understand it.</td>
<td>--</td>
<td>I missed 2 classes last week because of my son being sick. During this time, I missed a test. I found this test to be more difficult because the problems were not fresh in my head. It proved to me how important it is to stay on top of your homework. I have made it a point to make sure I continue to review and practice the information.</td>
<td>My main problem is not taking the time to read a problem or rewriting it correctly. I am trying to focus more on taking my time.</td>
<td>I feel I am doing well. I do my homework which is helpful. It is more of a review of things I learned in the past, but forgot how to do. I work through it by reviewing my notes and textbook.</td>
<td>I am working hard to complete all assignment and I make sure to be in class.</td>
<td>Math is going well. Word problems were the hardest I come to class and I review my notes prior to doing my homework.</td>
<td>MPST-10 MSAI-93 CMAS-51</td>
<td>Final - A MPST-12 MSAI-96 CMAS-49</td>
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<td>H2KF</td>
<td>(6)² wasn't reading the problem correctly. Learned to read the problem correctly.</td>
<td>I am more careful when reading the problem and I also double check.</td>
<td>Factor tree and determining LCD. I will keep making up problems to do for practice.</td>
<td>Nothing is too difficult if the present. I have been doing all the homework problems in a chapter, not just the ones assigned to get more practice.</td>
<td>Keep doing extra problems for the practice.</td>
<td>Working with fellow classmates has helped with confusing problems.</td>
<td>Remembering formulas. Never learned them before. Memorize them.</td>
<td>Remembering to change decimal to %. Need to read what the problem is asking. Read more carefully.</td>
<td>Keep practicing and learning ways of memorizing things.</td>
<td>MPST-8 MSAI-91 CMAS-50</td>
<td>Final - A MPST-9 MSAI-89 CMAS-72</td>
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<td>Week</td>
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<td>Week 1</td>
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<td><strong>H</strong> A: The question about</td>
<td>**I am doing the chapter's review and</td>
<td><strong>Right now I am not having any difficulty.</strong></td>
<td><strong>Right now the only problem that I am having</strong></td>
<td><strong>I am a little confused about decimals, but I</strong></td>
<td><strong>What I am doing is asking for help when ever</strong></td>
<td><strong>I ask for help and I also review and review.</strong></td>
<td><strong>I am having a little problem with the proportions. Putting the problem from words into a proportion. I will keep attending tutoring, getting help and reviewing my notes and textbook.</strong></td>
<td><strong>I always ask for help and review my notes and go over the textbook.</strong></td>
<td><strong>Final A</strong></td>
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<td>explaining the cumulative property. It was a</td>
<td>chapter's test on the rath book. I review</td>
<td>understanding the material and I am reviewing</td>
<td>a problem. I am not overwhelmed. I will just keep</td>
<td>a problem, but I am not overwhelmed. I will just keep</td>
<td>a problem, I have been going to tutoring, and</td>
<td>a little problem with the proportions. Putting the problem from words into a proportion. I will keep attending tutoring, getting help and reviewing my notes and textbook.</td>
<td>a little problem with the proportions. Putting the problem from words into a proportion. I will keep attending tutoring, getting help and reviewing my notes and textbook.</td>
<td><strong>Final A</strong></td>
<td><strong>MPST-5</strong></td>
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<td>little confusing because I thought it asked</td>
<td>the material right when I get home from</td>
<td>over and over again.</td>
<td>reviewing my notes and attending tutoring.</td>
<td>reviewing my notes and attending tutoring.</td>
<td>attending tutoring, and at home. My husband is helping me too. I also review my book and notes right after class.</td>
<td>reviewing my notes and attending tutoring.</td>
<td>reviewing my notes and attending tutoring.</td>
<td>reviewing my notes and attending tutoring.</td>
<td><strong>MSAI-101</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>something else. I got a little confused. I</td>
<td>class, which has helped me understand it</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>CMSAS-86</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>overcame the challenge by re-reading the notes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>CMSAS-77</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>L</strong> D: The problem that I was having</td>
<td>**Combining like terms. Study more get more</td>
<td>**Combining like terms and complex fractions. How I</td>
<td>**Right now what is difficult for me are complex</td>
<td>**The equations containing decimals. Because I have a learning disability in math and it takes a little longer to grasp the concept. Get either more one on one instruction with a tutor.</td>
<td><strong>Well equations that include decimal or fractions. More one on one instruction, more tutoring online.</strong></td>
<td><strong>Equations It is difficult because of the variables and stuff. Go talk to my teacher or Elena to get more help.</strong></td>
<td><strong>Well equations are still giving me problems but I'm getting a bit better. Because of my learning disability in math it hard for me to grasp the concept right away. Talk to my teacher or Elena, or tutoring</strong></td>
<td><strong>Initial C</strong></td>
<td><strong>MPST-5</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trouble with was problem that were like -4+</td>
<td>tutoring or one on one instruction</td>
<td>combination parts and one on one instruction</td>
<td>fractions and ?? decimals. What I can do to improve is go and get one on one instruction from either my teacher or tutor.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>MSAI-73</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8(-8)-16(-10) and vertical line 3 vertical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>CMSAS-69</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>line -3 vertical line, and also 10-[8(2-6)^2] and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>CMSAS-83</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16(2)-2(-12) divided by -4 so I've had trouble</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>CMSAS-83</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with those. If I can get more help in tutoring or one on one instruction, I'll do better.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>CMSAS-83</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Week 1</td>
<td>Week 2</td>
<td>Week 3</td>
<td>Week 4</td>
<td>Week 5</td>
<td>Week 6</td>
<td>Week 7</td>
<td>Week 8</td>
<td>Week 9</td>
<td>Pre-Eval Score</td>
<td>Post-Eval Score</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>-------------------------------------------</td>
<td>-------------------------------------------</td>
<td>--------</td>
<td>--------------------------------------------</td>
<td>--------</td>
<td>--------------------------------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>L2A</td>
<td>I have trouble with most of the math problems. I don't comprehend math at all. It almost makes no sense. I can't solve this problem. I am going to rent more math videos and see a math tutor. I just need more help than others.</td>
<td>--</td>
<td>--</td>
<td>I am going to see a doctor about it. I think during my accident I might have lost the part of my brain where I can remember math. Last September I had brain bleeding and that is why I think I can't remember.</td>
<td>Everything is the same but I went to my doctors and I suffer from long and short-term memory loss and getting help.</td>
<td>--</td>
<td>I have difficulty remembering steps. Second part of question - Because it is frustrating. Third part of question - I am not sure what to do or if there is anything to do.</td>
<td>--</td>
<td>interest rate; a lot of steps to remember; practice more</td>
<td>MPST-0</td>
<td>MSAI-50 CMAS-24</td>
</tr>
<tr>
<td>L3J</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>The difficulty in class right now is just the different shortcuts or ways of solving an equation. The way that I am used to isn't the same as what is being taught. Practicing the new way will help me understand and more successful.</td>
<td>Solving equations with fractions is somewhat difficult for me. I am going to resolve it by studying that portion of the book for the final so I can do better when ...???</td>
<td>Division is always a difficulty for me. Today I learned a new shortcut that I understand and will use when a hard division problem arises.</td>
<td>--</td>
<td>--</td>
<td>MPST-7</td>
<td>MSAI-76 CMAS-55</td>
<td></td>
</tr>
<tr>
<td>L4E</td>
<td>I do good in the homework but when it comes time for the test I can't think.</td>
<td>--</td>
<td>--</td>
<td></td>
<td></td>
<td>--</td>
<td></td>
<td>--</td>
<td>Nothing really it's going good now. Keep studying</td>
<td>MPST-4</td>
<td>MSAI-70 CMAS-33</td>
</tr>
</tbody>
</table>

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146
It is interesting to note that EK did not note any specific difficulty other than mentioning in his first log, “I do good in the homework but when it comes time for the test I can’t think.” His two additional logs indicated “none” in terms of perceived difficulty, yet he received a C grade for the course despite his claim that he “plan(s) to keep up with [his] school work.”

