

THE EFFECTS OF PRACTICE AND WORKING-PRACTICE HOMEWORK ON THE  
MATH ACHIEVEMENT OF ELEMENTARY SCHOOL STUDENTS SHOWING  
VARYING LEVELS OF MATH PERFORMANCE

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Doctor of Philosophy

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by

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The undersigned, appointed by the Dean of the Graduate School, have examined the dissertation entitled

THE EFFECTS OF PRACTICE AND WORKING-PRACTICE HOMEWORK ON THE  
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VARYING LEVELS OF MATH PERFORMANCE

presented by Jill C. Roper,

a candidate for the degree of Doctor of Philosophy,

and hereby certify that in their opinion it is worthy of acceptance.

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## DEDICATION

To RV. Using Brian Wilson and Tony Asher's words, "God only knows what I'd be without you."

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ABSTRACT

While homework has been an active research area, clear documentation of the effects of homework on academic achievement using students showing varying levels of academic performance has not been explored. The purpose of this study was to examine the effects of math calculation homework on the math performance of elementary school students demonstrating varying levels of achievement in math. The study also explored the effects of practice homework and a different type of homework, working-practice homework, which incorporated drill ratio procedures on math achievement. Ninety participants, who were all enrolled in the fifth grade at a Mid-Atlantic, suburban school district, completed the study. After completing a pretest, the participants were blocked into one of three achievement groups (top, middle, and lower) based on their pretest scores and randomly assigned either practice or working-practice homework for 6 weeks. The posttest results indicated no statistically significant differences between the two homework types overall or within each level of achievement group. Regardless of homework type assigned, participants on average demonstrated academic progress for the math calculation skills covered in the presence of instruction; however, between the level of achievement groups, the participants appeared to respond differently.

## Chapter One: Introduction

### *Mathematics: Performance, Curriculum, and Evidenced-Based Practices*

During the last half of the twentieth century and the beginning of the twenty-first century, increased evidenced has suggested that a significant number of American students are not sufficiently learning important mathematics skills. Public and professional concerns pertaining to mathematics performance dates back to the late 1950s when math and science achievements in the United States lagged behind the math and science achievements of other industrialized nations (Cooper, 1989; Cooper, Greathouse, Lindsay, & Nye, 1998; Olympia, Sheridan, & Jenson, 1994; Walberg, Paschal, & Weinstein, 1985). For example, in 1983 the landmark publication of *A Nation at Risk: The Imperative for Educational Reform* concluded that American schools were failing miserably in mathematics as evidenced by scores dropping by nearly forty points on the mathematics section of the College Board's Scholastic Aptitude Tests (SAT; The National Commission on Excellence in Education, 1983). *A Nation at Risk* also included a discussion pertaining to unfavorable comparisons of the mathematics achievement of American students to students in other nations. Consequently, *A Nation at Risk* suggested to the public that American education systems were at risk of producing a generation of students with considerable deficiencies in mathematics.

More recently, the National Center for Educational Statistics reported the average math scores for fourth grade students has increased only 27 points in the past 17 years (Lee, Grigg, & Dion, 2007). Reportedly, the average math scores for eighth grade students increased merely 19 points in the past 17 years. A Children's Defense Fund

study published in 2005 indicated that greater than 50% of fourth grade students are below grade level in the area of math. Data from the National Assessment of Educational Progress suggested that only a small percentage of American students are considered proficient in the area of mathematics (Children's Defense Fund, 2005; Lee, Grigg, & Dion, 2007).

As a result of the lackluster academic performances observed in American school children, waves of educational initiatives were developed and implemented in an attempt to achieve educational reform, including "Goals 2000" and the No Child Left Behind Act. "Goals 2000" produced lofty educational goals for American students to be, for instance, first in the world in both science and mathematics achievement. The No Child Left Behind Act, which was signed into law in early 2002, established grade level achievement standards, adequate yearly progress primarily determined through standardized assessment, and an expectation of student skill proficiency by 2014 through the use of research supported instructional practices (No Child Left Behind Act, 2001). One significant feature of the No Child Left Behind Act was its requirements for curriculum. According to the No Child Left Behind Act, students must have access to effective, scientifically based instructional strategies, and challenging academic content as a requirement of the Act. Reportedly, curriculum that cannot satisfy the scientifically based criteria of the Act cannot be purchased with No Child Left Behind funds by American schools.

Despite the requirements presented in the No Child Left Behind Act, math instruction traditionally falls well behind reading instruction in most everyday educational practices (Clarke, Baker, & Chard, 2008). According to the federal

government's periodic national survey of teachers, reading instruction consumed on average 36% of instructional time per school week in comparison to mathematics instruction which showed on average 17% of instructional time during the school week. (Rothstein & Jacobsen, 2006). Educational professionals consistently suggest and expect reading to be taught for at least 90 minutes per school day, especially for students struggling with the skills necessary to read (Clarke, Baker, & Chard, 2008). In addition, educational professionals are expected to incorporate the five identified essential components for reading, including phonemic awareness, phonics, vocabulary, fluency, and comprehension in their instructional practices (Lee, Grigg, & Donahue, 2007). Such specificity does not exist for mathematics and the implication is that schools dedicate fewer resources for mathematics instruction in comparison to reading instruction (Clarke, Baker, & Chard, 2008).

Yet, the need for high quality math instruction is beginning to receive some increased political and professional attention. For example, in 2006 a National Math Panel was created within the United States Department of Education. The National Math Panel, which is similar in structure to the 1997 creation of the National Reading Panel, offered the following general themes in regards to mathematics instruction: (1) math knowledge is critical to a well rounded education; (2) long-term success in mathematics is contingent upon a solid foundation of mathematics learning and achievement; (3) the United States needs to improve on how mathematics is taught (Lee, Grigg, & Dion, 2007). Additionally, the National Council of Teachers of Mathematics has advocated for fluent computation as a goal for elementary mathematics instruction and a solid background in algebra as a goal for middle school mathematics instruction (National

Council of Teachers of Mathematics, n.d.). Presently, the National Council of Teachers of Mathematics adopted a concrete set of mathematics goals and objectives, termed curriculum focal points, or key mathematical ideas and concepts for students in Kindergarten through the eighth grade (National Council of Teachers of Mathematics, n.d.). According to the National Council of Teachers of Mathematics, the curriculum focal points were created because American students are expected to acquire a wide range of mathematics topics in a short time period. As a result, the curriculum focal points offer a focused framework designed to guide states and school districts with the development of mathematics expectations, standards, and curriculum. For example, the curriculum focal points for fifth grade mathematics instruction include the following three objectives: (1) developing an understanding of and fluency with division of whole numbers; (2) developing an understanding of and fluency with addition and subtraction of fractions and decimals; (3) describing three-dimensional shapes and analyzing their properties, including volume and surface area. The curriculum focal points for eighth grade mathematics instruction also consist of three objectives: (1) analyzing and representing linear functions and solving linear equations and systems of linear equations; (2) analyzing two and three dimensional space and figures by using distance and angles; (3) analyzing and summarizing data sets (National Council of Teachers of Mathematics, n.d.).

On account of the No Child Left Behind Act, scientifically based instructional strategies, or evidenced-based practices, have also received increased attention from politicians and professionals for the purpose of improving the academic achievement of all students in order to meet annual assessment standards (Odom et al., 2005). However,



in the past, most research attention to evidenced-based practices has focused primarily on reading, which is comparable to the emphasis placed on reading instruction (Daly & McCurdy, 2002). Research attention related to evidenced-based practices in mathematics instruction and intervention has lagged behind comparably, despite national organizations, such as the National Council for Teachers of Mathematics, emphasizing the need for more useful evidenced-based practices to be implemented by educators for the purpose of increasing mathematics achievement (National Council for Teachers of Mathematics, n.d.).

### *Homework: An Evidenced-Based Practice*

Historically, public attitudes toward homework have been cyclical (Gill & Schlossman, 1996). Today in the United States, the influence of popular social values, national organizations, and most importantly federal legislation has repositioned focus on scientifically supported instruction and interventions for students enrolled in American educational systems. Consequently, homework, as either an instructional strategy or intervention designed to provide increased opportunities to respond, appears at a crossroads in regards to its overall academic effectiveness as perceived by policymakers, educational practitioners, and the public.

According to the research literature, parental, political, and professional pressure to emphasize homework may be justified because of perceived potential benefits, including improved academic achievement (Keith & Keith, 2006). Researchers have consistently concluded that time spent on homework has a positive relationship with academic achievement for both junior high and high school students (Cooper, 1989; Cooper, Robinson, & Patall, 2006; Keith, 1982). According to the results of Cooper's

(1989) meta-analysis, 14 studies showed students earning higher scores of academic achievement when assigned homework. Although Cooper's (1989) meta-analysis demonstrated that homework had a positive effect on academic related outcomes, the grade level of the student influenced the effect homework had on academic achievement with minimal effects observed for elementary school students.

Cooper et al. (2006) examined the impact of grade level on correlations between time spent on homework and academic achievement. They concluded that a consistent and conclusive causal link exists between homework and academic achievement. The strong effects observed between the assignment of homework and academic achievement for secondary students were consistent with Cooper's previous results, yet a similar effect was also observed with elementary school students, especially in the primary grades (Cooper, 1989; Cooper et al., 2006). Homework completion caused improved academic achievement and Cooper later opined that the purpose for homework in upper elementary grades should be to foster academic achievement (Cooper, 2007; Cooper et al., 2006).

#### *Purpose of Study*

The need for research in mathematics instruction and intervention is crucial for three key reasons, which are: (1) the preponderance of evidence suggesting that American students are not acquiring mathematics skills; (2) the federal expectation of skill proficiency by 2014 through the use of research supported instructional practices; (3) the beliefs of national mathematics organizations that American students need to acquire, at minimum, calculation skill fluency and algebraic knowledge by the end of the eighth grade. The need for research in mathematics instruction and intervention is also crucial because math calculation skills can greatly differ between students in public

elementary schools. According to Fuchs, Fuchs, and Karns (2001), the distribution of math calculation skills in the public schools has shown considerable variability. The National Center for Educational Statistics identified only 39% of fourth grade students as performing at or above the proficient range in mathematics (Lee, Grigg, & Dion, 2007).

Albeit controversial at times in part because of researchers showing some divided conclusions pertaining to its benefits and limitations, homework, as an instructional strategy, is a part of most elementary school students' daily routines (Cooper et al., 2006). According to the most current research published in the literature, elementary schools students were assigned homework on an average of 3.31 nights per school week and the average quantity of homework assigned for the elementary school student was 41.5 minutes per evening (Roderique, Polloway, Cumblad, Epstein, & Bursuck, 1994). Additionally, over two-thirds of all 9-year old students reported completing homework daily (Campbell, Reese, O'Sullivan, & Dossey, 1996). Among students ranging between 6 to 8 years of age, homework appears to have increased from 52 minutes a week in 1981 to 128 minutes in 1997 (Hofferth & Sandberg, 2000). As a result, homework has been a practicing area of study among educational researchers as evidenced by a number of synthesis studies conducted on the topic of homework.

Even though research studies examining the influence of homework on the academic achievement of elementary school students, especially those enrolled in primary grades, have shown mixed results, homework researchers for the most part support the use of homework in upper elementary grades for the purpose of fostering academic achievement (Cooper, 1989; Cooper et al., 2006). So far, research studies attempting to establish a causal relationship between homework and academic

achievement are traditionally characterized by two types of designs: randomly assigning classrooms or students within classrooms to homework and no homework conditions; and assessing the amount of homework completed by students and their corresponding academic achievement (Cooper 1989; Cooper et al., 2006). A contribution of the current study to the research literature on homework was to deviate from traditional designs. To date documentation of any causal relationships between homework and varying levels of achievement, including high, average, and low achieving students, has yet to be established in the research literature in spite of evidence that elementary school students show a wide distribution of math calculation skills (Fuchs, Fuchs, & Karns, 2001). According to Cooper et al. (2006), “nearly all the literature that we uncovered looked at the effect of homework on students who might be labeled ‘average,’ or examined broad samples of students, but did not look for moderating effects of student characteristics” (p. 53). Therefore, one purpose of the present study was to examine the effects of math calculation homework on the mathematics achievement of fifth grade elementary school students demonstrating varying levels of academic achievement in mathematics.

The research literature has consistently demonstrated that increased practice, or increased opportunities to respond, enhances student learning (Skinner, 2008). Consequently, educational researchers have often studied different practice, or drill, models for the purpose of determining the instructional effectiveness of repetition (MacQuarrie, Tucker, Burns, & Hartman, 2002). One of the oldest drill models is practice homework, which typically consists of opportunities for students to practice or review newly acquired skills or procedures presented in class during non-school hours (Cooper, 1989; Lee & Pruitt, 1979). A more recent drill model presented in the drill ratio

literature, incremental rehearsal, has demonstrated that interspersing, or folding-in, known information with unknown information increases academic skill acquisition during in-class activities (MacQuarrie et al., 2002; Nist & Joseph, 2008). Despite the attention to drill models in the research literature, research designs comparing the influence of a traditional drill model to a more recent drill model through homework assignments on academic achievement have not been presented in the research literature. Thus, another purpose of the present study was to examine the effects of two different drill models as presented in homework assignments on participants' academic achievement in mathematics. The present research used practice homework as the traditional drill model and working-practice homework as a more recent drill model. For this study, practice homework consisted only of math calculation skills in need of acquisition. Working-practice homework, a new type of homework created for the study, was derived from the drill ratio research pertaining to incremental rehearsal. For this study, working-practice homework consisted of both math calculation skills already covered in the curriculum and math calculation skills in need of acquisition using a 'folding-in' technique across assignments.

Based on the purposes of the study, research hypotheses were formulated as follows: (1) participants assigned working-practice homework will achieve higher posttest scores compared to participants assigned practice homework; (2) participants blocked in the top third achievement group will achieve higher posttest scores after exposure to working-practice homework compared to those exposed to practice homework; (3) participants blocked in the middle third achievement group will achieve higher posttest scores after exposure to working-practice homework compared to those

exposed to practice homework; (4) participants blocked in the lower third achievement group will achieve higher posttest scores after exposure to working-practice homework compared to those exposed to practice homework.

## Chapter Two: Review of the Literature

### *The Fundamentals of How Students Learn*

#### *Learning and Memory Theory*

Learning and memory are often considered intertwined. Few acts of cognition and learning do not involve memory (Byrnes 2001, 2007). Information must be encoded and associated with or related to other known information in memory. The existing knowledge stored in memory influences the ease with which new information is stored and later retrieved. Thus, what is remembered about some information is often a function of how the information was learned (Bjorklund, 1995; Byrnes, 2001, 2007).

The key elements of a memory system include sensory buffers, rehearsal systems, records, cues, working memory, and permanent memory (Byrnes, 2001, 2007). When students experience an event, such as completing their math homework, their sensory detectors and perceptual systems register the stimulation from the event, interpret it, and retain it for a very short period of time. As a result, the sensory buffer is useful because it retains information long enough for the student's mind to interpret the information. Rehearsal systems often involve the use of a sensory system to register verbal, visual, or spatial information. The information is rehearsed before the sensory trace (associated with the information) fades. Anderson (1995) used the term "record" to refer to a mental representation of an item of information permanently stored in memory. According to Anderson when a student "knows" a large quantity of information, the student has many records in his or her memory. Records correspond to four different types of knowledge: declarative, procedural, conceptual, and episodic (Anderson, 1995; Byrnes, 2001, 2007).

Declarative knowledge is a compilation of all the facts a student knows. While procedural knowledge is a compilation of all the skills and habits a student has learned, which according to Byrnes (2001), appears to be associated with environmental cues. When a student is presented with a set of fractions showing common denominators, for example, procedural knowledge may be cued to retrieve the procedure for adding the set of fractions presented. Conceptual knowledge reflects an individual's understanding of their declarative and procedural knowledge, while episodic knowledge represents where someone was when something happened and when the event took place (Bjorklund, 1995; Byrnes, 2001, 2007).

Two constructs explain why students have an easier time remembering some information instead of other information: strength and activation level (Anderson, 1995; Byrnes, 2001, 2007). The strength of a record is the degree to which the record can be retrieved from memory and made available to consciousness. Higher strength records are well-learned facts, procedures, explanations, or personal events easily retrieved from memory, whereas lower strength records are not well-learned facts or procedures and are difficult to recall from memory. According to the research literature, the amount of practice obtained through increasing the number of academic opportunities to respond led to improved retention of newly learned items (Cates, 2005; Greenwood, Delquadri, & Hall, 1984; Skinner et al., 1999). Skills, facts, or procedures practiced regularly through repeated academic trials, such as homework, influences the strength of a record and promotes higher levels of strength than those not practiced to the same degree (Byrnes, 2001, 2007). The activation level of a record is a records' current degree of availability (Anderson, 1995; Byrnes, 2001, 2007). Records considered in a higher state of activation



are conscious and available, while records considered in a low state of activation are not quite conscious or available. Therefore, higher strength records, or information, come up more quickly than lower strength records. In sum, the activation level refers to the current state of a record and strength corresponds to the potential of the record for activation. A student's memory system relies on cues, or environmental stimuli such as homework, shifting records from a state of low activation to a state of higher activation. If the level of activation is high enough, the record is available to consciousness (Anderson, 1995; Byrnes, 2001, 2007).

In contemporary cognitive psychology, the concept of working memory refers to any information currently available for working on a problem (Bjorklund, 1995; Byrnes, 2001, 2007). Thus, items in the sensory buffers or rehearsal systems are in working memory as are permanent records in a highly active state. In direct contrast to working memory, permanent memory pertains to any student's storehouse of records. In order to form permanent records, three main processes can occur: encoding, elaboration, and rehearsal. Encoding is a general term used to describe the process of taking sensory information and transforming the information into a permanent record. Elaboration pertains to the process of embellishing a sensory experience with additional details. However, rehearsal is the process of repeating, re-experiencing, or practicing some stimulation over and over (Bjorklund, 1995; Byrnes, 2001, 2007). An example of the rehearsal process is when a student completes a homework assignment containing 30 division problems.

The three main ways information is retrieved from permanent memory include inferential reconstruction, recall, and recognition (Bjorklund, 1995; Byrnes, 2001, 2007).

Inferential reconstruction is used when environmental cues result in the retrieval of only a few fragments of a more complete record. Recall is when a student is presented with a limited number of environmental cues and attempts to retrieve information associated with those cues. Recognition is the process involved when a student experiences a stimulus and the student matches that stimulus with a permanent record. Whereas recognition directly matches a permanent record with an environmental cue, recall only retrieves information merely associated with that cue (Bjorklund, 1995; Byrnes, 2001, 2007).

Regardless of the cognitive development or learning theory examined, memory is a constant concept used to explain mental processes, including thinking, remembering, and problem solving (Byrnes, 2001, 2007). Furthermore, most theories of cognitive development and learning emphasize the role of practice, repetition, or rehearsal (Bjorklund, 1995; Byrnes 2001, 2007). For behaviorists such as Thorndike (and information processing theorists), practice is thought to increase or modify the strength of associative bonds between individual segments of knowledge. However, for constructivists (such as Piaget and Vygotsky), practice assists students with internalizing skills and eliciting meaning through a process of abstraction. Consequently, the suggestion that academic exercises emphasizing practice, repetition, or rehearsal, such as homework, is detrimental to cognitive development and meaningful learning appears to be theoretically unfounded (Bjorklund, 1995; Byrnes, 2001, 2007).

#### *Academic Skill Development*

Haring and Eaton (1978) presented a hierarchical theory of academic skill development that emphasized drill and practice as two crucial procedures used to teach

skills to a variety of students. They described skill development as occurring in a sequence of four distinct stages (acquisition, fluency, generalization, and adaptation) and also argued that the concept of maintenance occurred throughout the hierarchy. Even though various instructional strategies are available for facilitating the development of academic skills, Haring and Eaton advocated for the inclusion of drill and practice in students' educational environments for the purpose of teaching academic skills. Drill and practice procedures serve different functions. They defined drill as those procedures aimed at the repetition of responses to be learned, while practice was defined as those procedures focused on combining a number of learning responses in order to solve problems. Both drill and practice procedures necessitate numerous opportunities for accurate academic responses.

The first stage in the academic skill development model is acquisition and defined as learning, or acquiring, a new academic skill through the provision of numerous opportunities to accurately respond (Haring & Eaton, 1978). The purpose of the acquisition stage is for students to acquire a set of specific responses (declarative knowledge) or procedures (procedural knowledge) not yet stored in permanent memory. The acquisition stage is mastered when students produce accurate academic responses under specific conditions. For example, a student who was able to verbally provide the answer "eight" to a verbal cue ("What is  $2 \times 4$ ?") would demonstrate mastery of the acquisition stage for this skill only.

The second stage of Haring and Eaton's academic skill development model is fluency, which requires students to perform acquired skills or procedures more proficiently, often in the absence of instruction, while maintaining accurate responses.

Fluency also involves the ability to recall responses quickly and with little cognitive effort. As a result, fluency is often referred to as overlearning, or automaticity, in the cognitive and learning theory literature and consists of intense and repeated drills or practice following the mastery of the acquisition stage (Bjorklund, 1995; Byrnes, 2001, 2007; Haring & Eaton, 1978). According to Haring and Eaton (1978), instructional approaches for developing fluency typically emphasize both drill and practice procedures. As an example, a student who has mastered the fluency stage could demonstrate not only the accurate response of “eight” in the presence of a verbal cue (“What is  $2 \times 4$ ?”) but could also produced the response quickly and with relatively little effort.

Haring and Eaton’s third and fourth stages are generalization and adaptation. In the generalization stage, students are expected to perform a newly learned, or acquired, academic skill across different conditions. For instance, when students who were taught to provide the verbal response of “eight” following a verbal cue (“What is  $2 \times 4$ ?”) could also provide the written response “8” following the same verbal cue (“What is  $2 \times 4$ ?”), the students demonstrated generalization. Haring and Eaton described the adaptation stage as students modifying learned, or acquired, responses to fit different situations. Students who were able to produce the written response “8” somewhere in a long division problem, such as  $168/2$ , were adapting their mathematics skills to different situations stretching beyond acquisition, fluency, and generalization.

Haring and Eaton’s (1978) theory of academic skill development is useful to understand how homework can effectively facilitate academic skill development by increasing opportunities for a student to respond. Because developing the ability to

respond accurately is the first step to skill mastery, procedures designed to enhance accuracy can also impact subsequent stages of skill development including fluency, generalization, and adaptation (Poncy, Skinner, & Jaspers, 2007). The research literature has consistently shown that providing more student opportunities to respond, by increasing the number of presentations through rehearsal led to improved retention of newly learned items (Cates, 2005; Greenwood et al., 1984). Although increased opportunities to respond is important for student learning, especially with students showing low academic performance, general education teachers seem to lack effective and research supported methods to provide the necessary repetition (Burns, 2004).

#### *Historical Perspective on Attitudes Towards Homework*

While the body of research literature demonstrates that homework can effectively facilitate academic skill development by providing increased opportunities for a student to respond, attitudes toward homework have changed in accordance with shifts in economic trends, values, and norms. Homework has been perceived at times as counterproductive to student's educational and social development. At other times, homework has been viewed as an effective instructional tool in the educational environment for the purpose of enhancing the acquisition of academic knowledge.

#### *Late Nineteenth Century: 1880-1900*

Although historians remain uncertain as to how frequently, how much, and with what variety students at each grade level were assigned homework during the late nineteenth century and early twentieth century, educational historians believe the intellectual demands placed on children in early elementary school were not great (Gill & Schlossman, 1996). However, by the fifth grade, intellectual demands increased and

educational instruction focused strictly on “the classic trinity” of academic instruction: drill, memorization, and recitation (Gill & Schlossman, 1996; Klavan, 1992). In daily classroom lessons, students were drilled on the “Three R’s” (‘reading, ‘riting, and ‘rithmetic’) and were not called upon to think creatively by applying recently acquired knowledge to their lives outside of the classroom environment (Klavan, 1992). Additionally, in the remaining academic disciplines, such as history, science, and literature, students were expected to memorize material at home in order to recite the information the following school day (Gill & Schlossman, 1996). Students had no choice but to devote substantial blocks of time each night preparing for daily recitations and examinations through the memorization of historical dates, scientific facts, and literary concepts (Barber & Doyle, 1990; Cooper, 1994; Gill & Schlossman, 1996; LaConte, 1981). Consequently, the educational community perceived homework not only as a determinant for knowledge acquisition and grade promotion, but also as a method of disciplining children’s minds through mental exercise (Cooper, 1989; Cooper et al., 1998; Gill & Schlossman, 1996; Klavan, 1992). Homework was heralded as a prerequisite to intellectual growth and development.

*First Half of the Twentieth Century: 1900-1950*

During the first half of the twentieth century, the majority of educational professionals supported the assignment of homework for the purpose of memorizing information. Yet, a group of educational administrators (including William Torrey Harris), social scientists (such as John Dewey), and journalists (such as Edward Bok), started to question the benefits of homework as an instructional strategy (Gill & Schlossman, 1996; Klavan, 1992). Inspired by the publications of Joseph Mayer Rice (a

doctor who attacked the purpose of recitation), William Torrey Harris (the Commissioner of Education) testified before the United States Congress in 1900 that homework should not be assigned before the age of 12 (Gill & Schlossman, 1996). In addition, Dewey, an educational theoretician, argued for the importance of demonstrating problem-solving skills in the educational environment rather than assigning homework stressing rote memorization for the purpose of drilling students during daily recitations (Baber & Doyle, 1990; Klavan, 1992; LaConte, 1981). By far, the most vocal individual in the early years of this seemingly antihomework movement was Edward Bok, the editor of the *Ladies' Home Journal* (Gill & Schlossman, 1996). Under Bok's editorial direction, the *Ladies' Home Journal* advocated against the assignment of homework because the hours spent on homework assignments caused students crooked spines, night terrors, and nervous breakdowns (Gill & Schlossman, 1996). As a result of Bok's antihomework opinions, which were not scientifically based, the *Ladies' Home Journal* supported the abolition of homework for all students under the age of 15 - as well as the idea that high school students should not receive more than one hour of homework per night. Reportedly, Bok personally believed if supplementary study was necessary, a study period needed to be incorporated into the regular school day (Gill & Schlossman, 1996).

Beginning in 1913, antihomework literature flooded the publication markets as evidenced by articles in the *Ladies' Home Journal*, the *New York Times*, the *San Francisco Chronicle*, and the *Elementary School Teacher*. These articles fueled a public outcry against the assignment of homework (Cooper et al., 1998; Gill & Schlossman, 1996; Klavan, 1992). Middle class Americans not only called into question the purpose of homework, but also perceived homework as an intrusion on students' time to pursue

either leisure activities or engage in family interactions outside of the school environment (Baber & Doyle, 1990; Cooper et al., 1998; Gill & Schlossman, 1996; Klavan, 1992; LaConte, 1981). Supporters of an antihomework movement advocated for the development of student problem-solving skills, initiative, and interest in learning rather than the ‘drill and skill’ approach of the late nineteenth century (Cooper, 1989; Cooper et al., 1998; Gill & Schlossman, 1996). Consequently, American school districts, provoked by the American Child Health Association’s classification of homework as a form of child labor, either severely limited the amount of homework or abolished homework altogether from academic curricula. Both the New York City and San Diego public school districts banned homework until the fourth grade and eighth grade, respectively, and the Sacramento school district prohibited the assignment of homework to elementary school students altogether (Gill & Schlossman, 1996).

#### *Second Half of the Twentieth Century: 1950-1999*

Following the end of World War II, the homework debate underwent another renaissance as a result of emerging educational philosophies. The United States experienced significant changes in demographic patterns after the war, primarily characterized by the shift from a rural to an urban society and new developments in technology to gather, store, access, and transmit information (Baber & Doyle, 1990; LaConte, 1981). Amidst the changes and confusion of America’s “Information Age” (Baber & Doyle, 1990, p. 23), opinions pertaining to American educational systems and homework were in a state of controversy. As an instructional tool, homework was both championed and challenged. While defended by some as an academic necessity for achievement, other individuals regarded homework as useless busywork (Baber & Doyle,



1990; LaConte, 1981). However when the Russians started the “race for space” (Klavan, 1992, p. 22) with the launching of the Sputnik satellite in 1957, politicians, educational professionals, and the general public became concerned with the absence of rigor in American educational systems (Cooper, 1989; Cooper et al., 1998; Olympia et al., 1994; Walberg et al., 1985). American students were viewed as lacking in the knowledge base to tackle the complexities of a technological future and perceived as inadequately equipped to compete against the ideological adversaries of the United States (Cooper, 1989; Cooper et al., 1998). As a result, homework was reintroduced into the American educational environment in order to reestablish academic rigor and prepare students for future technological competition (Cooper, 1989; Cooper et al., 1998; Klavan, 1992; Olympia et al., 1994).

During the 1960s, attitudes toward homework experienced, yet again, another ideological shift (Cooper, 1989; Cooper et al., 1998; Klavan, 1992). Contemporary learning theories called into question the value of homework and the impact of homework on students’ mental health (Cooper, 1994; Cooper et al., 2006). Rather than enforcing the memorization and regurgitation of factual information, educators, now concerned with the needs of the whole child, emphasized thinking creatively, working cooperatively, and learning simply to learn in the educational environment (Klavan, 1992). In an article written for the *Peabody Journal of Education*, Wildman (1968), an education professional, wrote: “Whenever homework crowds out social experience, outdoor recreation, and creative activities, and whenever it usurps time devoted to sleep, it is not meeting the basic needs of children and adolescents” (p. 203). Once again, the American public was more concerned with preserving children’s after school hours for

leisure activities that stimulated emotional, mental, and physical development (Cooper, 1989; Cooper et al., 1998).

In 1983, the National Commission on Excellence in Education released *A Nation at Risk: The Importance for Educational Reform*, which transformed general attitudes toward homework and shifted the perception of homework towards a more positive light. In *A Nation at Risk*, the Commission argued that young adults were graduating from secondary schools inadequately prepared for either a post-secondary education or entry-level employment (The National Commission on Excellence in Education, 1983). In addition, the average performance of American high school students on most standardized achievement tests was reported as lower than twenty-six years earlier. As an example, the Commission presented information from the College Board's Scholastic Aptitude Tests (SAT), which displayed an unbroken decline from 1963 to 1980, with verbal scores decreasing by over fifty points and mathematics scores dropping by nearly forty points. Members of the Commission also reported that "the amount of homework for high school seniors has decreased (two thirds report less than 1 hour a night) and grades have risen as average student achievement has been declining" (The National Commission on Excellence in Education, 1983, pp. 19-20). In order to reverse the declining trend in academic achievement the Commission proposed that "we must demand the best effort and performance from all students, whether they are gifted or less able, affluent or disadvantaged, whether destined for college, the forum, or industry" (The National Commission on Excellence in Education, 1983, p. 24). One of the Commission's recommendations was to devote significantly more time to learning the "New Basics" by the assignment of far more homework than was the case in the past

(The National Commission on Excellence in Education, 1983, p. 29).

In order to reinforce homework's return to prominence, the United States government addressed the topic in a booklet titled *What Works* (U.S. Department of Education, 1986). As a public 'cheat sheet' for information pertaining to research on education, *What Works* reported, "student achievement rises significantly when teachers regularly assign homework and students conscientiously do it" (U.S. Department of Education, 1986, p. 41). Furthermore, the booklet concluded that homework benefits all students regardless of ability because of the relationship between total time dedicated to studying and how much information is learned (U.S. Department of Education, 1986). In other words, *What Works* advocated for 'the more homework, the better' approach to assigning homework.

#### *Early Twenty-First Century: 2000-2008*

The topic of homework continues to be a zealous subject for nationwide debate, due to studies, policies, and legislation citing poor academic performance and a need for increased academic expectations (Marzano & Pickering, 2007). A Children's Defense Fund study published in 2005 indicated that greater than 50% of fourth grade students are below grade level in the areas of reading and math, and data from the National Assessment of Educational Progress suggested that only a small percentage of American students are considered proficient in the areas of language arts and mathematics (Children's Defense Fund, 2005; Lee, Grigg, & Dion, 2007). Furthermore, the Department of Health and Human Services campaigned for policy reform focused on improving student academic achievement, and the No Child Left Behind Act (P.L. 107-110) established standards for minimum grade level achievement and skill proficiency for

all students by 2014 (Department of Health and Human Services, 2001; No Child Left Behind Act, 2001). As a result, research-based instructional strategies, such as homework, are perceived by some as one solution to failing academic standards (Cooper et al., 2006).

The American popular press, including *Newsweek* and the *New York Times*, has joined the efforts of political and professional organizations, like the National Education Association (NEA), the National Parent Teacher Association (NPTA), and the U.S. Department of Education, in maintaining the positive position of the homework pendulum with the publication of articles discussing the advantages of homework for students in the educational environment. In the article *Helping your student get the most out of homework*, the NPTA supports the assignment of homework for all grade levels because “teaching and learning research indicates that children who spend more time on regularly assigned, meaningful homework, on average, do better in school” (National Parent Teacher Association [NPTA] & National Educational Association [NEA], n.d.). Homework also reportedly helps students further understand and review the material presented in class and assists them in learning how to locate and apply more detailed information on a topic (NPTA & NEA, n.d.). Homework is no longer an option for instructors and students in the American educational system, but rather it is an expectation and a part of the daily routine.

Nevertheless, arguments against homework remain popular (Marzano & Pickering, 2007). In the book *The End of Homework: How Homework Disrupts Families, Overburdens Children, and Limits Learning* (Kralovec & Buell, 2000) the authors argued that homework promoted a competitive nature and demanded work while

sacrificing personal well-being and positive family interactions. Additionally, others claim that the research literature fails to demonstrate the effectiveness of homework as an instructional tool and criticize both the quantity and quality of homework (Bennett & Kalish, 2006; Kohn, 2006). Despite a lack of research evidence, these opponents to traditional homework assignments advocate for designing shorter, more effective homework assignments and receiving breaks from the daily homework routine (Bennett & Kalish, 2006; Kohn, 2006).