The strategies or approaches the interviewed students utilized in resolving their difficulty include:

- Do all assigned homework (CZ, KF)
- Do the practice tests or extra problems (CZ, KF, JA, JT)
- Review notes and textbook (CZ, JA, JT)
- Be in class (CZ)
- Read the problem correctly, carefully (KF, DP)
- Work with peers (KF)
- Memorize formulas (KF)
- Awareness of what one is doing (DP)
- Check answers (JT, DP noted need to “triple check”)
- Take time in solving the problem (JT)
- Seek help from friend, significant other (DP, JA)
- Seek help from a tutor—live or online (JA, DR)
- Seek help from instructor (DR)
It is known that there are various strategies or approaches students can use to understand and learn a task or skill, or solve a problem. According to NICHCY (1997), strategies include what we think about (e.g., planning before writing, realizing when we are not understanding something we are reading, remembering what we have learned previously on the topic under study) and what we physically do (e.g., taking notes, re-reading to clear up confusion, making a chart, table, or story map to capture the most important information). Research has shown that using knowledge about learning strategies, including which strategies to use in different situations, can help make students more effective, purposeful, and independent learners.

Perhaps, and based on students’ responses, most of them would benefit from knowing the learning strategies they need for mathematics study and course success. They would also benefit from understanding that learning math is different from learning other subjects. Nolting (2008) pointed out that unlike other courses, students in a math course must be able to do four things: “(1) understand the material, (2) process the material, (3) apply what you have learned to solve a problem correctly, and (4) remember what you have learned in order to learn new materials” (p.2). Other reasons he mentioned to contrast math learning from other subjects/courses are the following: math follows a sequential learning pattern, it is like a foreign language, it is a skill subject, and it is a speed subject (Nolting, 2008).
Summary

This chapter presented the results of the study based on the statistical analyses performed on the data collected in this study as well as additional case study analysis. It also presented the results from an examination of the reliability of the surveys used in the study. Tests for reliability using Cronbach’s alpha showed that both surveys, namely the MSAI and CMAS, were reliable.

When considering the impact of the CMLL intervention on students’ mathematics course success and problem solving performance, based on grouping them as intervention versus control, no significant difference was found. A significant difference was found. However, based on grouping them by the number of weekly logs written and submitted; i.e., those with 5-9 CMLLs outperformed those with 0-4 CMLLS. No significant difference was found based on problem-solving performance. A significant difference was found in terms of mathematics attitude. Those who participated in the CMLL intervention were found to have a more positive attitude towards mathematics. Attitude towards the log writing did not result in significant change or more positive attitude for those in the intervention group. Finally, the case study analysis based on interviews and logs written by students provided
additional insight into their thoughts and perceptions, supplementing the story gathered from the quantitative data. A discussion of findings will be presented in Chapter 5.
CHAPTER 5
CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Overview

This chapter presents a summary of the results of this study which reveal five major findings. Discussions and analysis of these findings are presented here along with prior or related research. Educational implications of the study and recommendations for future research are presented as well.

Summary of Major Findings

This study explored the impact of using the cognitive monitoring learning log (CMLL), a meta-cognitive strategy, on students' mathematics course success, problem-solving performance, and attitudes towards mathematics and CMLL. It explored the cognitive and affective benefits of the CMLL intervention on 42 students who participated in the study.

Mathematics course success (also referred to as math achievement in this study) was examined using data obtained from final course grades. Problem-solving performance was examined using the Mathematics Problem Solving Test (MPST). Mathematics attitude was examined using the modified Mathematics and Science Attitude Inventory (MSAI).
Cognitive monitoring learning log (CMLL) attitude was examined using the CMLL attitude survey (CMAS). Additional case study analysis that focused on the benefits of the CMLL strategy and student perceptions of the CMLL strategy are presented after t-test and ANOVA results for math course success, problem-solving performance, and attitudes are discussed.

Important findings that emerged from this study are as follows: (1) the CMLL strategy can positively impact specific student outcomes (such as final grades, also referred to in this study as math course success), (2) the strategy can also positively influence the students’ attitudes towards math, (3) no significant difference in problem-solving performance was found between those who participated (or engaged) in the strategy and those who did not participate (or engage) in the strategy, (4) no significant difference in attitude towards the cognitive monitoring learning log (CMLL) was found among those who participated in the intervention, but (5) eighty-eight percent (88%) of those interviewed and who participated in the intervention reported benefits of the CMLL strategy. These findings are discussed in detail below:
CMLL Strategy and Mathematics Course Success

During the course of this study, results of the impact of the CMLL strategy on math course success or achievement (based on final grades) was found to be inconclusive. An initial analysis of the data based on the grouping variable, intervention versus control, found no significance in terms of math success. The lack of student understanding on CMLL intervention may be partly to blame. As Commander and Smith (1996) noted:

Learning logs are not without potential problems. [Students] fail to see the value of the learning logs. The log is then treated as any other assignment that is not turned in or poorly done. (p.452)

Additionally, some students may very well hold negative notions of the writing task involved with the strategy. Bangert-Drowns, Hurley, and Wilkinson (2004) pointed out that “for poor writers, or students with little confidence or interest in writing, writing tasks can be detrimental to motivation” (p. 33). Needless to say, one’s level of motivation has a lot to do with persistence level and academic performance.

Another reason for the apparent lack of improvement in the mathematics course success of students in the CMLL intervention group may be attributed to the lack of feedback (or none at all) received from instructors on the intervention. While the strategy provided an avenue for
students to explain their difficulty in the course, express their frustration or confusion, discuss their action plan, or share feelings of success in the course, feedback from instructors may be helpful in the learning process. This feedback would have provided motivation for students to work harder for the sake of learning (and, thus, improve their performance). Black and Williams (1998) claim that feedback can improve student achievement. Various studies (Bauman, 1992; Bell & Bell, 1985; Dipillo, 1994; Goss, 1998) that investigated student’s writing, and involved feedback given to students, resulted to positive outcomes for academic achievement in math. Unfortunately, the researcher had not specifically asked instructors who participated in this study to provide feedback. Since it is perceived that reading and commenting on the logs is a time-consuming task (Hettich, 1980), the researcher did not want to trouble the instructors with an additional responsibility. In fact, asking these instructors to have their students engage in the CMLL strategy already took up part of their class time and personal time.

Meanwhile, statistical significance found on the impact of CMLL strategy on math course success resulted from the analysis of the data based on the grouping variable, 5–9 weekly logs versus those who had 0–4 weekly
logs during the nine-week intervention. Students who wrote and submitted 5-9 weekly logs outperformed those who wrote and submitted 0-4 logs. This is also supported by the case findings wherein students, who had submitted more weekly logs and, needless to say, took time to reflect and elaborate on their responses to the log questions, seem to have experienced a greater level of math course success. Based on this finding, the study did support claims (Bell & Bell, 1985; Evans, 1984; Rheinheimer, 1993; Shepard, 1993) that there is a positive impact of such intervention strategies (i.e., journal writing) on mathematics course success.