Over the course of 128 years (1880-2008), attitudes pertaining to the assignment of homework have varied with time, American economic interests, and published literature. In view of both opinion-based and research-oriented publications, the assignment of homework as an instructional strategy for improving the academic achievement of students has been embraced as a means to establish excellence in American educational systems. Yet, the assignment of homework has been shunned at other times because of the perceived emotional, mental, and physical consequences suffered from the hours of memorization and the rigid demands of tasks that typically disregard learning through creativity or exploration. Although the discussions over homework are often influenced by social beliefs and the information in some research literature, the presence of homework in American educational environments and the debate over the advantages and disadvantages of homework seem to transcend time. As a result, the homework debates and the assignment of homework continue to linger in American schools and the American public.

### *The Effects of Homework on Academic Achievement*

Homework has been an active area of research for researchers throughout the past 70 years (Cooper et al., 2006). Consequently, a review of the literature yielded a number of synthesis studies conducted on the topic of homework, spanning a wide range of time and methodologies. The conclusions of these synthesis studies varied in their conclusions pertaining to the benefits and limitations of homework in part because they covered different periods of time, used different criteria for inclusion, and applied different statistical methods for the synthesis of the study results (Cooper et al., 2006).

#### *Studies that Compare and Contrast the Effectiveness of Homework versus No Homework*

*General homework studies.* In an effort to review the trends in the research pertaining to the effects of homework on student achievement, Goldstein (1960) examined all articles on “home study” listed in the Education Index from 1928 through 1958. Of the 280 articles located by Goldstein, only seventeen were actual reports of experimental research on homework. Goldstein criticized the poor experimental designs of the studies and cautioned his readers that even in the well-designed studies, the results were misconstrued in order to support popular notions about the harmful effects of homework on academic achievement or students’ emotional, mental, or physical states. Nevertheless, from these studies Goldstein concluded, “the data in most of the studies suggest that regularly assigned homework favors higher academic achievement, and a few of the best-designed experiments show this quite clearly” (Goldstein, 1960, p. 221). Goldstein also believed the studies he reviewed indicated that homework may be more beneficial for certain grade levels than for other grade levels. No statements about the value of homework at the early elementary level (Grades 1-4) were made, since none of

the research studies Goldstein analyzed addressed this population. According to Goldstein, the seven investigations focusing on grades 5 and 6 demonstrated positive effects of homework on academic achievement.

In 1981, Knorr synthesized the research literature pertaining to homework and academic achievement. Focusing on studies conducted from 1900 to 1959, Knorr (1981) discussed the twelve designs originally omitted from Goldstein's (1965) review. Knorr found eight studies favoring students who were assigned homework. She concluded that the findings from the twelve studies added greater support to the positive relationship between homework and academic achievement, as well as feedback provided on homework assignments and academic achievement. In her review of the research literature, Knorr also discussed twenty-two research designs published from 1960 to 1979, of which 14 studies showed significant academic differences on several different measures of achievement favoring students enrolled in different grade levels who were assigned homework. Six studies showed no difference and Knorr (1981) concluded that the information presented throughout 80 years of empirical research on the effects of homework on academic achievement remained inconclusive.

Paschal, Weinstein, and Walberg (1984) conducted a quantitative synthesis investigating the effects of homework on academic achievement. Of the 67 documents obtained in a literature review, 15 studies met the criteria for study. These studies included a diversity of students and the quantity of homework assigned. The meta-analysis showed that 69 of the 81 comparisons, or 85%, favored the groups assigned homework. The authors also discovered that when homework was assigned and returned to students with comments or grades, it positively influenced student levels of academic

achievement. In sum, homework appeared to benefit academic achievement, especially when the assignments were either graded or commented on by the instructor (Paschal et al., 1984).

In 1989, Cooper published a review of research conducted on the effects of homework on academic achievement with studies published between 1936 and 1986. Attempting to overcome the weaknesses of previous literature reviews, Cooper (1989) examined 120 empirical studies pertaining to homework's influences. Three types of homework research were selected to assist in drawing conclusions about the overall effectiveness of homework: homework versus no homework, homework with in-class supervised study, and the relationship between time spent on homework and academic related outcomes. Homework was defined as teacher assigned tasks completed by students during after school hours. The overall results revealed a positive effect of homework.

According to Cooper (1989), 20 studies were identified as favorable for exploring the achievement levels of students assigned homework to the achievement levels of students assigned no homework. The studies reviewed consisted of 3,300 students across 85 classroom and 30 schools in 11 states. The results from 14 of the studies showed students earning higher scores of academic achievement when assigned homework and six of the studies showed students earning higher scores of academic achievement when assigned no homework. The average student merely completing homework academically outperformed 60% of students not doing any homework. Although Cooper's meta-analysis demonstrated that homework had a positive effect on academic related outcomes, the grade level of the student influenced the effect homework had on academic



achievement. For young children, the effect of homework on academic achievement appeared to be minimal. According to Cooper, studies of time spent on homework and academic achievement revealed a strong positive relationship for high school students, an average relationship for junior high school students, and a weak relationship for upper-level (grades 4-6) elementary school students. Comparing homework to in-class supervised study, Cooper located eight studies containing over 1,000 students across 40 classrooms and 10 schools in six states. His results showed the average student completing homework academically outperformed approximately 54% of students fulfilling supervised study demands.

Most recently, Cooper et al. (2006) synthesized the research pertaining to the effects of homework, albeit positive or negative, from January 1987 through December 2003. With the goal of updating past conclusions pertaining to the effects of homework, they located research studies examining the effects of homework on a measure of achievement. Two sampling restrictions were established before a homework study was included in the synthesis: each study had to include students in Kindergarten through the twelfth grade and studies had to be conducted in the United States (Cooper et al., 2006).

The literature search located six studies using a research design in which a homework condition and a no homework condition was imposed on students specifically for the purpose of examining the effects of homework (Cooper et al., 2006). Although the six studies varied across research designs, subject matter, grade levels, duration, amount of homework assigned, and the degree of alignment between assignments and outcome measures, all six studies revealed a positive effect of homework on unit tests for

both elementary and secondary school students despite design concerns pertaining to students not being randomly assigned to a homework condition.

Furthermore, the authors examined whether the grade level of the students impacted the magnitude of the correlations between time spent on homework and academic achievement (Cooper et al., 2006). Correlations were grouped into those involving elementary school students (Kindergarten through sixth grade) and secondary school students (seventh through twelfth grade). The correlation between time spent on homework and academic achievement using a fixed-error model was significantly higher for secondary school students than for elementary school students. In addition, a random-error model showed a significantly higher correlation for secondary school students than for elementary school students.

Cooper et al. (2006) concluded that research studies have established a consistent and conclusive causal link between homework and academic achievement using several different research designs including: randomly assigning classrooms or students within classrooms to homework and no homework conditions, assigning homework to classrooms in a non-random manner, and using naturalistic measurement to assess both the amount of homework students complete and their academic achievement. The results revealed a positive relationship between homework and academic achievement that was robust against conservative statistical analysis. Consequently, Cooper et al. stated:

with only rare exception, the relationship between the amount of homework students do and their achievement outcomes was found to be positive and statistically significant. Therefore, we think it would not be imprudent, based on the evidence in hand, to conclude that doing homework causes improved

academic achievement. Of course, this assertion should not inhibit future efforts to establish more firmly this productive relationship. (2006, p. 48)

Even though the authors determined that strong evidence existed indicating a positive relationship between homework and academic achievement, a weak relationship was observed between homework and achievement in early elementary school grades. Yet, Cooper et al. admitted that the grade level effect on homework must be interpreted with caution because evidence from previous research studies on homework indicated that homework was used for purposes other than increasing academic outcomes and study habits, including time management. As a result, Cooper et al. advocated for future controlled studies examining the causal relationship between homework and academic achievement using students from a variety of grade levels. Finally, a positive relationship between the time spent on homework completion and achievement based on student reports and no relationship between time dedicated to homework completion and achievement based on parent reports was found. According to the authors, parents likely viewed only selected segments of their child's homework behavior and, as a result, parents may not have been able to accurately estimate the amount of time their child spends on homework. Although some students may have exaggerated the quantity of time they spend on homework, the correlation between homework and academic achievement can reportedly still be trusted because the inflation of some student responses was roughly equivalent across students. Nevertheless, future research should compare both student and parent reports pertaining to homework with behavioral observations (Cooper et al., 2006).

While Cooper et al. (2006) showed a positive causal effect of homework on achievement measures of immediate outcomes, such as the unit test, conclusions pertaining to homework's causal effects on long-term measures of achievement, including class grades and standardized tests, and the effectiveness of homework in the elementary school grades, cannot be established because of limited well-designed research studies. Additionally, almost all of the literature reviewed by the authors examined the effects of influence of homework on students who might be labeled as "average" or looked at broad samples of students, but the literature analyzed did not include homework studies focused on varying characteristics of students. Consequently, Cooper et al. argued that future research studies addressing the topic of homework should attempt to address gaps in the literature through experimental, qualitative, or longitudinal designs and include variations in potential factors. Reportedly, the factors in need of exploration included: students in multiple grades (especially elementary school grades), students with varying characteristics (especially varying ability levels and socio-economic factors), variations in the subject matter content presented on the homework assignments, variations in the amount of homework assigned, and measures of the non-achievement related influence of homework. Even though the design variations in need of future research may be examined within a large scale, single research project, the authors admitted it is more likely that numerous small-scale research projects will gather data on one or a few areas only. The advantage of using small research projects to address the literature gaps on homework resides in the implementation of well-controlled treatments, fewer expenses, and increased power for detecting effects (Cooper et al., 2006).

*Mathematics-specific homework studies.* While considerably less research has been conducted on the effects of homework for elementary age children, a handful of researchers have discovered significantly positive effects for mathematics homework at the elementary school level. In 1965, Koch reported the results of an experiment that examined the effects of homework on academic achievement in a single disciplinary area: mathematics. Three treatment groups (N = 75) were formulated from a population of sixth grade students enrolled in an urban elementary school. Group A was assigned by the general educational teacher 30 minutes of daily mathematics homework, Group B was assigned 15 minutes a day, and Group C was not assigned any homework over the course of the 10 week study. An analysis of variance indicated no significant differences between the three groups on the California Test of Mental Ability. The homework assignments were designed to emphasize repetition of the concepts and problem solving information presented in the daily math lectures. A pretest, the Arithmetic Concepts and Arithmetic Problem Solving sections on the Iowa Tests of Basic Skills (ITBS), Form 1, was administered prior to the introduction of the independent variable and a posttest, Form 2 of the ITBS, was presented at the end of the 10-week period. Koch's results displayed significant differences on the weekly tests of mathematical concepts favoring the students assigned homework, yet no significant differences were found between the groups on tests of problem solving skills. The mean difference score on the posttest for the students assigned 30 minutes of homework was larger than the mean difference score for the students assigned 15 minutes of homework in the mathematical concepts section of the ITBS. The mean difference between Group A and Group B was rather small on

the mathematical problem solving section of the ITBS and a significant difference was not observed.

Koch (1965) concluded that homework designed to review or reinforce skills introduced in classroom instruction increased achievement in mathematical computation. He also deduced that 15 minutes of homework did not provide enough practice and suggested that longer homework assignments were necessary to increase academic achievement. Despite his results, Koch maintained the limitations of the study, such as small population, generic assignments which ignore individual differences, and differences in presentation of the material by the teachers, prevented the generalization of the conclusions to all sixth grade students enrolled in public elementary schools.

Following Koch's lead, Maertens (1969) designed a study examining the effects of mathematics homework on computational skills, knowledge of mathematical processes, and problem solving ability of third grade students. A total of 319 third grade students from four different suburban elementary schools were selected to participate in the study. Prior to the beginning of the study, the participants completed the Lorge-Thorndike Intelligence Test, Primary Battery, Level II, Form A, and a mathematical pretest designed by the researcher to measure students' knowledge of mathematical processes and computational skills. Students with scores of 112 and above on the Lorge-Thorndike Intelligence Test were assigned to the "high group." Students with scores of 102 and below were assigned to the "low group" and students with scores falling between 103 and 111 were assigned to the "middle group". Three experimental treatments were assigned to the classrooms during the study: no homework; teacher prepared homework; and experimenter prepared homework. Even though every classroom experienced each

of the three treatments, the order in which a classroom received the three treatments varied. After each classroom completed a treatment, experimenter designed achievement tests were administered to measure students' knowledge of mathematical processes, computational skills, and problem solving ability.

According to Maertens (1969), the results showed the mean differences among treatment effects on tests of computation, knowledge of mathematical processes, and problem solving ability were not significant. In addition, the differences among treatment effects within ability groups on achievement tests were not significant. While the results did not support Koch's (1965) conclusions, Maertens believed methodology differences, such as grade level of the participants and the achievement test utilized to measure the effects of the independent variable, might have influenced the effects of homework on the academic achievement in mathematics. Maertens also argued that assignments requiring more than the 20 minutes might demonstrate a positive effect on the levels of achievement. Even so, Maertens concluded from the results of the study that the assignment of mathematics homework to third grade students was ineffective in increasing achievement scores.

In an attempt to further validate Koch's (1965) findings and recommendations, Gray and Allison (1971) designed a study investigating the effect of homework on mathematics achievement. The study occurred over eight weeks and included 55 students in two sixth grade classrooms located in a suburban elementary school. The students were randomly assigned to Treatment Group I (homework) and Treatment Group II (no homework) by the researchers. Students assigned to Treatment Group I received, as a supplement to classroom instruction, three 20-minute homework

assignments per week to practice the material presented in class. The parents were asked not to provide assistance to their children during the course of the study. After the first four weeks of the study had passed, the treatments were reversed to control for a possible effect in the variation of teaching styles, allowing all of the participants to experience both experimental conditions. Achievement tests, designed by Gray and Allison based on the information presented in the classroom lessons, were administered at the end of each four-week period. The researchers found no statistically significant differences in the scores on the mathematics achievement tests between the students assigned practice homework and the students who were not assigned homework. In addition, no statistically significant differences were observed on the measure of understanding the mathematical concepts between the two groups; however, the researchers questioned the sensitivity of the measure selected to examine the independent variable. While the results of the study disagreed with Koch's conclusions, Gray and Allison (1971) concluded "that while this study produced no evidence to suggest that homework was in any way harmful, certainly it is quite possible the non significant findings may indicate that drill type homework is in fact unrelated to pupil growth in computational skills" (p. 345).

Maertens and Johnston (1972) used children from eight elementary schools (146 fourth grade students, 137 fifth grade students, and 134 sixth grade students) in a large rural area to study the effects of mathematics homework on the scores of a pretest-posttest and weekly quizzes, both of which assessed computation and problem solving skills. Students in the homework groups were assigned homework reviewing material previously presented in lecture four days a week. The participants were instructed to complete their homework assignments at home in the company of their parents. The



mean scores for the weekly quizzes were higher for the groups of students assigned homework than the groups of students receiving no homework across all participants. Students in the fifth grade who were assigned homework scored significantly higher on the problem solving quizzes than the students in the fifth grade not assigned any homework, while the differences on the fourth grade problem solving quizzes were only significant at the .10 level. Interestingly, differences between sixth grade students assigned homework and sixth grade students not assigned any homework were not statistically significant for the weekly quizzes. Significant differences between students assigned homework and students receiving no homework assignments were observed on the pretest-posttest across all three grade levels. For example, fourth grade students assigned homework scored significantly higher on the computation and problem solving posttests than fourth grade students not assigned any homework. Based on the results of the study, Maertens and Johnston concluded that homework assignments had a significant effect on computation and problem-solving performances when combined with parent involvement. The researchers believed inconsistencies in the results might be a function of the psychometric power of the dependent measures or may have indicated the presence of confounding variables. All of the discoveries must be interpreted with caution (Maertens & Johnston, 1972).

Examining studies published between 1900 and 1977, Austin (1979) summarized the research on mathematics homework. In his review of the literature, Austin did not locate a single study including students in grades 1, 2, 11, or 12. Austin also found several of the studies experienced procedural problems and, as a result, the reliability and validity of the data was called into question. Even though the studies considered several

different grade levels and several different achievement measures, Austin found 16 studies showing significant differences favoring students who were assigned mathematics homework. Thirteen studies showed no differences. When considering only the post-1950 studies, seven displayed significant differences in favor of the groups assigned mathematics homework and four comparisons did not find significant differences. Based on the information provided in the post-1950 studies, Austin concluded that homework appeared to significantly improve not only computational skills, but also academic achievement in mathematics for students in grades 4 through 10.