It is to be noted, however, that other factors can account for course success since it is also a function of other variables in the educational process (such as the instructor, curriculum, environment, motivation, and possible interaction among these variables). In this case, something else improves the scores and keeping logs is only an intermediate correlated event. It could be that student commitment to effort is the factor. This commitment yields two effects: 1) student is more likely to keep or write more logs and 2) student is more likely to have higher score or grade. If this is the case, then it is likely that the logs did not actually improve scores; it only
appears that way because it is a correlated event that goes along with commitment to effort which is the real factor or one of the many factors.

CMLL Strategy and Problem-Solving Performance

An initial analysis of the data based on the grouping variable, intervention versus control, found no significance in terms of mathematics problem-solving performance. The fact that students in the intervention group did not do any better than students in the control group suggests that the CMLL strategy alone cannot account for one’s problem-solving performance. Of course, the results may have been different had there been an effort to model problem-solving or give students practice in performing a mathematical task, along with modeling the reflective thinking necessary in problem-solving and in response to the CMLL questions. It is to be noted that participants in this study were students in a developmental math course and were, therefore, limited in their math knowledge and skills. The CMLL strategy involves a process of reflection that results in evaluation, implementing an action plan, or further reflection. Dewey (1933) noted that reflection involves action in response to a perceived problem. But, some students may not even realize or
acknowledge that they have a problem or are experiencing difficulty in the course, such as in the case of one student (EK). Some other students may have difficulty articulating their thoughts since reflection is placed in Bloom’s (1956) taxonomy as the highest educational goal. It may, therefore, be too much to expect that a change in these students would take place within a short period of time given that modeling reflection and problem-solving is limited in the type of course the students were in and investigated in this study. Given more practice, time, and explanation of strategies in the area and process of reflection and problem-solving may result in better or improved student problem-solving performance.

CMLL Strategy and Mathematics Attitude

Findings on the impact of the CMLL strategy on students’ attitude towards mathematics provided a more optimistic view. Students who participated in the CMLL strategy seemed to have an improved, if not better, attitude towards mathematics. This supports the assertion made by Borasi and Rose (1989) that writing in mathematics has a beneficial effect on the feelings and attitudes of students. Based on students’ interview responses, it is
encouraging to note that students viewed the CMLL strategy as a tool to help them reflect on their learning.

The qualitative finding showed that the strategy had influenced students’ attitudes towards math “in a good way” as one of the participants put it. One of the participants, KF, best expressed how the strategy impacted her attitude during an interview (see Table 4.15):

“I learned that I don’t have to be afraid of numbers with letters beside them. I learned that just because it might be more challenging for people like me that it doesn’t mean I can’t do it, that I just have to sit down and figure out a plan for me to learn it. There’s a solution to every problem.”

The qualitative finding seemed to be consistent with the quantitative results which showed that students who were engaged in the CMLL strategy had, in the end, a better attitude towards math. The finding also supports the notion that attitudes can be ameliorated (Hembree, 1990; Tobias & Weissbrod, 1980). The finding is noteworthy since attitudes have been found to influence or have some effect on achievement (Braswell et al, 2001, Gallagher & DeLisi, 1994; Hembree, 1992; Ma & Kishor, 1997). Mager (1968) pointed out that favorable attitudes towards academic areas would increase the likelihood that students will remember
what they have learned, be willing to learn more about the subject, and use what they have learned. Papanastasiou (2002) pointed out a positive relationship between mathematics attitudes and math achievement. Needless to say, attitudes also impact students’ decision to persist in class and learn math (Schwartz, 2006).

It needs to be pointed out, however, that as much as various factors can have an effect on achievement, one’s attitude is also a complex concept that needs to be clearly defined and can be impacted by various factors as well. This study took on a simple definition of attitude that describes it as a positive or negative construct or affect towards mathematics (McLeod, 1992). It did not look at the important dimensions of attitude described by Hart (1989) involving one’s emotional response (“I hate math”), beliefs regarding the subject (“Math can be useful”), and behavior related to the subject (“I am doing my homework and reading the book for the class”).

CMLL Strategy and CMLL Attitude

Unlike the positive outcome reported on the impact of the CMLL strategy on math attitude, attitude towards the CMLL was not significantly changed. The students in the intervention group reported mixed feelings towards the
strategy. However, it needs to be clarified whether it is the process (meta-cognitive strategy) that they were reacting to or the task itself (writing in response to the CMLL questions posed). According to research, it can be expected that attitude towards writing worsens as one gets older (Krudson, 1991, 1992, 1993).

Meta-cognitive strategy could be facilitated in various ways, individual or group, such as by verbalizing or discussing it (collaborating) in a group, thinking aloud, or making graphic representation. As noted earlier, participants in this study were students in a developmental math course and may, therefore, have limited knowledge and experience with the cognitive process. An instructional component that teaches students what the process strategy (thinking) and task strategy (writing) entail would have been helpful. This way, they can also better clarify their reaction to the intervention and their experience with it.

Educational Implications

Students in this study were enrolled in a mathematics course (pre-algebra) where foundational/fundamental concepts and skills are learned to prepare them for a more rigorous or theoretical study of math. Because the participants were a representative sample from the
developmental math student population at large, it is reasonable to assume that their past experiences involved little of the mathematics (concepts and procedures) needed for mathematics course success and effective problem-solving. It is, therefore, a challenge for educators to help these students not only to have a better understanding of the skills and concepts to be learned, but to also have better appreciation for mathematics as a course of study.

Results from this study indicate that the CMLL strategy or a similar type of meta-cognitive strategy involving writing shows promise in helping students experience success in their developmental mathematics course. This and prior research have indicated positive impact on specific student outcomes and attitudes towards math. In this study, student interviews have supported and confirmed the benefits of the CMLL strategy for the students who persist with the strategy. However, getting students to consistently use the strategy was more difficult than expected and provides the opportunity for additional study.

Recommendations

Findings from this study support Pugalee’s (2001) call “for additional research on writing in mathematics” (p. 1),
especially at the college level, and "for research focusing on the relationship between writing and metacognition in math" (p.237) which he claims to be non-existent. More specifically, further research is needed to look into the interaction among mathematics course success or specific student outcomes, problem-solving ability, and attitudes when a cognitive-monitoring learning log (CMLL) strategy (or even a modified version of such) is introduced in either the developmental or college level mathematics classroom.

While findings from this study may be seen as inconclusive as to the impact of learning logs in the cognitive aspects, it was not shown to be a detriment either. Efforts should then be made as to how best to intertwine this strategy with other methods of instruction that will benefit developmental college students the most.

For future research, it should be made clear to participants at the onset as to the value of a meta-cognitive strategy, such as CMLL or some form of reflective writing, based on empirical research. Perhaps, it would help when students are given examples or given the opportunity to discuss their responses in class. It would be of benefit, both to students and instructors, to provide students the training or some type of instruction on the
process of reflection and the writing necessary with this type of strategy.

Any teaching strategy or tool by itself cannot account for student success or learning. While it is evident that a metacognitive strategy investigated in this study can have an impact on student learning, the impact of a multi-dimensional definition of attitude (one that takes into account the student’s emotional response towards, beliefs regarding, and behavior towards math) on success in mathematical tasks or on problem-solving are also worth investigating. Differences between genders, age, or among ethnic/racial groups in terms of improvement in attitude may also be worth investigating. Instructors’ attitudes towards the strategy may need to be assessed or determined since previous studies have identified faculty attitudes or their interaction with students to have an influence on students’ performance or attrition (Belcheir, 1998; Lamport, 1993).