According to the literature review, the most recent study located pertaining to the effect of mathematics homework on academic achievement was published in 1994. Barone (1994) examined the effect of assigning math homework on mathematics achievement scores for two fourth grade classrooms located in a Midwestern school district. Prior to the manipulation of the homework assignments, the pretest from the math section of the Iowa Test of Basic Skills (ITBS), Form J, was completed by the students (N = 41). Teacher "A" then assigned 15 to 30 math practice problems, to be completed at home, four days a week for five months. Teacher "B" did not assign any homework. Both teachers presented instruction in mathematics for 50 minutes everyday, utilizing the same lesson plans and manipulatives. Both teachers "A" and "B" discussed each week what methods and materials to use for instruction. Following the five month experimental period, both fourth grade classes completed the posttest of the ITBS. The data indicated that fourth grade students who were required to complete homework in mathematics did not exhibit significant differences in achievement when compared to fourth grade students who were not assigned math homework. Even though a small,

selective sample was used in the study and random assignment was not utilized in the design, Barone concluded that mathematics achievement does not demonstrate significant increases from pretest to posttest, when mathematics homework emphasizing practice and repetition is assigned at the elementary level.

*Research on the Effects of Time Spent on Homework*

Fredrick and Walberg (1980) discussed learning as a function of time by summarizing theoretical models and research conducted on the topic from 1928 to 1979. According to Fredrick and Walberg, the research studies indicated a moderate and persistent relationship between time dedicated to a subject and achievement. As a result, theoretical models started conceptualizing learning as a function of ability and time, with all other variables being equal. Fredrick and Walberg (1980) reported that in measuring time the theoretical models included not only instructional time, but also out of class time, or time dedicated to homework. The addition of out of class time increased the explanatory power of the models and provided the opportunity to further examine differences in academic achievement.

Keith (1982) attempted to examine the causal effects of homework time on high school seniors' academic achievement using the data from the National Center for Education Statistics' High School and Beyond longitudinal study of 1980. The sample included 20,364 high school seniors. Variables observed in the study included: race, family background, ability, field of study, times spent on homework, and grade point average (G.P.A.). Keith's path analysis confirmed that after controlling for race, family background, ability, and the student's course program, an increase in the amount of time spent on homework had a positive effect on grades for high school seniors of all ability

levels. Homework appeared to have compensatory effects with low ability students achieving grades comparable to higher ability peers through increased study. Reportedly, when assigned one to three hours of homework a week, low ability students could achieve grades comparable to the grades of average ability students who completed no homework. Although both time spent on homework and G.P.A. were collected from traditionally unreliable student self-reports, Keith (1982) argued that increased time spent on homework is a partial answer to the quandary of how to improve the American educational system.

Shortly after the publication of Keith's article, Epstein (1983) discussed the influence of six variables, including homework time, homework quality, student attitudes, teacher practices, and parent abilities as well as resources, on reading and mathematics achievement, homework performance, and classroom behavior. The study's participants were randomly selected from 16 Eastern school districts and included 3,700 first, third, and fifth grade teachers and their principals, 1,269 parents, and 600 fifth grade students. The participants were asked to complete a survey, which presented different topics including: amount of homework assigned, purpose of homework, estimates of students completing homework, amount of time dedicated to homework, habits for completing homework, help at home on homework, and appropriate level of challenge in homework. The results showed a negative relationship between homework time and parent help on student achievement in reading and mathematics. Epstein reported that students who spend more time on homework and received more help from parents displayed lower achievement in reading and mathematics than students who spent less time on homework. Despite the information obtained in the study, Epstein (1983) encouraged future research

designs to focus on whether increased time spent by struggling students results in the improvement or maintenance of academic achievements.

Kappa Delta Pi, the international honor society in education, published a booklet discussing the relationship between homework and academic achievement written by Keith (1986). Keith stated that the majority of quality homework research had been conducted with high school participants and large, representative data sets. As a whole, these analyses revealed two crucial conclusions: the amount of time spent on homework by high school students had a significant influence on academic achievement, whether achievement was measured by grades or test scores; and homework had a considerably positive impact on academic achievement. Even though Keith (1986) found considerably less homework research on younger age participants, Keith concluded that the larger picture indicated a positive relationship between homework and academic achievement for students above the fourth grade level of education.

Fehrmann, Keith, and Reimers (1987) also examined the influence of homework time on academic achievement by analyzing data from a large, contemporary sample of 28,051 high school seniors. Participants for the study were randomly selected from nationally representative longitudinal studies conducted by the National Center for Educational Statistics at the United States Department of Education. Data was obtained through questionnaires on eight variables including: ethnicity, family background, gender, ability, parental involvement, homework, TV time, and grades. Homework was measured through students' perceptions of how much time was dedicated to the completion of homework on a weekly basis. The path analysis showed the effect of homework time on grades as beneficial; the sample of seniors enrolled in high school

showed higher grades when dedicating more time to homework (Fehrmann et al., 1987). Despite the reliability and validity limitations inherent in self-report measures, Fehrmann et al. (1987) concluded that increased time on homework could lead to higher achievement, a finding that was consistent with Keith's (1982) previous research.

Keith and Cool (1992) examined the relationship between homework and academic achievement using a large, longitudinal data set of high school students (N = 25,875). Students were surveyed as sophomores by the National Center for Education Statistics' High School and Beyond Longitudinal Study in 1980, and once again as high school seniors in 1982. Of the sophomores originally surveyed in 1980, 95% of the participants were included in the 1982 follow-up study. Although the results showed ability as the strongest direct effect on academic achievement, homework demonstrated a meaningful influence on high school seniors' academic achievement. Even though the data used in this research was derived from students' self-reports of time spent on homework, thereby warranting questions pertaining to the reliability and validity of the responses, the results indicated that homework had an influence on academic achievement (Keith & Cool, 1992).

When reviewing the research literature on homework, the two meta-analyses conducted by Cooper and his colleagues (Cooper, 1989; Cooper et al., 2006) are considered the most comprehensive and rigorous. In 1989 when examining the relationship between time spent on homework and academic achievement across 50 correlational designs, Cooper (1989) found that 43 of the correlational designs showed increased achievement scores for students who completed homework. The average student spending more time on homework academically outperformed 65% of students

completing less homework (Cooper, 1989). Homework had a larger effect when class tests or grades, rather than standardized achievement tests, measured achievement. The subject matter incorporated into the homework assignments did not affect the relationship between homework and achievement (Cooper, 1989).

Recently, Cooper et al. (2006) located 32 studies examining the correlations between the quantity of time students dedicated to homework and academic achievement in their comprehensive meta-analysis on the topic of homework. Reportedly, the 32 studies appeared in the research literature between 1987 and 2004. The sample sizes ranged from 55 to approximately 58,000, with a mean sample size for an adjusted data set of 7,742 and a standard deviation of 10,192. Because limited information pertaining to students' socioeconomic status, sex, and gender was reported in the 32 studies examined, statistical analyses were not conducted on any of these variables. Reportedly, only three of the studies noted that students were drawn from general education classrooms and the remaining research studies did not report information on students' achievement or ability levels (Cooper et al., 2006).

Across the 32 studies, 69 correlations were found between homework and academic achievement. According to Cooper et al. (2006), 50 correlations were in a positive direction and 19 were in a negative direction. Mean weighted correlations were determined using both a fixed error model and a random-error model. Based on these results, Cooper et al. (2006) concluded that the hypothesis stating that the relationship between homework and academic achievement is  $r = 0$  could be rejected under either error models. A positive relationship between time spent on homework and academic

achievement was observed and considered robust against conservative re-analyses (Cooper et al., 2006).

### *Types of Homework*

As a common term used in the day-to-day jargon of the educational environment, few administrators, educators, and researchers have formally defined “homework”.

Maertens (1969) defined arithmetic homework as arithmetic-based material emphasizing information covered in class and completed outside of the regular school day. Keith (1986) defined homework as work teachers assign for completion outside the classroom environment. Refining Keith’s definition, Cooper (1989) perceived homework as tasks to be carried out during non-school hours that are assigned by teachers to students.

Although students had the option of completing homework during the school day, such as in study halls or subsequent classes, Cooper assumed the majority of assigned work was finished at home by students enrolled in elementary school, junior high school, or high school. Excluded from his definition were practices including in-school guided study, audio-visual lessons, and extracurricular activities (Cooper, 1989). Some of the few documented definitions of homework have also incorporated more detailed descriptions and classifications of specific homework practices.

*Practice homework.* As a traditional drill model, practice homework is the oldest and most common form of homework. Lee and Pruitt (1979) defined practice homework as an opportunity for students to practice or review newly acquired skills or material presented in class. Some examples of practice homework include: end of chapter review questions, repetitive sentence writing, or mathematics calculations. According to LaConte (1981), practice homework assignments, although crucial for learning, are far



too often dull, unimaginative, repetitive exercises producing a state of student boredom. An average student typically masters the skill quickly and continues mechanically through the rest of the exercise simply for the sake of completion, while a less able student, needing more practice, may quit to maintain pace with their peers (Baber & Doyle, 1990; LaConte, 1981). Practice assignments may also be especially susceptible to cheating. However, practice homework may be valuable when the assignment is carefully matched to the ability of the student (Baber & Doyle, 1990; Keith, 1986; LaConte, 1981). The most effective type of practice homework requires the students to apply newly acquired knowledge in a direct and personal way (Baber & Doyle, 1990; LaConte, 1981). For example, students who have recently studied different types of trees may be asked to locate and label old magazine photographs of various trees.

*Preparation homework.* Another commonly used homework assignment with students in both junior and senior high schools is preparation homework (Baber & Doyle, 1990; LaConte, 1981). The purpose of preparation assignments is to provide students with sufficient background information in order to prepare them for future class discussions and help the students obtain the maximum benefit when the new material is presented in class (Lee & Pruitt, 1979; Muhlenbruck, Cooper, Nye, & Lindsay, 1999). For example, prior to the lecture students may be instructed to read chapter five in their history books. By focusing on the introduction of a topic, Keith (1986) believes preparation homework lays the foundation for additional learning in the classroom environment, by demanding initiative and individual effort (Baber & Doyle, 1990; LaConte, 1981).

*Extension homework.* Extension assignments encourage students to creatively extend or generalize concepts or skills from the familiar to new, highly individualized, situations (Baber & Doyle, 1990; Keith, 1986; LaConte, 1981). Where practice homework is characterized as “more-of-the-same” and preparation assignments as “read-to-get-ready” (LaConte, 1981, p. 11), extension homework requires a “transfer of learning” (Keith, 1986, p. 13). According to both LaConte (1981) and Baber and Doyle (1990), typical extension assignments are identified as an ongoing, continuous project running parallel to class work while emphasizing production rather than reproduction. For example, students studying theology may be assigned to read *Uncle Tom’s Cabin* and write an essay discussing the religious significance of the text’s central characters. The goal of such assignments is to stimulate the student’s initiative to learn by allowing a great deal of student choice in the expansion of learning already started in the classroom environment (Baber & Doyle, 1990; LaConte, 1981). Often constructed around problems, extension homework enables the student to apply previously acquired information in order to discover new understandings, and the opportunity to demonstrate individuality.

*Creative homework.* In theory, most homework assignments succumb primarily to the practice, preparation, or extension categories; in practice, numerous homework assignments cut across these classifications (Cooper et al., 2006; Keith, 1986). For example, in a Spanish class, a new verb may be conjugated during the class lecture and supplemented with a homework assignment to construct sentences using the new verb in various forms. Such an assignment falls into two homework domains: practice (practice conjugating the verb) and extension (using the verb in sentences). The blending of

different homework designs is often characteristic of creative homework assignments (Keith, 1986). Demanding the integration of a variety of concepts and skills, creative assignments require the extension of previously learned skills and a great amount of student artistry. Usually demanding more time than the other types of assignments, ranging from several days up to an entire semester, traditional examples of creative assignments are research papers, presentations, skits, or simple experiments (Keith, 1986).

*Studies that Compare and Contrast the Effectiveness of Different Homework Types*

Homework not only varies in type, but also varies by grade level (Keith, 1986). The type of homework assigned to high school students enrolled in college preparatory courses significantly differs from assignments presented to elementary school students. Even though enhancing instruction is the goal of homework at all grade levels, homework designed to promote abstract thought or a creative performance will likely be more important at higher grade levels, whereas, practicing a basic skill for mastery may be more appropriate for students in earlier grades (Keith, 1986). Therefore, if the types of homework are perceived as a hierarchy, with practice at the lowest level and creative at the highest, the quantity of higher-level homework assignments should increase with grade level. Although practice homework is required at all grade levels and appropriate forms of creative homework would be valuable for elementary school students, the general progression from lower to higher level homework should occur as students acquire more knowledge and grow cognitively. According to Keith (1986), intellectual maturation is necessary because higher levels of homework demand higher levels of learning, such as abstraction, artistry, and generalization.

Even though types of homework have been categorized and defined by researchers, few studies have examined the effects different types of assignments had on academic achievement. In a study designed to compare the effects of practice and preparation homework on academic achievement, Foyle (1984) used 131 sophomore students enrolled in the fall semester's general educational American History courses offered at a Midwestern high school. During the seven-week experiment, two experienced history teachers, who had worked closely together over the previous four years, taught five sections of an American History course while the experimenter taught one section of the course. Prior to the application of the research design, the teachers and the researcher prepared a homework schedule, constructed the homework assignments, and formulated a multiple-choice test, assessing factual recall of information, to measure comprehension of the material presented in class.

On the first day of class, all of the students were administered a multiple-choice pretest, with one make-up day available for absent participants. The topic of study during the experiment was "United States' Domestic and Foreign Politics: 1865-1932," a six-week unit consisting of 24 lessons and covering six chapters of the textbook. Once instruction began, four randomly assigned classes received two to five pages of daily homework assignments from the section survey at the end of each reading section, which consisted of term identification from the text and content questions from the text and lecture. Students (N = 50) in only two of the four classes were assigned the homework as practice for the lesson topic covered in class. Students (N = 43) in the other two classes were assigned the section survey homework as a method of preparation for the following day's lesson topic to be discussed in lecture. Homework was collected, graded, and

returned to the students on a daily basis. Two sections (N = 38) were not assigned homework as a supplement to the content presented in lecture. To ensure consistency in instruction concerning the lesson topic and presentation, the teachers and the experimenter met twice a week for collaborative discussions of instructional strategies. At the end of the six-week unit, a multiple-choice posttest was administered to all of the students enrolled in the American History courses. The same multiple-choice pre- and posttests administered to the participants. The experimenter also administered the Verbal Reasoning subtest of the Differential Aptitude Test to measure the participant's levels of ability.

Foyle's (1984) results showed a significant difference in the achievement mean scores between the students assigned homework and the students assigned no homework. Thus, Foyle's results clearly demonstrated the positive impact of homework on the academic achievement of high school students. Yet, his results did not indicate a significant difference in the achievement mean scores between the students assigned practice homework and the students assigned preparation homework. Foyle anticipated a difference in the achievement mean scores because the assigning of preparation homework was the traditional supplemental approach to the academic instruction of social studies. The demand for factual recall of information on the multiple-choice tests did not support Foyle's rationalization. Despite the results, Foyle argued that a difference between the mean scores was not observed because the section surveys assigned as preparation homework were not the appropriate advanced organizer for the daily social studies lesson. Nonetheless, when homework was regularly assigned, regularly collected, promptly graded, and promptly returned, high school students showed increased levels of

academic achievement. Either preparation or practice homework could be assigned in high school social studies courses because both types of homework, as shown by Foyle's results, increased academic achievement. Because the study was limited to a high school of one thousand students located in a moderately sized suburb and the participants of the study were not randomly selected from the population, the results should be interpreted in the context of the research literature for homework.

Roper (2000) also designed a study exploring the effectiveness of practice and preparation homework on the academic achievement of elementary school students with learning disabilities. Set in a special education resource room, the study was a single subject design repeated for four participants. The study's participants included four students in grades 5 and 6 who received reading instruction as a group in a special education resource room at a public Midwestern, urban school district. The study's participants were identified as learning disabled according to a state definition, had a goal on their Individualized Education Plan in reading, received primary instruction for reading in a special education classroom for students with learning disabilities, and received reading instruction in a group of at least two students.

Two types of homework were assigned to the participants during the study: practice and preparation. The practice and preparation homework assignments were brief (10 to 15 minutes) and developed by the experimenter, using teacher input, and the curriculum used in the instructional setting. The homework assignments included a list of ten vocabulary words and definitions to be read orally by each student in the presence of a parent or guardian. The instructions on the homework requested for a parent or guardian to orally read the vocabulary words and definitions to their child, followed by

the student's oral recitation. The homework also included ten vocabulary application tasks, such as sentences with the vocabulary words omitted, and ten written review tasks, such as crossword puzzles or word finds, to be completed and returned by each student the following school day. The vocabulary words adopted for each assignment changed weekly according to the ten vocabulary words emphasized in class instruction.