Conclusions

In sharp contrast to Jurdak and Zein’s (1998) finding that writing in mathematics has no impact on mathematical attitudes or achievement, the cognitive monitoring learning log (CMLL), as a meta-cognitive strategy, has been shown in
this study to have positive impact on specific student outcomes (final grades) in mathematics. This impact was effective for students who were engaged in the CMLL strategy, writing 5 or more logs. While the impact was not the same on students’ problem-solving performance, the impact on students’ attitudes towards mathematics was also positive. As such, the CMLL strategy has the potential to be included in an instructor’s repertoire of teaching strategies that benefit student learning and course success.

Obviously, additional research is in order to further support and validate the results of this study. In fact, future research should consider a modified version of this study that examines differential changes in attitudes between the genders, age group, and among ethnic groups. Moreover, research is needed in order to determine the extent to which the CMLL strategy, as a form of reflective writing, can be developed for the benefit of both students and their instructors in such a way that its impact on cognitive and affective areas is made more effective. Whether or not the strategy itself also helps develop or facilitate students’ meta-cognitive awareness or thinking is worth investigating.
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APPENDICES
Course Form 335 must be updated at least every five years to qualify for state reimbursement.

1. **Digital Description [§335.2]:**
   
   Credit hours: 3  
   Lecture hours: 3  
   Lab hours: 0

2. **Catalog Description [§335.2]:**
   Designed to review the basic operations of arithmetic and introduce algebraic representation and application.

3. **Prerequisites:**
   - English 001 for students required to take reading by the College Testing and Placement Program.  
   - Placement through the College Testing and Placement Program, or completion of MATH 005.  
   
   **Corequisites:** None

4. **Learning Outcomes [§335.2]**
   [These outcomes are necessary to enable students to attain the essential knowledge and skills embodied in the program’s educational objectives.]
   
   Upon successful completion of this course the student will be able to:
   1. Demonstrate a good foundation in basic arithmetic skills.  
   2. Perform arithmetic application problems including; percent, measurement, statistics, and geometry.  
   3. Demonstrate the ability to simplify, solve, and interpret first degree equations.

5. **Planned Sequence of Learning Activities [§335.2]**
   [These must be designed to help students achieve the learning outcomes.]

<table>
<thead>
<tr>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review of Whole Numbers</td>
</tr>
<tr>
<td>Definitions of and operations on signed numbers</td>
</tr>
<tr>
<td>Solution of first degree equations</td>
</tr>
<tr>
<td>Definitions, operations and applications of fractions</td>
</tr>
<tr>
<td>Decimal operations, area and volume</td>
</tr>
</tbody>
</table>
6. List of Texts, References, Selected Library Resources or other Learning Materials

(code each item based on instructional use: C-lecture/lab, A-lecture, B-lab, I-internet, and V-videocourse) [§335.2] [These resources must be easily accessible to students.]

Prealgebra, 2nd ed. by Lial and Hestwood;  Addison Wesley

7. Prepared by Faculty Member: _____ Mary Sarvis Brown _____ Date: 8/26/04

8. Approved by Dean: ________________ Thomas Starke __________ Date: 9/22/04

This course meets all reimbursement requirements of Chapter 335, subchapters A / B.

This course was developed, approved, and offered in accordance with the policies, standards, guidelines, and practices established by the College. It is consistent with the college mission.

If the course described here is a transfer course, it is comparable to similar courses generally accepted for transfer to accredited four-year colleges and universities.

Whether transfer or career, this course is articulated with other courses so that it is an elective or a requirement of one of the college programs and it does not require students to have more than 30 credit hours of post secondary study prior to enrolling in the program.

9. VP, Instruction and Educational Services: Ronald Young _____ Date: 9/29/04

10. Original Date of course approval by the college: 7/11/78

11. Date(s) of subsequent reviews: 1985
    1987
    1996
    2003 – April
    2004
Appendix B

SAMPLE COURSE SYLLABUS
**MATH 010 SYLLABUS - 30 CLASSES**

**TEXT:** Prealgebra, 4th edition by K. Elayn Martin-Gay; Prentice Hall 2004

**MINIMUM Daily Assignment:** Complete ALL the odd numbered problems in the Chapter Section(s) which are covered in the day's lesson.

<table>
<thead>
<tr>
<th>LESSON</th>
<th>SECTIONS</th>
<th>LESSON</th>
<th>SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1 - 1.5</td>
<td>16</td>
<td>5.6 - 5.8</td>
</tr>
<tr>
<td>2</td>
<td>1.6 - 1.8</td>
<td>17</td>
<td>6.1 - 6.3</td>
</tr>
<tr>
<td>3</td>
<td>1.9, 2.1 - 2.2</td>
<td>18</td>
<td>6.4 - 6.5</td>
</tr>
<tr>
<td>4</td>
<td>2.3 - 2.5</td>
<td>19</td>
<td>Problem Solving Session, 7.1</td>
</tr>
<tr>
<td>5</td>
<td>Problem Solving Session, 3.1 - 3.2</td>
<td>20</td>
<td><strong>TEST 4</strong> - Chapters 5 &amp; 6</td>
</tr>
<tr>
<td>6</td>
<td><strong>TEST 1</strong> - Chapters 1 &amp; 2</td>
<td>21</td>
<td>7.2 - 7.3</td>
</tr>
<tr>
<td>7</td>
<td>3.3 - 3.4</td>
<td>22</td>
<td>7.4 - 7.5</td>
</tr>
<tr>
<td>8</td>
<td>3.5, 4.1</td>
<td>23</td>
<td>7.6, 8.1</td>
</tr>
<tr>
<td>9</td>
<td>Problem Solving Session, 4.2 - 4.3</td>
<td>24</td>
<td>Problem Solving Session, 8.2 - 8.3</td>
</tr>
<tr>
<td>10</td>
<td><strong>TEST 2</strong> - Chapter 3</td>
<td>25</td>
<td><strong>TEST 5</strong> - Chapter 7</td>
</tr>
<tr>
<td>11</td>
<td>4.4 - 4.5</td>
<td>26</td>
<td>8.5 (8.4, 8.6 optional)</td>
</tr>
<tr>
<td>12</td>
<td>4.6 - 4.8</td>
<td>27</td>
<td>9.1 - 9.2</td>
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<td>13</td>
<td>Problem Solving Session, 5.1 - 5.2</td>
<td>28</td>
<td>9.3</td>
</tr>
<tr>
<td>14</td>
<td><strong>TEST 3</strong> - Chapter 4</td>
<td>29</td>
<td>9.4</td>
</tr>
<tr>
<td>15</td>
<td>5.3 - 5.5</td>
<td>30</td>
<td>Final Review</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>FINAL EXAM</strong></td>
</tr>
</tbody>
</table>

(8/17/04)
Appendix C

INSTRUCTOR’S SAMPLE SYLLABUS
Course Information: CRN: 31111
Course: Math 010 – Pre-Algebra Rm: Main 330
Days/Time: MWF 11 – 11:50 PM Delay Schedule Time: 12:00 – 12:35 PM

Instructor Information: Mrs. Deb Rothermel
Office Location: Main 318-B
Office Hours: Mon. Wed, Fri 10 – 11AM; Tues. Thurs. 12:15 – 1:15 PM Any other times, see me for an appointment
Office Phone: 358 – 2247

Grading System:
5 Tests each worth 50 – 100 points; 5 Quizzes each worth 10pts. You may miss 1 quiz during the semester.
All grades are recorded as points scored (not %) Final grade is calculated by: Total Pts Earned \( \div \) Total Pts Possible

<table>
<thead>
<tr>
<th>Grading Scale</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 – 100%</td>
<td>A</td>
</tr>
<tr>
<td>80 – 89%</td>
<td>B</td>
</tr>
<tr>
<td>70 – 79%</td>
<td>C</td>
</tr>
<tr>
<td>60 – 69%</td>
<td>D</td>
</tr>
<tr>
<td>Below 60%</td>
<td>F</td>
</tr>
</tbody>
</table>

Notes: NO EXTRA CREDIT IS GIVEN!
Class Participation will be considered in the event of a borderline grade

Withdrawal Policy:
It is the student’s responsibility to fill out withdrawal slip and see me to sign it if you wish to withdraw.
Students may withdraw without a grade during the Refund Period. (Full Refund – 1/17 ; 50% Refund - 1/31)
Withdrawals after refund period will receive a grade of “W” or “F” at the discretion of the instructor.

Incomplete Grades:
An incomplete grade (“I”), will only be given in extreme cases. Remember that an “I” will become an “F” if all work is not made up within 8 weeks into the next semester.

Academic Honesty:
Anyone caught cheating in any way on any quiz, test or assignment, will receive a “0” for that test or assignment.

Cell Phones:
All cell phones are to be turned off or on silent during classes or test.
No Cell phones can be used as calculators.

Attendance:
Class attendance is extremely important to the learning process. Students who frequently miss class will find it hard to understand the material, and will probably affect your learning and quiz and test grades.
Students will not be penalized for missed classes, except on quiz or test days, (See below), or on any day when an assignment is due.
Be sure to read the MSAH division attendance policy.

Other Course Information and Requirements:
2. Tests: There will be 5 tests throughout the semester each worth 60 – 100 points.
   Test dates are listed on the Course Schedule. These dates are tentative. Changes to any test dates will be announced in class as necessary.
   You are required to be present on test days.
   If you have a problem being present for a test due to some, uncontrollable circumstances that you know about ahead of time (work conflict, etc…), see me before the test, and I will make special arrangements for you to take the test early.
   If an emergency arises, (illness, car accident, etc.), you must contact me by phone or email, the day of the test.
   If you do not contact me by the test date, you will not be allowed to make up the test.
You will only be able to make up a test if you have a written verifiable note from doctor, auto mechanic, etc.... as to your emergency and reason for your absence.

You are only allowed 1 make up test during the semester.

All decisions with respect to tests and any exceptions to this policy will be made at my discretion and will be final.

3. Quizzes: There will be 5 quizzes throughout the semester. Each quiz will be worth 10 points. Quiz dates are listed on the Course Schedule. These dates are tentative. Changes to any quiz dates will be announced in class as necessary. The lowest quiz grade will be dropped at the end of the semester. You are allowed to miss 1 quiz throughout the semester without penalty. Any other quizzes missed will receive a grade of 0. You cannot makeup a quiz for any reason.

4. Homework: Homework assignments will be handed out one chapter at a time.

Homework is not graded or collected. These exercises are to be used for you to practice and learn the material we have gone over in class. You will not learn how to do math if you don’t do your homework!!!!

There are rarely any other assignments that will be turned in for a grade during the semester. If there is an outside assignment to be turned in, it must be turned in by the due date. No exceptions!!!!! You may turn it in early, but no assignments will be accepted late!!!!!!!

5. Getting Help: See me as soon as you are having trouble! Don’t wait until it is too late!

Use the Learning Center. Tutors are there to help you at no cost to you!
Use Smarthinking – Internet Tutoring Website
Lessons on Video in Library
Other Materials with Textbook - My MathLab
Tips for Homework, Better Grades, and Success in Mathematics

1.) Come to class on a Regular Basis. Missing classes will cause you to miss explanations and examples of material and will probably hurt you on tests.

2.) Come to class prepared: Text, Notebook to take notes, Pencil, (Calculator)

3.) Read Section(s) that will be covered each day before coming to class. Having some idea of the material being taught that day will help you to understand what we will do in class. I will also not always go over every detail from text.

4.) Take good notes. Write down everything I put on the board including all examples. It will help you to do homework.

5.) DO ALL Homework!!! If you only do a few problems from the homework, it doesn’t really mean that you understand every detail.

- Put homework in your notebook.
- Keep homework neat and orderly, and show all steps so you can look back at it and be able to follow what you did.
- You can check homework in back on text since odd problems will be assigned. You should try to correct any homework problems you get incorrect. If you have any questions on homework, highlight or circle problems you have trouble with, and ask at the beginning of class or see me during office hours.
- You should be doing homework after each class for that day’s lessons. Don’t just do all homework for the whole week or a whole chapter all at one time.
- You should be spending 2-3 hours doing homework, studying, and reading for each 1 hour you spend in class.

6.) Don’t become too dependent on the Solutions Guide. Don’t look at work for the problems before you try them!

7.) GET HELP!!!! Don’t wait until the day before the test when you have been having trouble throughout the chapter.

a) Instructor
b) Learning Center
c) Smarthinking
d) Practice CD
e) Math Computer Lab
f) Study Buddy or Study Group
f) Video Lessons in Library or Online
g) One Hours Workshops

8.) You do not have to be the Smartest Student to be successful. You just have to work hard and follow these Steps above!!!
Appendix D

COURSE COMPETENCIES
PA AREA COMMUNITY COLLEGE  
MATH 010 - PRE-ALGEBRA  

COURSE DESCRIPTION: Designed to review the basic operations of arithmetic and introduce algebraic representation and applications.  

COMPETENCIES  

I. WHOLE NUMBERS  
1. Write a given number in expanded form or in words.  
2. Perform operations on whole numbers.  
3. Identify and apply the commutative, associative and distributive real number properties with whole number operations.  
4. Round a whole number to a specific place value.  
5. Estimate the result of a computation using rounding.  
6. Simplify expressions with whole numbers using order of operations.  
7. Evaluate algebraic expressions by substitution.  
8. Solve applications by translating English word phrases into arithmetic expressions.  

II. SIGNED NUMBERS  
1. Apply definitions of signed numbers, opposites, and absolute value.  
2. Perform operations on expressions involving signed numbers.  
3. Simplify expressions with signed numbers using order of operations.  
4. Identify and apply the commutative, associative and distributive real number properties with integer operations.  
5. Solve applications by translating English word phrases into arithmetic expressions.  

III. LINEAR EQUATIONS IN ONE VARIABLE  
1. Simplify algebraic expressions by combining like terms.  
2. Solve equations using addition and multiplication principles.  
3. Translate English sentences into mathematical equations.  
4. Solve applications by translating to linear equations.  
5. Identify plane geometric figures and determine their perimeters using correct formulas.  

IV. FRACTIONS  
1. Identify proper and improper fractions and mixed numbers.  
2. Simplify a fraction to an equivalent fraction by removing factors common to the numerator and denominator.  
3. Change a mixed number to an improper fraction.  
4. Change an improper fraction to a mixed number.  
5. Determine the least common multiple of the denominators of two or more fractions.  
6. Convert two or more fractions to equivalent fractions with a common denominator.  
7. Perform operations on expressions involving fractions and mixed numbers.  
8. Simplify complex fractions.  
10. Solve linear equations involving fractional coefficients.  
11. Solve applications by translating to linear equations with fractional coefficients.
V. DECIMALS
1. Identify the place value and word names of decimals.
2. Write decimal numbers in expanded form.
3. Approximate decimals by rounding to a given place value.
4. Rank decimals in ascending order.
5. Perform operations on expressions involving decimals.
6. Simplify expressions with decimals using order of operations.
7. Change fractions to decimals and decimals to fractions.
8. Solve linear equations involving decimal coefficients.
9. Determine the square root of a given number using calculator.
10. Use the Pythagorean Theorem to determine the missing side of a right triangle.
11. Determine the area of geometric plane figure and the volume of a geometric solid figure.
12. Solve applications by translating to linear equations with decimal coefficients.