Rate of homework return, homework completion, and percent correct on all the practice and preparation homework assignments were recorded. In order to receive credit, the homework had to have been returned the following school day. A student's assignment was considered complete when 90% or more of the questions showed an answer in the space provided on the page and had a parent or guardian's signature somewhere on the assignment. The participants were required to return at least 70% of their homework assignments to be included in the study and were required to attain an average of 70 % correct on the homework assignments. As a result, the data obtained from Student 3 was not included in the results because his rate of homework return was 25% and his average percentage correct was 14%.

The study was conducted in four phases. The first condition, Baseline, was conducted for a total of 10 school days with no homework assignments. The following two conditions were treatment conditions in which the researcher implemented two interventions: practice homework and preparation homework. The treatment conditions were 15 school days each. Following the end of the second treatment condition, the participants, once again, returned to Baseline for a total of 10 school days. Specifically, the participants were not assigned homework for the first 10 school days of the study. On day 11, Student 1 and Student 2 were assigned practice homework and Student 3 and

Student 4 were assigned preparation homework for the following 15 school days. On day 26, Student 1 and Student 2 were assigned preparation homework rather than practice homework and Student 3 and Student 4 were assigned practice homework rather than preparation homework for the next 15 days of school. Beginning on day 40, the participants were not assigned homework for the final 10 days of the study. The effectiveness of the practice and preparation homework assignments was measured across four dependent measures: word lists, curriculum-based measurement administered story passages, comprehension tests, and a cumulative word list.

According to Roper (2000), the participants' results were not consistent across dependent measures when examining the effectiveness of homework assignments versus no homework assignments on academic achievement. The data obtained from Student 1 supported Roper's hypothesis that higher achievement scores on the curriculum-based measurement administered story passages would be observed when assigned homework versus when she was not assigned homework. However, the data obtained from Student 1 did not support this hypothesis on the other three dependent measures administered: word lists, comprehension tests, and a cumulative word list. Additionally, the data obtained from Student 2 and Student 4 did not support this hypothesis across all dependent measures. Homework did not appear to be an effective intervention for increasing the academic achievement of elementary school students with learning disabilities.

When examining the effectiveness of preparation homework in comparison to practice homework on academic achievement, the results were inconsistent across participants and dependent measures. Although Student 1 and Student 2 showed



increased achievement scores on the story passages and comprehension tests, Student 1 and Student 2 did not exhibit increased achievement scores on the word lists. The data obtained from Student 4 did not show increased achievement scores on any of the dependent measures. Preparation homework did not appear to be a more effective intervention in comparison to practice homework for increasing the academic achievement of elementary school students with learning disabilities (Roper, 2000).

### *The Effects of Drill and Practice to Enhance Skill Acquisition*

According to learning theories and the research literature, practice, or opportunities to respond, improves academic skill acquisition for students. Researchers have previously studied different practice, or drill, models for the purpose of determining the instructional effectiveness of repetition (MacQuarrie, Tucker, Burns, & Hartman, 2002). Drill ratios are a more recent drill model presented in the literature as an effective in-class intervention for academic skill acquisition. In spite of the attention to drill ratios in the research literature as an in-class intervention, research designs incorporating drill ratios in homework assignments as a means for academic skill acquisition has not been designed or evaluated.

Even though Haring and Eaton (1978) identified drill and practice as separate concepts with different definitions, terminology in the drill ratio literature uses the drill and practice concepts interchangeably. Researchers have examined different drill models, which were designed to provide opportunities to academically respond, through increasing the amount of drills, or practice, students receive in the educational environment (Chase & Symonds, 1992). Neef, Iwata, and Page (1977) were the first to study the effects of a drill ratio by combining known and unknown items during drill

tasks by teaching a list of 50% known spelling and sight words with 50% unknown spelling and sight words. The authors' suggested that this concept of drill procedures helped with the acquisition and retention of unknown words more effectively than the presentation of all unknown material. Following the research conducted by Neff et al. (1977), Gickling and his colleagues proposed a ratio of 70% to 85% known items and 15% to 30% unknown items when rehearsing drill tasks (Gickling & Havertape, 1981; Gickling & Rosenfield, 1995). According to Gickling and his colleagues, any ratio below 50:50 known to unknown would likely result in frustration for students while ratios beyond 90:10 known to unknown would not provide sufficient academic challenge.

In an attempt to apply these drill ratio ideas into practice, two specific flash card techniques were developed to provide opportunities to respond by combining known and unknown items: drill sandwich and incremental rehearsal. The drill sandwich concept was designed to teach new items by intermixing unknown items with known items (Coulter & Coulter, 1989). One example of a drill sandwich model is based on a drill ratio of 30% unknown and 70% known items; the unknown items were combined with known items and the entire problem set was rehearsed three times (Coulter & Coulter, 1989). This technique has been shown to lead to better retention than using 100% unknown items (Browder & Shear, 1996; Shapiro, 1992). Incremental rehearsal also teaches new items by intermixing unknown items with previously learned ones; however, each new item is introduced one at a time and each new item is rehearsed through multiple presentations (Tucker, 1989). Using Gickling and his colleague's conclusions regarding drill ratios, Tucker developed an incremental rehearsal model with a drill ratio of 90% known to 10% unknown items. In Tucker's incremental rehearsal model, the

unknown items were gradually introduced using a folding-in technique. Previous research studies comparing incremental rehearsal to a drill sandwich method indicated that the incremental rehearsal procedure was more effective for the acquisition of academic skills (Burns, 2004; MacQuarrie, Tucker, Burns, & Hartman, 2002).

According to the research literature, implementation of incremental rehearsal techniques has demonstrated a high rate of success due to the high number of known items, sufficient practice to move unknowns items from working memory to permanent memory, and the increased opportunities for students to respond to the material (MacQuarrie et al., 2002; Tucker 1989). An important aspect of incremental rehearsal using a folding-in technique is its unique recognition of the need for repetition through drill or practice in academic skill acquisition. In 1930, Gates identified a strong relationship between ability level as measure by an intelligence quotient and the number of repetitions of facts necessary for students to acquire new information. Gates' conclusions indicated that students with "average" intelligence quotients required approximately 35 repetitions of information to achieve rapid and accurate word recognition. In an attempt to replicate Gates' findings, a more recent study by Hargis et al. (1988) suggested that students with learning difficulties may require up to 50 repetitions to achievement rapid and accurate levels of recognition.

Although a number of research studies have been designed for the purpose of determining the optimal ratio of known and unknown material, the research focused on determining the ideal drill ratio has been inconclusive (Burns 2004; Gravois & Gickling, 2008). Contingent upon the design of the study, the population of the participants, and the content of the tasks introduced, the research literature provides a range of ratios for

achieving the best conditions for drill and practice using drill ratios. For example in his empirical analysis of the drill ratio research, Burns identified 13 studies using drill ratios of known and unknown items to determine the influence on academic outcomes. The results showed large effect sizes for drill ratios including 50%, 60%, 70%, 85%, and 90% known items. The results also showed a large effect size for skill acquisition and a small effect size for skill fluency. Based on the results, Burns (2004) could not recommend one drill ratio over other drill ratios and concluded that drill ratio tasks were more effective for the acquisition of skills rather than practicing skill fluency. While the data presented in Burns' meta-analysis must be used cautiously in educational practice, perhaps the potential implications for future research are even more significant. One specific aspect of the drill ratio research that was not discovered during the literature review was the application of drill ratios in homework assignments for the purpose of skill acquisition.

#### *Purpose of the Study*

Based on the review of the homework and drill ratio literature, the following research hypotheses were formulated for the proposed study: (1) participants assigned working-practice homework will achieve higher posttest scores compared to participants assigned practice homework; (2) participants blocked in the top third achievement group will achieve higher posttest scores after exposure to working-practice homework compared to those exposed to practice homework; (3) participants blocked in the middle third achievement group will achieve higher posttest scores after exposure to working-practice homework compared to those exposed to practice homework; (4) participants blocked in the lower third achievement group will achieve higher posttest scores after

exposure to working-practice homework compared to those exposed to practice homework.

## Chapter Three: Methodology

### *Participants*

The study was conducted at an elementary school in a Mid-Atlantic, suburban school district. The elementary school housed 536 general and special education students enrolled in classrooms ranging between Kindergarten and the fifth grade (*School Data Profiles*, 2006). The elementary school's racial or ethnic labels included 42.7% of the student population identified as Hispanic, 20.8% of the population identified as White/Non-Hispanic, 22.1% of the population identified as Black/African American, 7.9% of the population identified as Asian/Pacific Islanders, and 6.4% identified as "Other". Reportedly, 11.7% of the student population were identified as gifted, 8.4% of the students received Title I support, 12.8% received special education services, 38.7% of the students participated in English Learners of Other Language programs, and 46.2% of the population were considered economically disadvantaged. The average daily attendance for the elementary school was 95.5% (*School Data Profiles*, 2006).

All fifth grade classes at one elementary school agreed to participate in the study, which included 94 students across four fifth grade general education classrooms. The participants included fifth grade students receiving academic instruction for the area of mathematics in the general education classroom. Any special education students mainstreamed for mathematics were assumed to be able to meet the academic demands of the class with minimal supports. Although 94 students agreed to participate in the study, 4 students independently withdrew from the school district during the study.

Consequently, a total of 90 students, 45 females and 45 males, completed the 6 week study. The school's 4 fifth grade classrooms had 22, 22, 23, and 23 students, respectively, that completed the study.

### *Measures*

#### *Curriculum Objectives*

Since 2001, the participating Mid-Atlantic school district was required by the state Board of Education to follow Standards of Learning (SOL) for core academic areas, including mathematics (Commonwealth of Virginia Board of Education, 2002). SOL are intended to provide an academic framework by establishing clear and concise content expectations for both teachers and students enrolled in Kindergarten through the 12<sup>th</sup> grades. Consequently, the school district adopted all of the state identified SOL as curriculum objectives for all academic areas. The fifth grade SOL and school district's math calculation curriculum objectives emphasized proficiency in manipulating whole numbers, fractions, and decimals to solve problems. See Appendix A for the school district's math calculation curriculum objectives for grade 5. Three of the school district's curriculum objectives (Objectives 5.5, 5.6, and 5.7) were covered during instruction throughout implementation of the study. Objective 5.5 stated that students would find the quotient and remainder (if any), when provided with a dividend of 4 digits or fewer and a divisor of 2 digits or fewer. Following the curriculum, the teachers covered Objective 5.5 by presenting the content across four concepts and 1 week of instruction. According to Objective 5.6, students would find the quotient, when given a dividend expressed as a decimal through the thousandths and a single digit divisor. The teachers covered Objective 5.6 by presenting the content across three concepts and 2

weeks of instruction. Objective 5.7 stated that students would not only add and subtract with fractions and mixed numbers (including common and uncommon denominators), but also express answers in the simplest form. The teachers covered Objective 5.7 by presenting the content across 10 concepts and 3 weeks of instruction. See Table 1 for a description of the 17 concepts covered across the three curriculum objectives.

### *Homework*

Homework was operationally defined as mathematics tasks assigned by the two participating general education teachers to be carried out anytime after the block of time assigned for mathematics instruction was completed. The definition excluded in-school guided study, homestudy courses provided by mail, television, or audio/video cassettes, and extracurricular activities (*e.g.*, sports teams and clubs) (Cooper, 1989; Power, Dombrowski, Watkins, Mautone, & Eagle, 2007). However, for this study, the definition acknowledged that participants might complete homework in school during the block of time labeled Core Extension, in after school programs, or at home.

### *Practice and Working-Practice Homework*

The homework assignments were developed by the experimenter and participating teachers, requiring approximately 30 to 45 minutes for the participant to complete. The content of the homework assignments were driven by the school district's curriculum objectives and the 17 concepts used to guide instruction (see Table 1). All homework assignments (practice homework and working-practice homework) included calculation tasks. The items adopted for each assignment changed according to the material emphasized in class instruction. To establish the content validity of the



Table 1

*Curriculum Objectives and the Concepts Covered during 6 Weeks of Instruction*

Curriculum objective	Description of Concepts
5.5 <sup>a</sup>	Division of 1 digit divisors with 1, 2, 3, and 4 digit dividends (NR); division of 1 digit divisors (R); division of 2 digit divisors with 1, 2, 3, and 4 digit dividends (NR); division of 2 digit divisors (R).
5.6 <sup>b</sup>	Division of 1 digit divisor with 1 decimal point in the dividend; division of 1 digit divisor with 2 decimal points in the dividend; division of 1 digit divisor with 3 decimal points in the dividend.
5.7 <sup>c</sup>	Addition of fractions with common denominators (NSS); subtraction of fractions with common denominators (NSS); addition of fractions with uncommon denominators (NSS); subtraction of fractions with uncommon denominators (NSS); addition of fractions with uncommon denominators (SS); subtraction of fractions with uncommon denominators (SS); addition of mixed numbers with common denominators (SS); subtraction of mixed numbers with common denominators (SS); addition of mixed numbers with uncommon denominators (SS); subtraction of mixed numbers with uncommon denominators (SS).

*Note.* R=remainders in quotient. NR = no remainders in quotient. NSS = Fraction problems with no simplification of solution. SS = Fraction problems requiring simplification of solution.

<sup>a</sup>Covered in Week 1. <sup>b</sup>Covered in Weeks 2 and 3. <sup>c</sup>Covered in Weeks 4, 5, and 6.

homework assignments, the study's participating teachers reviewed the types of math calculation problems presented on the homework assignments to confirm that the content accurately reflected the skills presented during instruction and the school district's curriculum objectives. Altogether, 18 practice homework assignments and 18 working-practice homework assignments were presented across the 6 week study.

For this study, 100% of the practice homework covered the first step of academic skill development as defined by Haring and Eaton (1978): acquisition. For the purpose of the study, "acquisition" skills referred to new skills in need of practice through the provision of numerous opportunities to respond (Haring & Eaton, 1978). Practice homework assignments were designed for participants to acquire specific mathematical procedures, or procedural knowledge, not yet in their academic repertoire. Practice homework assignments consisted of 30 problems per assignment and were assigned to the participants on Tuesdays, Wednesdays, and Thursdays of a regular school week. Tuesdays' practice homework assignment included problems reviewing the mathematical material covered in class on Monday and Tuesday. On Wednesdays' and Thursdays' practice homework assignments, all of the problems reviewed material covered in class on that same day. For example, after the teacher instructed the participants on the topic of division with 1 and 2 digit divisors on a Wednesday, the practice homework assignment required the participants to calculate division problems with 1 and 2 digit divisors using paper and pencil. See Table 2 for a description of the content covered in each practice homework assignment. See Appendix B for all of the practice assignments used in the study.

Table 2

*The Math Content Covered in Practice Homework and Working-Practice Homework Assignments*

Day	Practice homework	Working-practice homework	
		Acquisition material <sup>a</sup>	Maintenance material
Week 1			
Tuesday	Division with 1 digit divisors and 1-4 digit dividends (NR) (30).	Division with 1 digit divisors and 1-4 digit dividends (NR) (12).	Multiplication with 1-3 digit whole numbers (18).
Wednesday	Division with 1 digit divisors and 1-4 digit dividends (R) (15); division with 2 digit divisors and 1-4 digit dividends (NR) (15).	Division with 1 digit divisors and 1-4 digit dividends (R) (6), 2 digit divisors and 1-4 digit dividends (NR) (6).	Multiplication with 1-3 digit whole numbers (6) <sup>b</sup> ; Tuesday acquisition problems (12) <sup>c</sup> .
Thursday	Division with 2 digit divisors and 1-4 digit dividends (NR) (15); division with 2 digit divisors and 1-4 digit dividends (R) (15).	Division with 2 digit divisors and 1-4 digit dividends (R) (12).	Tuesday acquisition problems (9) <sup>d</sup> ; Wednesday acquisition problems (9) <sup>e</sup> .

Table 2

*The Math Content Covered in Practice Homework and Working-Practice Homework Assignments*

Day	Practice homework	Working-practice homework	
		Acquisition material <sup>a</sup>	Maintenance material
Week 2			
Tuesday	Division with 1 digit divisors and 1 decimal point in dividend (30).	Division with 1 digit divisors and 1 decimal point in dividend (12).	Multiplication with 1-3 digit whole numbers (18).
Wednesday	Division with 1 digit divisors and 1 decimal point in dividend (30).	Division with 1 digit divisors and 1 decimal point in dividend (12).	Multiplication with 1-3 digit whole numbers (6) <sup>b</sup> ; Tuesday acquisition problems (12) <sup>c</sup> .
Thursday	Division with 1 digit divisors and 2 decimal points in dividend (30).	Division with 1 digit divisors and 2 decimal points in dividend (12).	Tuesday acquisition problems (9) <sup>d</sup> ; Wednesday acquisition problems (9) <sup>e</sup> .