VI. RATIO AND PROPORTION
1. Identify ratios and rates.
2. Determine whether a proportion is true or false.
3. Solve proportions.
4. Use proportions to determine missing sides of similar geometric figures.
5. Solve applications by translating to ratios and proportions.

VII. PERCENT
1. Apply the definition of percent.
2. Change decimals to percents and percents to decimals.
3. Change fractions to percents and percents to fractions.
4. Solve applications by translating to linear equations involving percents.
5. Use formulas to calculate simple interest, compound interest, sales tax, and others.

VIII. MEASUREMENT
1. Apply definitions of U.S. and metric units of length, weight, capacity, and mass to approximate measurements.
2. Convert U.S. units from one unit to another.
3. Convert metric units from one unit to another.
4. Convert U.S. units to metric units and metric units to U.S. units given the conversion factors.
5. Convert temperature from Fahrenheit to Celsius and Celsius to Fahrenheit.

(4/4/2001)
MATHEMATIC PROBLEM SOLVING TEST

Direction: Please answer the following problems and indicate your solution for each on attached blank papers. Please encircle or identify your final answer/s. Also, as you work on each problem or as you review your solution, please indicate to the right of each item on this sheet if you thought the problem was hard (difficult) or easy (simple).

1) Mark & Stuart Martin collect foreign coins. Mark has twice the number of coins Stuart has. Together they have 120 foreign coins. Find how many coins Mark has. ___ Hard ___ Easy

2) Medication is prescribed in 7 out of every 10 hospital ER visits that involve an injury. If a large urban hospital had 620 ER visits involving an injury in the past month, how many of these visits would you expect included a prescription for medication? ___ Hard ___ Easy

3) A car manufacturer announced that next year the price of a certain model car would increase 4.5%. This year the price is $19,286. Find the increase and the new price. ___ Hard ___ Easy

4) Which is a better buy: a 16-ounce bag of frozen peas costing $1.19 or a 24-ounce bag costing $1.60? (Hint: find unit cost for each first.) ___ Hard ___ Easy

5) Anoa plans to use 26.3 meters of leftover fencing material to enclose a square garden plot for her daughter. How long will each side of the garden be? ___ Hard ___ Easy

6) On an airplane that was two-thirds full, 20% of the passengers were boys, ¼ of the passengers were women, 1/8 of the passengers were girls, and there were 68 men. How many seats are on the plane? ___ Hard ___ Easy

7) Incredibly Huge Motors is planning an employee and family day at a baseball park. They have reserved 6000 seats with the ball club. Each section at the ballpark has 15 seats in each row and is 18 rows deep. How many sections does the ball club need to set aside for the IHM employees and family? ___ Hard ___ Easy
Appendix F

MATHEMATICS COURSE SUCCESS ASSESSMENT
SAMPLE FINAL EXAM
Final Exam Test Form A

Perform the indicated operations.

1. 496 - 198

2. \[ \frac{279}{25} \]

3. \( 31,521 + 3 \)

Estimate the sum by rounding each number to the nearest hundred.

4. \( 5219 + 3852 + 1936 \)

Simplify:

5. \(-8 + (-7)\)

6. \(17 - 39\)

7. \(12(-3)\)

8. \((-36) + (-9)\)

9. \(7 - |12|\)

10. Evaluate \(3 - x(y + 2)\) when \(x = 2\) and \(y = -1\).

11. Find the perimeter for the triangle shown.

12. Solve the following equations:

   a. \(4x + 9 = 21\)

   b. \(7x - 9 = 6x - 13\)

Translate the following into a mathematical expression. Use \(x\) to represent “a number”.

13. The product of 3 and a number decreased by fifteen.

Perform the indicated operations. Write answers in simplest form.

14. \[ \frac{2}{5} \cdot \frac{3}{4} \]

15. \[ \frac{1}{8} + \frac{5}{6} \]

16. \[ \frac{16}{5} \cdot \frac{12}{5} \]
Final Exam Test Form A (cont.)

18. Simplify \[ \frac{7x}{8} \div \frac{21x}{16} \]

19. Solve \[ \frac{4}{5} + x = -\frac{1}{3} \]

20. Evaluate \(-4x - 5\) when \(x = -\frac{1}{4}\).

21. A piece 2 \(\frac{1}{2}\) feet is cut from an 8 foot board. How much is left after the piece is cut?

22. Find the area for the rectangle with dimensions \(\frac{2}{3}\) yd and \(1\frac{1}{2}\) yd.

Perform the indicated operations. Round the result to the nearest hundredth if needed.

23. \(-39.92 - (-61.58)\)

24. \(10.5 \times 2.34\)

25. \(0.089 + (-0.32)\)

26. Simplify \(2.3x - 1.6 - 0.9x\)

27. Find the square root \(\sqrt{\frac{81}{16}}\)

28. Find the unit rate for 197 miles for 10 gallons of gas. Round to the nearest tenth if needed.

Solve the proportions:

29. \(\frac{38}{3} = \frac{76}{x}\)

30. Given that the triangles are similar, find the missing length.

31. Write 3.6% as a decimal.

32. Write 25% as a fraction in simplest form.
Appendix G

MODIFIED MATHEMATICS AND SCIENCE ATTITUDE INVENTORY (MSAI)
MODIFIED MATHEMATICS AND SCIENCE ATTITUDE INVENTORY

The attached instrument is designed to measure attitude towards mathematics. Please respond to the questions on this page first, then, follow the instructions below. Thank you for your patience and assistance.

General Information:

Please place a check mark in the appropriate space next to each question:

1. Math section: A ___ B ___ C ____ D ____

2. Last 4 digits of HACC ID ________________ (Initials ____)

DIRECTIONS

The following statements are about the study of mathematics. Please read each statement carefully and decide whether it describes the way you feel about mathematics. Then, find the number of the statement on the answer sheet to the right, and put a circle around the appropriate response according to the following format:

If you Strongly Agree with the statement, circle SA.

If you Agree with the statement, circle A.

If you Disagree with the statement, circle D.

If you Strongly Disagree with the statement, circle SD.

Be sure to circle only one response for each statement. Please mark your answers only on the answer sheet, and do not write anything else on it. If you need to change your response, cross out (with an X) the response you don’t want considered.

Please respond to every statement.

Remember, this is not a test. Simply respond to each statement according to the way you feel right now.
MODIFIED MATHEMATICS & SCIENCE ATTITUDE INVENTORY

1. Mathematics is something which I enjoy very much.  
2. Solving mathematics problems is fun.  
3. There is little need for mathematics in most jobs.  
4. When I hear the word mathematics, I have a feeling of dislike.  
5. I would like to spend less time in school doing mathematics.  
6. Mathematics is helpful in understanding today's world.  
7. No matter how hard I try, I cannot understand mathematics.  
8. I often think, "I can't do it," when a mathematics problem seems hard.  
9. It is important to know mathematics in order to get a good job.  
10. I enjoy talking to other people about mathematics.  
11. Sometimes I do more mathematics problems than are given in class.  
12. I remember most of the things I learn in mathematics.  
13. I would rather be given the right answer to a mathematics problem than to work it out myself.  
14. It is important to me to understand the work I do in mathematics.  
15. I have a real desire to learn mathematics.  
16. It scares me to have to take mathematics.  
17. I have a good feeling toward mathematics.  
18. If I don't see how to do a mathematics problem right away, I never get it.  
19. I usually understand what we are talking about in mathematics.  
20. I feel uneasy when someone talks to me about mathematics.  
21. Mathematics is of great importance to a country's development.  
22. I would like a job which doesn't use any mathematics.  
23. I am good at doing mathematics problems.  
24. You can get along perfectly well in everyday life without mathematics.  
25. It makes me nervous to even think about doing mathematics.  
26. Mathematics is useful for the problems of everyday life.  
27. I don't do very well in mathematics.  
28. I would like to do some outside reading in mathematics.  
29. Mathematics is easy for me.  
30. Most people should study some mathematics.  
Appendix H

COGNITIVE MONITORING LEARNING LOG WRITING ATTITUDE SURVEY
COGNITIVE MONITORING LEARNING LOG WRITING ATTITUDE SURVEY

What is cognitive monitoring learning log?