Table 2

*The Math Content Covered in Practice Homework and Working-Practice Homework Assignments*

Day	Practice homework	Working-practice homework	
		Acquisition material <sup>a</sup>	Maintenance material
Week 3			
Tuesday	Division with 1 digit divisors and 2 decimal points in dividend (30).	Division with 1 digit divisors and 2 decimal points in dividend (12).	Multiplication with 1-3 digit whole numbers (18).
Wednesday	Division with 1 digit divisors and 3 decimal points in dividend (30).	Division with 1 digit divisors and 3 decimal points in dividend (12).	Multiplication with 1-3 digit whole numbers (6) <sup>b</sup> ; Tuesday acquisition problems (12) <sup>c</sup> .
Thursday	Division with 1 digit divisors and 3 decimal points in dividend (30).	Division with 1 digit divisors and 3 decimal points in dividend (12).	Tuesday acquisition problems (9) <sup>d</sup> ; Wednesday acquisition problems (9) <sup>e</sup> .

Table 2

*The Math Content Covered in Practice Homework and Working-Practice Homework Assignments*

Day	Practice homework	Working-practice homework	
		Acquisition material <sup>a</sup>	Maintenance material
Week 4			
Tuesday	Addition/subtraction of fractions with common denominators (NSS) (30).	Addition/subtraction of fractions with common denominators (NSS) (12).	Multiplication with 1-3 digit whole numbers (18).
Wednesday	Addition of fractions with uncommon denominators (NSS) (30).	Addition of fractions with uncommon denominators (NSS) (12).	Multiplication with 1-3 digit whole numbers (6) <sup>b</sup> ; Tuesday acquisition problems (12) <sup>c</sup> .
Thursday	Subtraction of fractions with uncommon denominators (NSS) (30).	Subtraction of fractions with uncommon denominators (NSS) (12).	Tuesday acquisition problems (9) <sup>d</sup> ; Wednesday acquisition problems (9) <sup>e</sup> .

Table 2

*The Math Content Covered in Practice Homework and Working-Practice Homework Assignments*

Day	Practice homework	Working-practice homework	
		Acquisition material <sup>a</sup>	Maintenance material
Week 5			
Tuesday	Addition of fractions with uncommon denominators (SS) (30).	Addition of fractions with uncommon denominators (SS) (12).	Multiplication with 1-3 digit whole numbers (18).
Wednesday	Subtraction of fractions with uncommon denominators (SS) (30).	Subtraction of fractions with uncommon denominators (SS) (12).	Multiplication with 1-3 digit whole numbers (6) <sup>b</sup> ; Tuesday acquisition problems (12) <sup>c</sup> .
Thursday	Addition of mixed numbers with common denominators (SS) (30).	Addition of mixed numbers with common denominators (SS) (12).	Tuesday acquisition problems (9) <sup>d</sup> ; Wednesday acquisition problems (9) <sup>e</sup> .

Table 2

*The Math Content Covered in Practice Homework and Working-Practice Homework Assignments*

Day	Practice homework	Working-practice homework	
		Acquisition material <sup>a</sup>	Maintenance material
Week 6			
Tuesday	Subtraction of mixed numbers with common denominators (SS) (30).	Subtraction of mixed numbers with common denominators (SS) (12).	Multiplication with 1-3 digit whole numbers (18).
Wednesday	Addition of mixed numbers with uncommon denominators (SS) (30).	Addition of mixed numbers with uncommon denominators (SS) (12).	Multiplication with 1-3 digit whole numbers (6) <sup>b</sup> ; Tuesday acquisition problems (12) <sup>c</sup> .
Thursday	Subtraction of mixed numbers with uncommon denominators (SS) (30).	Subtraction of mixed numbers with uncommon denominators (SS) (12).	Tuesday acquisition problems (9) <sup>d</sup> ; Wednesday acquisition problems (9) <sup>e</sup> .

*Note.* Each homework assignment contained 30 problems. (N) = number of each type of problem within the assignment. R = remainders in quotient. NR = no remainders in quotient. NSS = Fraction problems with no simplification of solution. SS = Fraction problems requiring simplification of solution.

<sup>a</sup>Acquisition material in working-practice homework was assigned to the following problem numbers: 1, 3, 6, 9, 11, 13, 16, 19, 21, 23, 26, and 29. <sup>b</sup>Maintenance material assigned to following problems numbers: 5, 10, 15, 20, 25, and 30. <sup>c</sup>Maintenance material from Tuesday assigned to following problem numbers: 2, 4, 7, 8, 12, 14, 17, 18, 22, 24, 27, and 28. <sup>d</sup>Maintenance material from Tuesday assigned to following problem numbers: 2, 4, 7, 12, 14, 17, 22, 24, and 27.

<sup>e</sup>Maintenance material from Wednesday assigned to following problem numbers: 5, 8, 10, 15, 18, 20, 25, 28, and 30.



Working-practice homework assignments consisted of 60% “maintenance” mathematics material and 40% acquisition skills. Maintenance material was defined as material already covered (Haring & Eaton, 1978). For the purpose of this study, maintenance material included mathematics calculation skills previously covered in the fifth grade curriculum prior to beginning the study. The participating teachers, who taught mathematics to all fifth grade students, were provided a list of the school district’s math calculation curriculum objectives, which reflected the state’s Standards of mathematics Learning for grade 5, and asked to identify a fifth grade objective already taught in the beginning of the school year to be used as maintenance material for this study. The participating teachers selected SOL Objective 5.3 as the maintenance material, which stated that students would solve problems involving multiplication of whole numbers using paper and pencil and mental computation. For the working-practice homework assignments, maintenance calculation problems involving multiplication of whole numbers were selected from the curriculum. Math calculation problems were introduced in working-practice homework assignments on a standardized schedule which maintained the 60:40 maintenance-to-acquisition ratio. Researchers have begun to investigate the relationship between ratios of maintenance material to acquisition material in academic skill acquisition (Cates, 2005). According to Burns (2004), research focused on determining optimal drill ratios for mathematics skill acquisition have been inconclusive and a single drill ratio is not preferred over another. The 60:40 ratio in this study was selected for ease of working-practice homework material development by the experimenter.

Working-practice homework consisted of 30 problems per assignment and was assigned to the participants on Tuesdays, Wednesdays, and Thursdays of a regular school week. See Table 2 for a description of the content covered in each working-practice homework assignment. See Appendix C for all of the working-practice assignments used in the study.

On Tuesdays' working-practice homework, 12 of the 30 problems presented the acquisition mathematical material covered in class on Monday and Tuesday. These acquisition problems were introduced into the working-practice homework assignment using specific problem numbers (see Table 2). The remaining 18 problems consisted of the maintenance calculation problems (whole number multiplication problems, which were randomly selected from the curriculum).

On Wednesdays' working-practice homework assignments, 12 of the 30 problems presented the mathematical material covered in class on Wednesdays (see Table 2). An additional 12 problems included in Wednesdays' assignments were the 12 acquisition problems from Tuesdays' assignments, which were considered maintenance problems for the existing assignment. The final 6 maintenance problems consisted of randomly selected whole number multiplication problems from the fifth grade curriculum. All problems were introduced into the working-practice homework assignment using specific problem numbers (see Table 2).

On Thursdays' working-practice homework assignments 12 of the 30 problems were acquisition problems taken from material covered in class on Thursday (see Table 2). The remaining 18 problems consisted of 9 acquisition problems from Tuesday's assignment as well as 9 acquisition problems from Wednesday's assignment, which were

identified as maintenance problems on Thursday's assignment. Again, all problems were introduced into the working-practice homework assignment using specific problem numbers (see Table 2).

### *Pretest and Posttest*

The pretest-posttest measure was developed by the experimenter, using teacher input, and measured selected math calculation skills required for fifth grade students. Calculation problems on the measure covered the 17 concepts presented in Table 1. Each of the 17 concepts was represented twice on the pretest-posttest measure for a total of 34 problems. See Table 3 for the number of problems presented and the description of the content covered for each curriculum objective on the pretest-posttest measure. The calculation problems on the pretest-posttest measure were randomly selected from a larger pool of problems in the school district's test bank, which included math calculation problems for curriculum Objectives 5.5, 5.6, and 5.7. The experimenter used a random number generator to randomly order the 34 calculation problems presented on the pretest-posttest measure (Urbaniak & Plous, 2000). The format of the pretest-posttest measure, including the layout of the calculation problems, matched the format of the homework assignments. See Appendix D for the pretest-posttest measure used during the study. To establish the content validity of the pretest-posttest measure, the study's participating teachers reviewed the types of math calculation problems on the pretest-posttest measure to confirm the content of the measure accurately reflected the skills presented during instruction, the school district's curriculum objectives, and on the homework assignments.

Table 3

*Math Content Covered on the Pretest-Posttest Measure*

Curriculum objective	Description of content presented
5.5 (n = 8)	2 division problems with 1 digit divisors and 1-4 digit dividends (NR); 2 division problems with of 1 digit divisors (R); 2 division problems with 2 digit divisors with 1-4 digit dividends (NR); 2 division problems with 2 digit divisors (R).
5.6 (n = 6)	2 division problems with 1 digit divisor and 1 decimal point in the dividend; 2 division problems with 1 digit divisor with 2 decimal points in the dividend; 2 division problems with 1 digit divisor and 3 decimal points in the dividend.
5.7 (n = 20)	2 addition problems with fractions and common denominators (NSS); 2 subtraction problems with fractions and common denominators (NSS); 2 addition problems with fractions and uncommon denominators (NSS); 2 subtraction problems with fractions and uncommon denominators (NSS); 2 addition problems with fractions and uncommon denominators (SS); 2 subtraction problems with fractions and uncommon denominators (SS); 2 addition problems with mixed numbers and common denominators (SS); 2 subtraction problems with mixed numbers and common denominators (SS); 2 addition with mixed numbers and uncommon denominators (SS); 2 subtraction problems with mixed numbers and uncommon denominators (SS).

*Note.* Maximum digits correct for the measure = 93. R = remainders in quotient. NR = no remainders in quotient. NSS = Fraction problems with no simplification of solution. SS = Fraction problems requiring simplification of solution.

The pretest was administered on the first day of the study and the same measure was administered on the last day of the study. Participants were provided 90 minutes to complete the pretest and 90 minutes to complete the posttest. In accordance with curriculum-based measurement, which is a standardized measurement procedure used to measure the level and trend of academic progress, or growth, in reading, written expression, spelling, and mathematics, each participant earned one point for each correct digit in the calculation's answer rather than the traditional test scoring method of giving one point for each problem solved correctly (Deno 1985; Shinn, 1989).

The total score on the pretest and posttest depended on the total number of correct digits the participant computed across all of the mathematics calculation items. Curriculum-based measurement scoring procedures were used because the research literature documents the utility of curriculum-based measurement for benchmarking participant performance in computation (Carson & Eckert, 2003; Crawford, Tindal, & Stueber, 2001; Good & Kaminski, 2002; Hintze & Silberglitt, 2005; Jones & Wickstrom, 2002). Curriculum-based measurement scoring procedures were also used because published norm-referenced tests are not sensitive to differences within a participant across time (Shinn & Bamonto, 1998). If a participant's math calculation skills changed as a result of an instructional approach or academic intervention, for example, published norm-referenced tests are unable to detect the short-term effects, or changes. According to the research literature, reliability estimates for curriculum-based measurement in mathematics ranges from .70 to .98 (Christ & Vining, 2006; Hintze, Christ, & Keller, 2002; Martson, 1989).

The researcher, who had training and experience with curriculum-based measurement, administered and scored both the pretest and posttest. For all computational skills, except long division, a correct digit was a digit written below the line and in the correct place value (Shinn, 1993). If a participant's answer was correct, the participant received the full problem value for digits correct despite the presence or absence of work. For computational problems identified as incorrect or incomplete, credit was given for the correct digits in the solution. When the calculation problems required regrouping, the steps involving "carrying" or "borrowing" were not counted as digits correct. For example, in a 4 digit by 3 digit addition with regrouping problem, the digits written above the tens, hundredths, and thousandths columns were not counted. The number of digits computed correctly was the data collected from the pretest and the posttest. The pretest and the posttest included a total of 93 possible digits placed correctly. To verify the reliability of the measure, a Cronbach's alpha of .94 and .92 was calculated for the pretest and posttest measures, respectively, demonstrating high internal consistency overall for the measure (Green & Salkind, 2003; Pagano, 2004; Shannon & Davenport, 2001).

### *Procedures*

#### *Consent Procedures*

Prior to starting the study, approval from the University of Missouri Campus Institutional Review Board was received. The classroom teachers distributed the letters of consent to the 98 potential participants during mathematics in their general education classrooms. The letters of consent were then distributed to the parents or guardians of the potential participants and requested voluntary consent for their child's inclusion in

the study (see Appendix E). The participants received his or her choice of a mechanical pencil or pen for returning the letters of consent to their classroom teacher. After obtaining consent from the parents or guardians, the participants were presented with letters of assent during mathematics in their general education classrooms (see Appendix E). Ninety-four students returned letters of consent and letters of assent agreeing to participate in the study. The students who did not participate in the study were provided with the standard instruction and homework but no data for the study was collected. Although 94 students agreed to participate in the study, 4 students independently withdrew from the school district during the study. Consequently, a total of 90 students, 45 females and 45 males, participated and completed the 6 week study. The school's 4 fifth grade classrooms had 22, 22, 23, and 23 students, respectively, that completed the study.

### *Pretest*

The study was conducted for six weeks from October 2006 to November 2006. On the first day of the study, all of the participants completed a pretest in their general education classrooms during mathematics. The researcher administered the pretest, scored the pretest, and recorded each score. Although the pretest was scored in compliance with curriculum-based measurement scoring procedures for math, the pretest was not administered in full accordance with curriculum-based measurement procedures because the participants were allowed 90 minutes to complete the pretest (Deno 1985; Shinn, 1989). The participants were read the same set of directions prior to starting the pretest adapted from Shinn's (1989) curriculum-based measurement procedures:

The sheets on your desk are math problems. There are several types of problems

on each sheet, like division, division with decimals, addition with fractions and mixed numbers, and subtraction with fractions and mixed numbers. Look at each problem carefully before you answer it. When I say “Start” turn your paper over and begin. Start on the first problem on the left of the top row (*point*). Work across and then go to the next row. If you cannot answer a problem, skip it and go on to the next problem. Are there any questions? Start.

Three participants were absent on the first day of the study and, as a result, were given the pretest as a small group the following school day in their general education environment during the Core Extension, or independent study, period of the blocked schedule. The researcher administered the pretest in compliance with the previously described pretest procedures.

#### *Random Assignment of Participants Within the Design*

After completing the pretest of selected math skills, the participants were blocked into one of the three math achievement levels, or groups, based on his or her total score of digits placed correctly: the top, middle, and lower thirds. The top third was defined as the participants who earned pretest scores in the top one-third, the middle third was defined as the middle one-third pretest scores, and the lower third was defined as the bottom one-third pretest scores. See Figure 1 for the distribution of the pretest scores among the blocked level of achievement subgroups.

Within each of the three math achievement levels, the participants were separated by gender and then randomly assigned to either the control (practice homework) group or treatment (working-practice homework) group using a random number generator, which assigned a random number to each participant (Urbaniak & Plous, 2000). Random



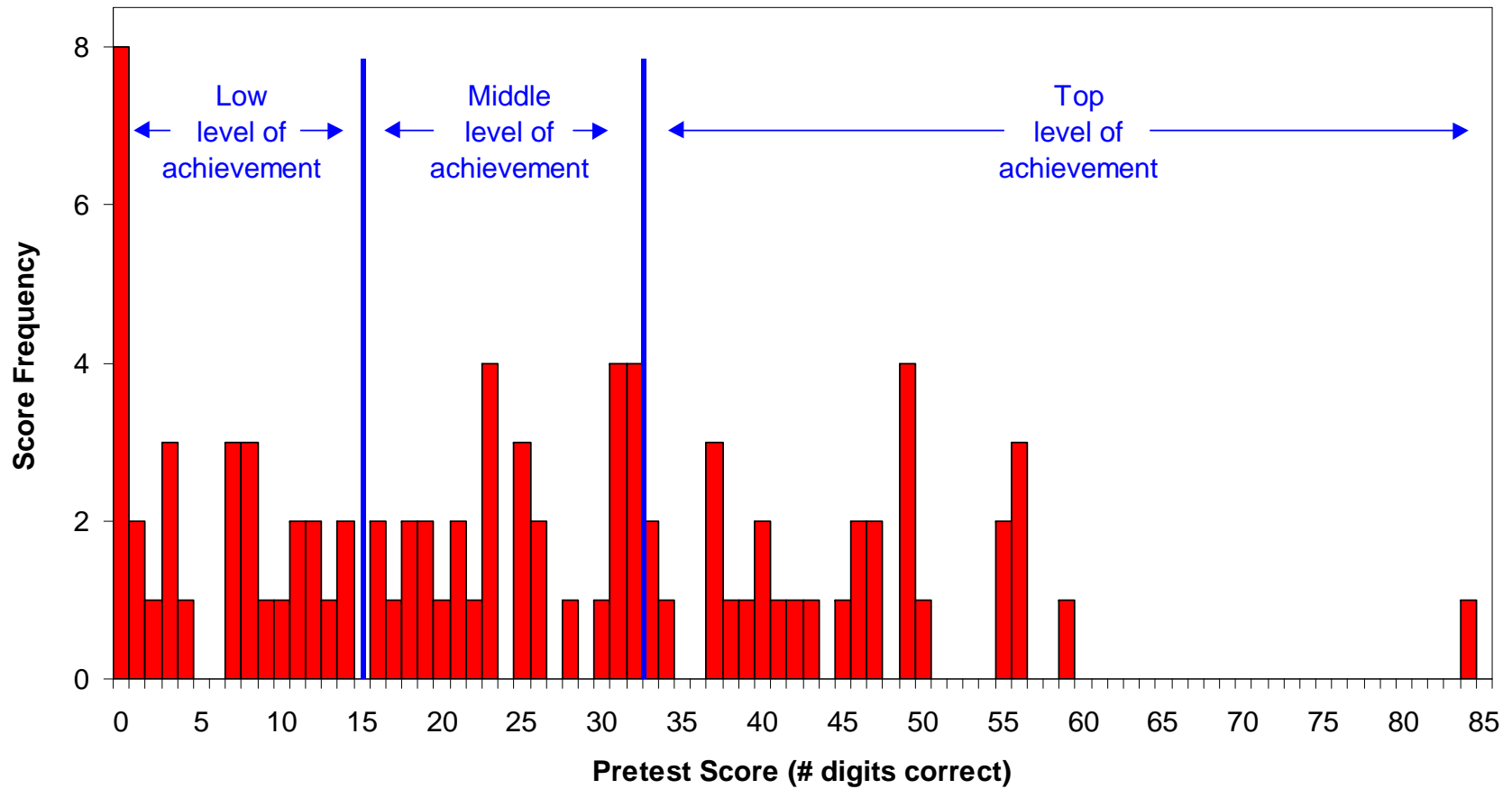


Figure 1. Distribution of pretest scores for sample population (N = 90). Each blocked level of achievement subgroup contained 30 participants. A maximum pretest score of 93 digits placed correctly was possible.

assignment in the design permitted an equal proportion of girls and boys to be placed into either the control group or the treatment group. For example, the thirty participants blocked into the top third group consisted of 18 girls and 12 boys. Consequently, 9 girls were randomly assigned to the control group (practice homework) and 9 girls were randomly assigned to the experimental group (work-practice homework), while 6 boys were randomly assigned to the control group and 6 boys were randomly assigned to the experimental group. See Table 4 for the assignment of female and male participants.