*Cognitive monitoring learning log (CMLL)* is a metacognitive (thinking about thinking) strategy by which reflective writing is utilized and through which students are encouraged to think, to question, and to evaluate their own understanding of concepts, processes, or skills discussed and learned in class; the metacognitive attributes of monitoring and evaluation seen in Polya’s problem solving steps is facilitated here.

Much like personal journal writing or reflective writing, a cognitive monitoring learning log (CMLL) will enable students to put into writing their thoughts, observations, reactions, questions, ideas, concerns, even doubts and fears. It will be an avenue for students to express and to reflect upon their thoughts and strategies used, even the successes, challenges & difficulties faced in dealing with mathematics problems, concepts or process learned and other issues pertaining to the mathematics course.

The following inventory is designed to record your attitude or feelings toward CMLL. Please read the following statements carefully. Indicate how much you agree with each statement by circling the one response below that best reflects how you feel about the statement.

**Example:** Getting an “A” in my class will help me feel better about myself.

**Scoring:** Strongly Agree=1  Agree=2  Undecided=3  Disagree=4  Strongly Disagree=5

If you really feel that this statement is true then you would circle “Strongly Agree”. However, if you feel that there is only a slight possibility that getting an “A” in your class would make you feel better about yourself, then you would circle “Disagree”.

Please read the following statements and circle the response below that best reflects your feelings, thoughts, and/or experiences.

1. I have never heard about cognitive monitoring learning log (CMLL) writing.
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree

2. I have heard about CMLL writing before but never participated in it.
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree

3. I do not understand what is expected of me with CMLL writing.
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree

4. I know someone who writes in a learning journal or log.
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree

5. I know someone who likes to write in a learning log.
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree
6. Writing makes me feel comfortable.  
   **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

7. I think learning log writing could help me feel better about the course.  
   **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

8. Writing in a learning log is a waste of time.  
   **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

9. I like answering questions about what I am learning and thinking.  
   **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

10. Answering questions about my thinking process in a learning log may help me do better in the course.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

11. I usually like to write about what I am learning.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

12. I feel good about the course when I write.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

13. Writing and answering different things about what I am learning may help me reflect on my learning better.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

15. I do not enjoy learning log writing.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

16. I would like to participate in learning log writing assignments in class.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

17. I would like to keep a learning log at home and write in it frequently.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

18. I cannot picture myself being serious about learning log.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

19. Learning log might cause me to have different feelings about the course I am taking.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**

20. Learning log will make me think differently about the mathematics course I am taking.  
    **Strongly Agree**  Agree  Undecided  Disagree  **Strongly Disagree**
Appendix I

CMLL QUESTIONS / PROMPT
CMLL Question / Prompt

Please write your response at the bottom half of this page and give to your instructor. It will be returned to you with possible feedback and for you to include with your CMLL notebook/binder. Copy the question on your CMLL notebook using the top half of this form and date your log/entry. Write freely on the CMLL notebook given you and expand on whatever response you write on this form. Thank you!

CMLL Questions / Prompt:

Based on your recent test, what problem or question was difficult or challenging for you? (or what is causing you difficulty in this course?)

Why was it challenging or difficult?

How do you plan to resolve this challenge or difficulty?

If you have already overcome the difficulty or challenge, how did you do it? Otherwise, what do you think you need to do to overcome it?
Appendix J

Student Consent Form
Participant Consent Form

**Title:** The Impact of Cognitive Monitoring Learning Logs on College Students' Developmental Mathematics Success, Problem-Solving Performance, and Attitudes

**Researcher/Principal Investigator:**
Dr. Jacqueline Leonard, CITE Department (Math Education), (215) 204-8042

**Student Investigator:**
Joy Garcia Tien, Doctoral Candidate, College of Education, (717) 358-2995

The researcher is attempting to study students' mathematics course success, problem-solving performance, and attitudes about mathematics and cognitive monitoring learning log (CMLL) writing. Signing this form will give the researcher consent for you to participate in this study. The risks involved in this research are minimal, and no greater than those encountered in everyday life.

As a participant in this research, you will be asked to complete a problem-solving test and surveys designed to measure attitude toward mathematics and CMLL. You may be asked to write in a log twice weekly for 5-10 minutes. The log entries will be responses to specific questions. This will take place for a nine-week semester. You will then be asked to complete the problem solving test and surveys again.

Your identity will be kept confidential. Any results will be presented in aggregate form, with no identification of the individual participants. Your information will be kept along with this consent form in a locked file cabinet. Each participant will be given the opportunity to receive individual interpretation of the results, after the project has concluded.

Participants may be interviewed by an interview expert or someone trained by the researcher to discover their thoughts and feelings about mathematics. If you choose not to participate in this study you will answer questions prepared by your instructor related to the subject area. If you have any questions about this research, please contact the researcher listed above.

Questions about your rights as a research participant may be directed to Mr. Richard Throm, Office of the Vice President for Research, Institutional Review Board, Temple University, 3400 N. Broad Street, Philadelphia, PA 19140, (215) 707-8757

I have read and understand the explanation of this study and agree to take part in this study.

___________________________________________   ____________________
Signature  Date

___________________________________________
Printed name
Appendix K

INSTRUCTOR AGREEMENT / CONSENT FORM
Instructor Agreement / Consent Form

Title: The Impact of Cognitive Monitoring Learning Logs on College Students' Developmental Mathematics Success, Problem-Solving performance, and Attitudes

Researcher/Principal Investigator:
Dr. Jacqueline Leonard, CITE Department (Math Education), (215) 204-8042

Student Investigator:
Joy Garcia Tien, Doctoral Candidate, College of Education, (717) 358-2995

The researcher is attempting to study students’ mathematics course success, problem-solving performance, and attitudes about mathematics and cognitive monitoring learning log (CMLL) writing. Signing this form will give the researcher consent for you to participate in this study. The risks involved in this research are minimal, and no greater than those encountered in everyday life.

As a participant in this research, you will be asked to lead your students in their participation of the study. You will administer a problem-solving test and attitude surveys to complete, emphasizing the importance of honesty when completing them. This test and surveys are to be given one week prior to the log writing. Your students who have a signed consent forms to participate in the study will then be expected to write weekly for 5-10 minutes for nine weeks. You will then ask students to again complete the test and surveys, one week after log writing ends. To discover their feelings about mathematics and CMLL, the students will also be interviewed at this time by an interview expert or someone trained by the researcher.