#### *Curriculum Instruction and Homework*

The participants' received mathematics instruction approximately 90 minutes per day, 5 days a week. The four participating fifth grade general education classrooms were organized according to a blocked schedule, where 2 of the classes received mathematics instruction from 10:30 a.m. to 12:00 p.m. in their general education classrooms and the remaining two classrooms received mathematics instruction from 1:15 a.m. to 2:45 p.m. every day of the school week in their general education classrooms. As determined by the school's administration prior to the start of the school year, two teachers taught the math curriculum to all fifth grade students, which helped maintain instructional consistency. Each teacher repeated the same lesson plan twice a day to groups of 20 or more students at a time. The mean number of years of teaching experience between the two participating teachers was 18.5 years.

Mathematics instruction was provided using the district mandated Scott Foresman-Addison Wesley math curriculum and materials, which included a student textbook, a student review and practice workbook, and a teacher sourcebook. The purpose of the teacher sourcebook (curriculum manual) was to develop students'

Table 4

*Assignment of Female and Male Participants to Practice and Working-Practice**Homework Groups*

Level of math achievement	Practice homework		Working-practice homework	
	Females	Males	Females	Males
Top	9	6	9	6
Middle	7	8	8	7
Low	6	9	6	9

understanding of mathematics skills through explicit, step-by-step instruction (Charles et al., 1999). Consequently, the sourcebook provided lesson plans that were, prior to the start of the school year, formally expanded in written form by the two participating math teachers and support staff, such as curriculum coaches, to reflect direct, or explicit, instruction. The lesson plans were uniform insofar as each lesson plan followed the same structural format, which included: stating the math objective; skill review; the presentation of the new information broken down into small steps; guided practice through group instruction, modeling of skills, feedback, and corrections; independent practice with the teacher assessing students' performances; further independent practice assigned through homework. See Appendix F for an example of a lesson plan used during the study. The two participating teachers selected and assigned the lesson plans for math to the fifth grade level curriculum calendar. The purpose of the fifth grade level curriculum calendar was to identify the lesson plans taught across subjects on any given date. Both participating math teachers followed the same lesson plan each day. Any

potential differences based on the two teachers' instruction skills and styles were minimized by randomly assigning homework type regardless of the teacher and gender. The frequently used alternative design where one teacher instructs the treatment group and another teacher instructs the control group often produces a nested design, which would have inherent validity problems due to limited replications and was not used.

For 6 weeks, the two participating teachers assigned the practice homework to the participants on Tuesdays, Wednesdays, and Thursdays of each week. Working-practice homework was also assigned to the participants on Tuesdays, Wednesdays, and Thursdays of a regular school week. The participants were instructed to return all homework assignments on the following school day to their general education mathematics teacher. If a participant submitted an unfinished assignment, the participant was required to complete that homework assignment during the Core Extension, or independent study, period the following day. Late homework assignments were accepted upon time of receipt. For example, when a participant did not return a homework assignment the following school day, he or she received the missed homework assignment and completed it during the Core Extension period of the blocked schedule. If a participant was absent from school, he or she received instruction from the teacher on the material and was given the missed homework assignment immediately upon returning to school during Core Extension. The participant was given one school night to complete the assignment. The homework assignments were both recorded and corrected by the researcher. The homework assignments were returned to the participants with feedback, including corrected answers and the steps necessary to calculate an incomplete problem. The overall rate of homework return, or homework returned to a student's general

education fifth grade math teacher, during the study was 92%. The participants assigned to practice homework group showed a 91% rate of homework return and the participants assigned to the working-practice group showed a 93% rate of homework return.

Furthermore, the participants blocked into the upper third group displayed a 92% rate of homework return, the participants blocked into the middle third group earned a 93% rate of homework return, and the participants blocked into the lower third group obtained a 91% rate of homework return.

### *Posttest*

On the last day of the study, the same measure administered on the first day of the study was administered as the posttest in the general education environment. The researcher administered the posttest, scored the posttest, and recorded each score. The posttest was scored in compliance with curriculum-based measurement procedures for math and administered following the same procedures for the administration of the pretest. As a result, the participants were provided 90 minutes to complete the posttest during math. Furthermore, the participants were read the same set of directions prior to the start of the posttest that the researcher read prior to the start of the pretest. Five participants were absent on the last day of the study. Consequently, the 5 participants were given the posttest as a small group the following school day in the general education environment during the Core Extension, or independent study, period of the blocked schedule. The researcher administered the posttest in compliance with the previously described posttest procedures.

## *Data Analysis*

### *Design*

The research implemented a two-group relative comparison blocked design. The research was an experimental design using random assignment to experimental and control groups in order to control for threats to internal validity. The dependent variable for the design was participants' posttest scores. The control group received a standard treatment: practice homework. The practice homework provided opportunities to respond to newly acquired skills, or procedures, presented during mathematics instruction. For the study, 100% of the practice homework covered acquisition, or recently presented, math calculation skills. The treatment group received a newly designed form of homework, working-practice homework, developed from drill ratio research, which concluded that participants learn best by including some familiar practice along with recently acquired skills or material (MacQuarrie et al., 2002). Working-practice homework was designed to provide more effective practice, or opportunities to respond, by incorporating new material with maintenance, or previously covered, material and was assigned to the treatment group. For this study, 60% of the working-practice homework covered maintenance mathematics material and 40% covered acquisition skills. The practice and working-practice homework were calculation assignments and the content was based on the curriculum presented throughout the study.

Blocking was utilized in the research design to form more homogenous subgroups, thereby controlling for within group variability and reducing error variance. As a result, participants were blocked according to their level of achievement on a math pretest. Participants' scores on the math pretest reflected their math calculation skill

knowledge relative to the content and prior to the experimental treatment. After completing a pretest of selected math skills, the participants were separated based on their pretest score into three groups: the top, middle, and lower third of the pretest score distributions.

### *Statistical Techniques*

The t-test for independent means was used to examine the effects of the independent variable, homework type (practice homework and working-practice homework) on the dependent variable, posttest scores (Aron & Aron, 1994; Maxwell & Delany, 2000, 2004; Shannon & Davenport, 2001). The t-test for independent means was used to examine the entire sample of 90 participants to determine whether the posttest means between the treatment group and the control group were statistically different and was also used to evaluate each blocked subgroup of participants (the top, middle, and lower thirds) to determine whether statistically significant differences existed within each group. Since the sample sizes were equal for each comparison, the t-test for independent means would be considered robust (Maxwell & Delaney, 2000). Paired-samples t-tests were used within each cell and for overall groups to verify that statistically significant differences existed between the pretest scores and the posttest scores.

Initially, the data was analyzed using an ANOVA for the purpose of determining whether a significant change occurred from pretreatment to posttreatment (Maxwell & Delaney, 2000). For the ANOVA, the dependent variable was the gain score, which was defined as the difference between a participant's posttest score and pretest score. In this analysis, two independent variables were included: homework type (practice homework and working-practice homework) and level of achievement (top, middle, and lower

thirds). Upon review of these results, inconsistent correlations between the pretest and posttest scores within each cell were observed, as evidenced by positive correlations in some cells, correlations appearing flat in other cells, and one cell correlation appearing negative and trending downward. The inconsistency in cell correlations could have been due to the relatively small sample sizes for the individual cells ( $n = 15$  within each cell). As a result, the reliability of gain scores as the dependent variable was questioned and this statistical procedure was not used with the data set (Maxwell & Delaney, 2000).

After considering the ANOVA of gain scores, an ANCOVA was considered for determining if differences existed between groups on the posttest measure despite preexisting differences (Maxwell & Delaney, 2000). For the ANCOVA, the dependent variable was the posttest score, the independent variables were homework type (practice homework and working-practice homework) and level of achievement (top, middle, and lower thirds), and the covariate was the pretest score. An ANCOVA relies on the homogeneity of regression slopes, which is established by examining the slopes of the regression lines in the different group to determine if they are equal within sampling error (Maxwell & Delaney, 2000). Upon review of these results, inconsistent correlations between the pretest and posttest scores within each cell were again observed, as discussed in the ANOVA of gain score analysis. Additionally, large differences among the cell variances on the pretest and posttest descriptive statistics were noted. When considering the inconsistent correlations within each cell and the large differences among the cell variances on the pretest and the posttest, it was questionable that the homogeneity of regression slopes within each cell could be established. Because this assumption



appeared to be violated, the ANCOVA was not used with the data set as the statistical procedure.

### *Assumptions*

The assumptions for t-tests of independent means were independence, normality, and homogeneity of variance (Maxwell & Delany, 2000, 2004; Shannon & Davenport, 2001). In the design, independence was established because random assignment was utilized in assigning participants to either the treatment group or the control group. As a result, the groups are considered independent (Green & Salkind, 2003; Morgan et al., 2004; Pagano, 2004). Prior to data analysis, the data was screened for any violations to the assumptions of normality and homogeneity of variance. The researcher analyzed both the skewness and kurtosis values across the entire sample and the subgroups to verify the normal distribution of posttest scores. Homogeneity of variance was analyzed using Levene's Test of Equality of Error Variances (Green & Salkind, 2003; Morgan et al., 2004; Pagano, 2004; Shannon & Davenport, 2001).

## Chapter Four: Results

### *Descriptive Statistics*

The mean score (as measured by number of digits placed correctly) and SD for each homework group crossed with level of achievement group are reported in Table 5 for the pretest measure. Based on the pretest scores, the participants were blocked into the top, middle, and lower level of achievement groups. The minimum and maximum pretest scores for each level of achievement group and homework group are also reported in Table 5. The distribution of pretest scores for each participant was presented in Figure 1. In the top level of achievement group, one participant scored an 84 out of a possible 93 digits correct, while the next highest participant was a 59 out of 93 digits correct, explaining the large difference in maximum scores for practice homework and working-practice homework groups. As a result, the SD of the top level of achievement group was higher than the middle and lower level of achievement groups.

For the posttest measure, the mean score, SD, and minimum and maximum scores are reported in Table 6 for each homework group and level of achievement group. The mean scores for the posttest measure exhibited a similar pattern to the pretest mean scores, where the top level of achievement group had a higher mean score than the middle level of achievement group, which had a higher mean score than the lower level of achievement. An interesting finding is the SD exhibited an inversely proportional relationship with respect to level of achievement group. The lower level of achievement group had a much higher SD than the middle achievement group, which had a higher SD

Table 5

*Descriptive Statistics for Pretest “Digits Correct” Math Scores*

Homework	N	M	SE M <sup>a</sup>	Min - Max	Median	Variance	SD	Skewness	SE S <sup>b</sup>	Kurtosis	SE K <sup>c</sup>
Top level of achievement											
Practice	15	46.93	3.33	34 – 84	42	166.07	12.89	1.851	.580	4.142	1.121
Working-practice	15	45.87	1.89	33 – 56	47	53.70	7.33	-.490	.580	-.473	1.121
All	30	46.40	1.88	33 – 84	46	106.39	10.31	1.622	.427	4.852	.833
Middle level of achievement											
Practice	15	25.87	1.31	17 – 32	26	25.70	5.07	-.396	.580	-1.111	1.121
Working-practice	15	23.20	1.44	16 – 32	23	31.03	5.57	.527	.580	-.881	1.121
All	30	24.53	.99	16 – 32	24	29.22	5.41	.042	.427	-1.320	.833
Lower level of achievement											
Practice	15	6.00	1.37	0 – 14	7	28.14	5.30	.176	.580	1.121	1.121
Working-practice	15	5.20	1.24	0 – 14	4	22.89	4.78	.372	.580	-1.258	1.121
All	30	5.60	.91	0 – 14	5.5	24.80	4.98	.270	.427	-1.426	.833
All participants regardless of level of achievement											
Practice	45	26.27	2.81	0 – 84	26	355.65	18.86	.621	.354	.524	.695
Working-practice	45	24.76	2.66	0 – 56	23	317.37	17.81	.231	.354	-1.199	.695
All	90	25.51	1.92	0 – 84	24	333.31	18.26	.441	.254	-.245	.503

Note. Maximum digits correct for the measure = 93.

<sup>a</sup>Standard error of the mean. <sup>b</sup>Standard error of skewness. <sup>c</sup>Standard error of kurtosis.

Table 6

*Descriptive Statistics for Posttest “Digits Correct” Math Scores*

Homework	N	M	SE M <sup>a</sup>	Min - Max	Median	Variance	SD	Skewness	SE S <sup>b</sup>	Kurtosis	SE K <sup>c</sup>
Top level of achievement											
Practice	15	78.80	2.22	61 – 91	79	74.17	8.61	-.490	.580	.034	1.121
Working-practice	15	81.80	2.21	65 – 92	84	73.46	8.57	-.956	.580	.074	1.121
All	30	80.30	1.57	61 - 92	80.5	73.60	8.58	-.652	.427	-.313	.833
Middle level of achievement											
Practice	15	70.73	3.52	41 – 89	70	185.64	13.62	-.539	.580	-.076	1.121
Working-practice	15	70.33	3.55	35 – 90	70	188.67	13.74	-.996	.580	2.027	1.121
All	30	70.53	2.45	35 - 90	70	180.74	13.44	-.728	.427	.622	.833
Lower level of achievement											
Practice	15	57.40	5.49	16 – 85	67	451.97	21.26	-.662	.580	-.686	1.121
Working-practice	15	51.67	5.00	16 – 75	59	375.52	19.38	-1.030	.580	-.390	1.121
All	30	54.53	3.69	16 - 85	60	407.98	20.20	-.712	.427	-.585	.833
All participants regardless of level of achievement											
Practice	45	68.98	2.61	16 – 91	73	306.11	17.50	-1.252	.354	1.381	.695
Working-practice	45	67.93	2.83	16 – 92	69	360.61	18.99	-1.211	.354	1.360	.695
All	90	68.46	1.91	16 - 92	71.5	329.89	18.16	-1.217	.254	1.266	.503

Note. Maximum digits correct for the measure = 93.

<sup>a</sup>Standard error of the mean. <sup>b</sup>Standard error of skewness. <sup>c</sup>Standard error of kurtosis.

than the top achievement group. The lower level of achievement group had a large difference in the minimum and maximum mean scores, further supporting this finding.

The entire sample population experienced an increase in the mean pretest score to the mean posttest score, from 25.51 out of 93 digits correct ( $SD = 18.26$ ) to 68.46 out of 93 digits correct ( $SD = 18.16$ ), respectively. There was a statistically significant difference between the mean pretest score and the mean posttest score indicating academic growth,  $t(89) = -24.265$ ,  $p < .01$ , two-tailed. Increases in mean scores from the pretest measure to posttest measure were observed for all groups, regardless of homework type or level of achievement. Paired sample t-test results confirmed the statistically significant differences between the mean pretest score and mean posttest score for all groups ( $p < .01$  for all cases), as reported in Table 7. The percentage of digits placed correctly for the pretest and posttest mean scores are reported in Table 8, further evidence of academic growth from the pretest measure to the posttest measure.