You will be expected to keep the students’ information in a locked file cabinet along with their signed consent form. You will be the only one allowed to remove any information from this locked file cabinet. Logs will be collected from students weekly after class and returned to them the following week prior to class. Students are to write in their logs during scheduled time in class, over the long weekends as they work on their math homework, or for you to check them. You and your students’ identities will be kept confidential. Any results will be presented in aggregate form, with no identification of the individual participants. Each participant will be given the opportunity to receive individual interpretation of the results, after the project has concluded.

You will be prepared by the researcher with the specifics concerning introducing the log to the students and the explanation of the guidelines of which both are to be handed out and clearly explained to students. If you have any questions about research, contact the researcher listed above.

I have read the introduction of the CMLL and instructor guidelines. (Documents are attached)

I have read and understand the explanation of this study, agree to participate, and commit to follow the study to the best of my ability.

___________________________________________ ___________________
Signature Date

___________________________________________
Printed name
Appendix L

COMMUNITY COLLEGE AUTHORIZATION LETTER
Community College Authorization Letter

August 21, 2006

Mr. Ron Young
Vice President of Academic Affairs & Enrollment Management
Address
City PA

Dear Mr. Young:

I would like to request your assistance in a study that examines the students' mathematics course success, problem-solving performance, and attitudes about mathematics and cognitive monitoring journal log writing. Specifically, my research requires the examination of the mathematics students' performances on Mathematics Problem Solving Test (MPST) and responses to the mathematics and CMLL attitude surveys, interviews, and CMLL questions/prompts.

Would you be kind enough to write a letter to me stating that I have your permission to conduct research at Northeast Area in PA Community College? Please state in the letter that I have permission to observe and further examine the students' assessment results, as well as permission to interview faculty, staff, and students to obtain additional data if needed.

This study is a dissertation research which represents the final phase of my doctoral program in the Department of Curriculum, Instruction and Technology at Temple University. Furthermore, this study will meet the requirements of the Temple University policy relative to human subject research.

Please know that all names, including the College name and participants' names, will be changed in the final document.

I am most appreciative of your support and I look forward to completing my doctoral program at Temple University.

I thank you, in advance, for your help.

Sincerely,

Joy Garcia Tien

Title: The Impact of Cognitive Monitoring Learning Logs on College Students' Developmental Mathematics Success, Problem-Solving Performance, and Attitudes

Researcher/Principal Investigator:
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Appendix M

COGNITIVE MONITORING LEARNING LOG GUIDELINES
Objective: To practice expressing your thoughts on your learning through writing by keeping logs; you are encouraged to think, to question, and to evaluate your own understanding of concepts, processes, or skills discussed in class.

Guidelines:

1. Start a new sheet of paper for each entry.

2. Write for yourself and no one else. This is your learning log.

3. Write with whatever you feel most comfortable with: a favorite pen, pencil, or colored pencil.

4. Number each page in your log.

5. Your log should only contain entries for this class (i.e., no notes, loose papers, etc.).

6. Entries will only be written towards the end of class once a week.

7. Each entry should contain the date, learning log question or prompt, and your response.

8. If there is something else that you would rather write about that pertains to you (e.g., your feelings, thoughts, etc.), you may choose to write them and not respond to the question.

9. Don’t be concerned with grammar, spelling, punctuation, etc. Write so that you get your thoughts down as quickly as possible.

10. If you choose not to have an entry read you must write on top of the entry that you choose not to have this read.
The instructors were given directions on how to distribute the documents (tests and surveys) to students and were not be encouraged to respond a certain way to students. The researcher met with said instructor prior to the beginning of classes to discuss the administration and scoring of tests.

The instructors administered to students all pre-test/post-test documents - a Mathematics Problem Solving Test (MPST), a Modified Mathematics & Science Attitude Inventory (MSAI), and CMLL Attitude Survey (CMAS) and collected the information during the first week of classes; the CMAS was given a week prior to the CMLL intervention. The achievement tests were also instructor-administered tests (mid-term and final exams) given according to the schedule on the course syllabus. The course syllabus indicated the number and frequency of tests and quizzes.

The Mathematics Problem Solving Test (MPST) was scored by the researcher and validated by an outside mathematics education expert, using a College-approved rubric (Analytic Scale for Problem Solving). The researcher also worked on the scoring independent of the instructor and outside expert to see if there is an agreement to the scoring.

The researcher met with said course instructors prior to the CMLL intervention to go over the CMLL guidelines that will be provided to the students as a handout. The instructors were prepared by the researcher with the specifics concerning introducing the CMLL to the students and the explanation of the guidelines of which both are to be handed out and clearly explained to students.

All student logs were provided to the students by the researcher through the instructor. They were required to write their initials and last four digits of their college ID number on the log for differentiation.

The instructors were the only one to distribute and collect the logs. The logs were kept in a locked file cabinet in the instructors’ offices and were handled only by the instructors.

The students who have a signed consent form to participate in the study and were selected to be in the CMLL intervention were then expected to write once a week. The instructors then
asked students to once again complete the attitude inventories, one week after CMLL intervention ended. The students were also interviewed during finals week to discover their feelings about mathematics, problem solving and log writing.

The Mathematics Problem Solving Test (MPST) was administered a week prior to finals exam as a post-test.

Over a nine-week period (weeks 4-13), all groups were exposed to problem solving - both as a concept and process. The two groups receiving the CMLL intervention were asked to respond to question prompts for their CMLL writing strategy and/or note their reaction/plan on a problem solving task. They were given 5-7 minutes towards the end of the class period to discuss the question prompts or assigned non-routine problem and/or to make notes for their responses that were written on their logs. The other group simply did additional textbook exercises. The written responses were collected individually on a weekly basis for a period of 10 weeks (week 3-13).

The researcher and another trained rater will each review the data and determine the number of steps it took for students to solve a problem. The data may be categorized depending on the responses (to look for errors - procedural, computational, and algebraic - and to identify the strategies used to solve the problems (diagrams, tables, lists, guess-and-check, working backwards, searching for patterns, reasoning, and so on). The researcher and rater will agree on 90 percent of the error categorizations and 95 percent of the strategies used, with all discrepancies to be resolved through further dialogue.
Appendix O

INTERVIEW PROTOCOL
Interview Protocol

The interview was semi-structured as discussed by Gay, Mills and Airasian (2006).

The researcher asked an interview expert to conduct the interviews a week after the CMLL intervention.

Students were asked to volunteer for the interviews.

Students who volunteered for the interview were asked to meet with the interview expert at an agreed upon date/time.

The researcher reviewed students’ responses to the post-MPST and shared with the interviewer.

The interviewer then proceeded with meeting identified volunteer interview participants and solicited their consent to audio-tape the interviews. The interviewer also took notes as appropriate.

The interviewer used the questions on the MSAI & CMAS to ascertain student attitudes for follow up or further probing on their answer. The semi-structured interview questions appear in APPENDIX P.

Student responses were transcribed.
Appendix P

SEMI-STRUCTURED INTERVIEW QUESTIONS
SEMI-STRUCTURED INTERVIEW QUESTIONS

The students can be asked questions about the attitude survey responses in order to get more questions. For instance, "On question one, you said........ Please elaborate......"

The students could be given a problem, or a solution to a problem that they already solved. The interviewer may say, "Please look over your solution to the problem. Please tell me how you solved this problem..."

Following are questions that may be asked:

1. Tell me about your experiences with the learning log in your math class?

2. What do you perceive as the benefits of writing logs, if any?

3. How has learning log helped you with math?

4. If you had to use learning logs in another math class, what recommendations would you offer to make it more effective for you?

5. How has the log writing affected your attitudes toward mathematics?

6. Please look over your solution (or thought process) to a problem you recently solved. Please tell me how you solved this problem. What would you do differently?