The correlations between the pretest scores and posttest scores of all groups are presented in Table 9. The correlation of the entire sample population ( $r = .575$ ) was sufficient to relate the pretest score to the posttest score. However, the correlation results for the individual groups (3 levels of achievement X 2 type of homework) were lower than those observed for entire sample population, the entire practice homework group, and the entire working-practice group, which could be due to the smaller sample sizes for the individual groups. These individual groups displayed inconsistent trends in pretest-posttest correlations. While 3 of 6 individual correlations were positive, albeit lower, the middle level of achievement group with working-practice homework had a negative correlation and the two lower level of achievement groups had correlations that

Table 7

*Paired Samples T-Test: Comparing Pretest and Posttest “Digits Correct” Means*

Homework	Paired differences			t	df	p
	M	SD	SE M <sup>a</sup>			
Top level of achievement						
Practice	-31.87	11.47	2.96	-10.761	14	.000*
Working-practice	-35.93	9.76	2.52	-14.252	14	.000*
All	-33.90	10.67	1.95	-17.404	29	.000*
Middle level of achievement						
Practice	-44.87	12.72	3.28	-13.665	14	.000*
Working-practice	-47.13	15.55	4.02	-11.738	14	.000*
All	-46.00	14.00	2.56	-17.404	29	.000*
Lower level of achievement						
Practice	-51.40	21.92	5.66	-9.081	14	.000*
Working-practice	-46.47	19.60	5.06	-9.181	14	.000*
All	-48.93	20.59	3.76	-13.019	29	.000*
All participants regardless of level of achievement						
Practice	-42.71	17.71	2.64	-16.179	44	.000*
Working-practice	-43.18	16.01	2.39	-18.086	44	.000*
All	-42.94	16.79	1.77	-24.265	89	.000*

*Note:* There was a maximum score of 93 digits correct on the pretest-posttest measure.

<sup>a</sup>Standard error of the mean.

\*  $p < .01$

Table 8

*Percent of Digits Placed Correctly for Pretest and Posttest Means*

Homework	N	% Digits Correct	
		Pretest	Posttest
Top level of achievement			
Practice	15	50%	85%
Working-practice	15	49%	88%
All	30	50%	86%
Middle level of achievement			
Practice	15	28%	76%
Working-practice	15	25%	76%
All	30	26%	76%
Lower level of achievement			
Practice	15	6%	61%
Working-practice	15	6%	56%
All	30	6%	59%
All participants regardless of level of achievement			
Practice	45	28%	74%
Working-practice	45	27%	73%
All	90	27%	74%

*Note:* There was a maximum score of 93 digits correct on the pretest-posttest measure.

Table 9

*“Digits Correct” Pretest-Posttest Correlations*

Homework	Level of achievement			
	Top	Middle	Lower	All
Practice	.490 (n = 15)	.359 (n = 15)	-.002 (n = 15)	.528** (n = 45)
Working-practice	.253 (n = 15)	-.146 (n = 15)	.076 (n = 15)	.623** (n = 45)
All	.374* (n = 30)	.095 (n = 30)	.045 (n = 30)	.575** (n = 90)

Note: (n) = number of participants.

\*  $p < .05$ . \*\*  $p < .01$

approached  $r = 0$ . Possible reasons for the inconsistent correlations are the smaller sample size in the individual groups or it could be due to differences in how the participants in each level of achievement responded to the treatments (homework type).

### *Data Inspection*

#### *Normality*

Prior to data analysis, the data was screened for assumption violations to normality. Reportedly, the skewness value was  $-1.217$  and the kurtosis value was  $1.266$  for the entire sample population. Although the descriptive statistics showed the distribution of posttest scores was negatively skewed and indicated a slightly taller distribution in comparison to a normal distribution, this feature likely reflects the interventions and the pretest-posttest measure used in the study (Aron & Aron, 1994). Both treatment and control groups received interventions designed to increase their skill acquisition and demonstrate skill mastery for problems similar in content to those on the pretest-posttest measure, which had a maximum score of 93 digits correct. The



maximum score may theoretically pose a limit, or ceiling, to the potential for increase in the posttest scores. Because the data were skewed in the same direction (negatively) and both skewness and kurtosis values fell within 1 *SE* and were less than  $\pm 2$ , data analysis using the t-test for independent means would be robust (Ramirez & Shapiro, 2006; Shannon & Davenport, 2001; Tabachnick & Fidell, 2007).

#### *Homogeneity of Variance*

The data was further screened for assumption violations to homogeneity of variance prior to analysis. According to the data screening, Levene's Test of Equality of Error Variances resulted in  $p > .05$ , meeting the criteria for homogeneity of variance (see Table 10). Consequently, the t-test for independent means was considered robust and the likelihood for Type I error was minimized (Green & Salkind, 2003; Maxwell & Delany, 2000, 2004; Morgan et al., 2004; Pagano, 2004).

#### *Research Hypothesis 1*

It was hypothesized that fifth grade participants exposed to working-practice homework would achieve higher posttest scores compared to the fifth grade participants exposed to practice homework. However, the mean posttest score for the treatment group, or the group receiving working-practice homework assignments, was 67.9 out of 93 digits correct ( $SD = 18.99$ ) and the mean posttest score for the control group, or the group receiving practice homework assignments, was 68.98 out of 93 digits correct ( $SD = 17.50$ );  $t(88) = .271$ ,  $p = .787$ , two-tailed (see Table 10). Consequently, the results showed no significant difference between the mean posttest scores for participants receiving working-practice homework and participants receiving practice homework. Research Hypothesis 1 was rejected.

Table 10

*T-Tests for Independent Means: Comparing Mean Posttest Scores for Practice Homework and Working-Practice Homework*

Level of achievement	Levene's test <sup>a</sup>		T-test					
	F	p	t	df	p	$\Delta M^b$	Effect size <sup>c</sup>	Observed power <sup>d</sup>
Top	.024	.878	-.956	28	.347	-3.00	-.35	.17
Middle	.125	.726	.080	28	.937	.40	.03	.08
Lower	.252	.620	.772	28	.447	5.73	.28	.13
All participants	.100	.753	.271	88	.787	1.04	.06	.16

<sup>a</sup>Levene's test for equality of variances. <sup>b</sup>Practice homework mean – working-practice homework mean. <sup>c</sup> $\Delta M/SD$  of both populations. <sup>d</sup>Estimated from Cohen (1988).

### *Research Hypothesis 2*

It was hypothesized that fifth grade participants blocked in the top third achievement group exposed to working-practice homework would achieve higher posttest scores compared to those exposed to practice homework. Yet, the mean posttest score for participants blocked in the top third achievement group and receiving working-practice homework was 81.80 out of 93 digits correct ( $SD = 8.57$ ) and the mean posttest score for participants blocked in the top third achievement group and receiving practice homework was 78.80 out of 93 digits correct ( $SD = 8.61$ ),  $t(28) = -.956$ ,  $p = .347$ , two-tailed (see Table 10). The results showed no significant difference between the mean posttest scores for participants blocked in the top third achievement group and receiving working-practice homework and those receiving practice homework. Research Hypothesis 2 was rejected.

### *Research Hypothesis 3*

It was hypothesized that fifth grade participants blocked in the middle third achievement group exposed to working-practice homework would achieve higher posttest scores compared to those exposed to practice homework. The mean posttest score for participants blocked in the middle third achievement group and receiving working-practice homework was 70.33 out of 93 digits correct ( $SD = 13.74$ ) and the mean posttest score for participants blocked in the middle third achievement group and receiving practice homework was 70.73 out of 93 digits correct ( $SD = 13.62$ ),  $t(28) = .080$ ,  $p = .937$ , two-tailed (see Table 10). The results showed no significant difference between the mean posttest scores for participants blocked in the middle third achievement group and

receiving working-practice homework and those receiving practice homework. Research Hypothesis 3 was rejected.

#### *Research Hypothesis 4*

It was hypothesized that fifth grade participants blocked in the lower third achievement group exposed to working-practice homework would achieve higher posttest scores compared to those exposed to practice homework. The mean posttest score for participants blocked in the lower third achievement group and receiving working-practice homework was 51.67 out of 93 digits correct ( $SD = 19.38$ ) and the mean posttest score for participants blocked in the lower third achievement group and receiving practice homework was 57.40 out of 93 digits correct ( $SD = 21.26$ ),  $t(28) = .772$ ,  $p = .447$ , two-tailed (see Table 10). The results showed no significant difference between the mean posttest scores for participants blocked in the lower third achievement group and receiving working-practice homework and those receiving practice homework. Research Hypothesis 4 was rejected.

## Chapter Five: Discussion

### *Interpretation of Results Relative to the Research Literature and Theory*

#### *Academic Growth*

The results indicated that on average the entire sample population showed a change, or academic growth, from the pretest measure to the posttest measure for the calculation concepts covered in the study after receiving instruction and completing homework assignments, as evidenced by descriptive statistics and the paired samples t-test results. Furthermore, participants on average displayed academic growth regardless of homework type or level of achievement in the presence of instruction.

However, analyzing the data from an educationally significant standpoint may be beneficial. Both the pretest and posttest measure were scored in accordance with curriculum-based measurement procedures, where the total score on the pretest or posttest measure was dependent upon the total number of digits placed correctly by the participant across all of the mathematics calculation items. Evaluation of academic growth using the percent of digits placed correctly further validated the growth demonstrated in the results. The overall growth for the sample population from 27% of the digits placed correctly on the pretest to 74% of the digits placed correctly on the posttest could be regarded as two letter grades in many educational systems (see Table 8). Similarly, the growth exhibited by the participants blocked into the top or middle third achievement groups could be regarded as an increase in three and two letter grades, respectively, when considering the number of digits placed correctly. Although academic growth was observed from the pretest measure to the posttest measure for the participants

blocked into the lower third group, on average these participants still showed failing outcomes using most educational systems grading scales. Consequently, within the level of achievement groups, the participants appeared to respond differently to the instruction and the homework assignments from an educational point of view.

For the study, the homework assignments were designed to provide opportunities for further academic responding, independent of instructional procedures to promote the acquisition of the calculation procedures as described by Haring and Eaton's (1978) academic skill model (Cates, 2005; Goldman & Pellegrino, 1987; Skinner, 1998; Skinner & Schock, 1995). The desired outcome of the homework intervention was for participants to acquire a set of calculation procedures, or procedural knowledge, through the process of rehearsal and store the procedures in permanent memory (Byrnes 2001, 2007; Haring & Eaton, 1978). This observed academic growth aligns with some of the research literature pertaining to the assignment of homework for upper level elementary school students as an effective instructional strategy implemented for the purpose of increasing academic achievement (Cooper, 1989; Cooper et al., 2006; Koch, 1965; Maertens & Johnston, 1972). In the presence of instruction, homework appeared as a useful evidenced-based strategy for facilitating calculation skill acquisition.

#### *Comparison of Homework Types*

An examination of the results suggested that regardless of homework type assigned, participants on average demonstrated academic progress for the math calculation skills covered throughout the study in the presence of instruction. This observation is preliminary in nature because the design of the study did not include a 'no homework' control group of fifth grade participants. Power estimates for all four t-tests

for independent means were low (see Table 10). Even though the power was low for all participants (.16), the difference between the homework groups is probably not large. Theoretically, a large effect size for the 45 participants in each homework group would have resulted in a much higher power (approximately .96), suggesting that the study design would be capable of detecting a significant difference in the posttest means if a difference actually existed (Aron & Aron, 1994). Examination of the percent of digits placed correctly further confirms the lack of significant differences between homework types and again provides insight from an educationally significant standpoint. For example, the participants blocked into the top third level of achievement group and assigned practice homework showed 85% of the digits placed correctly on the posttest measure, while those participants assigned working-practice homework showed 88% of the digits placed correctly (see Table 8). The difference between 85% and 88% on grading scales for many educational systems is negligible. In sum, the information obtained from the results indicated that differences between homework types were not statistically significant for the math calculation concepts covered in the study.

The research literature has documented the importance of increased opportunities for academic responding for the purpose of academic skill development (Cates, 2005; Goldman & Pellegrino, 1987; Haring & Eaton, 1978; Skinner, 1998, Skinner & Schock, 1995). Some researchers consider drill and practice an effective strategy for increasing academic skills and assisting with academic skill remediation (Chase & Symonds, 1992; Greenwood et al., 1984). As a result, specific drill approaches have been developed, including traditional drill (100% unknown items), drill sandwich (50% known items and 50% unknown items), and incremental rehearsal (gradually increasing the ratio of known

to unknown items using a ‘folding-in’ technique) (Burns, 2004, 2005; Coulter & Coulter, 1989). Seemingly, when rehearsing, or acquiring, new information, interspersing known items with unknown items appeared as an effective practice and a meta-analysis of the research literature pertaining to interspersal approaches, which consisted of 13 research studies, showed large effect sizes for activities involving 50% to 69% known items, 70% to 85% known items, and 90% known items (Burns, 2004, 2005).

The current study compared the effects of practice homework, a traditional drill approach using 100% acquisition skills requiring further practice, to working-practice homework, a new type of homework created specifically for the present study. Working-practice homework was developed from the incremental rehearsal literature and included 60% maintenance skills, or calculation skills previously covered in the fifth grade curriculum, and 40% acquisition skills. Although the drill ratio research literature yielded large effect sizes for drill activities incorporating at least 50% to 90% known items and suggested that including known items leads to positive outcomes, such as increased academic skills, no statistically significant difference was observed in the current study between the participants assigned practice homework and those assigned working-practice homework (Burns, 2004, 2005; MacQuarrie et al., 2002). As a result, the participants assigned 100% acquisition skills as homework and those assigned 60% maintenance skills and 40% acquisition skills showed no difference in their posttest results. Neither homework type emerged from this study as superior for the purpose of skill acquisition of the calculation tasks presented.



## *Differences Between the Results and the Research Hypotheses*

### *No Assessment of Maintenance Material*

Some reasons may explain the potential absence of statistically significant findings between participants assigned working-practice homework and those assigned practice homework. In this investigation, no initial assessment occurred for the purpose of identifying actual maintenance material prior to the implementation of the homework conditions. For the working-practice homework, the maintenance material was selected by the two participating teachers for the working-practice homework and included mathematics calculation skills previously covered in the fifth grade curriculum. The maintenance material selected was objective 5.3, which stated that students would solve problems involving multiplication of whole numbers using paper and pencil and mental computation. However, the study's design did not assess participants' acquisition of, or fluency with, objective 5.3. As a result, the content of the working-practice homework assignments, for some participants, may not have fully aligned with incremental rehearsal procedures and the drill ratio literature. For some participants in the study, the math calculation material identified as maintenance may have actually been skills in need of acquisition on the working-practice homework assignments, which may have impacted the results and lack of statistical significance for the research.

### *Limited Assessment of Acquisition Material*

According to the drill ratio research literature, the incremental rehearsal flashcard drill procedure typically involves presenting 90% known material to 10% unknown material using a 'folding-in' strategy (MacQuarrie et al., 2002). This procedure also involves practicing one specific set of concepts with the 90:10 ratio several times until

the skill was acquired and a new concept, or unknown material, was ‘folded-in’. For example, Burns’ (2005) study showed incremental rehearsal as an effective for increasing the acquisition and fluency with single digit multiplication facts using 3 third grade students. A drill ratio of 90% known math facts to 10% unknown math facts was used and required that new, or unknown, math facts were not introduced to each participant until the previous unknown math fact in the ratio was acquired. Although the current study incorporated aspects of incremental rehearsal into the working-practice homework assignments, these assignments did not show a 90:10 ratio, rather a 60:40 ratio. Additionally, the current study consisted of a larger group of students receiving the working-practice homework (N = 45), rather than a smaller group of individuals. As a result, skill acquisition of the “unknown” material was not determined with these participants before introducing new “unknown” material in the working-practice assignments. Because the development and implementation of the working-practice homework assignment did not fully adhere to traditional incremental rehearsal procedures, the results may have been impacted.

In addition, the implemented research design did not incorporate an examination of learning rates, or how quickly the homework assignments results in skill acquisition (Cates, 2005). The study’s design consisted of assigning practice or working-practice homework three times a week for 6 weeks, followed by the administration of the posttest measure on the last day of the sixth week. While no statistically significant difference was observed between the two homework groups at the end of the 6 week period, it is possible when considering the concept of learning rates that a difference may have occurred between the two groups at different points in time. Increased effectiveness for

the working-practice homework may have been observed with the implementation of individualized drill ratios for a small group of students rather than a universal drill ratio for a large group of students (Cates, 2005).

#### *No Assessment of Acquisition Skill Retention*

The drill ratio literature indicates that drill ratio procedures are not only effective for skill acquisition, but also effective for the retention of skills across time (MacQuarrie et al., 2002; Nist & Joseph, 2008). Another use of the term ‘maintenance’ in the research literature refers to how well the instructional strategies and intervention effects on the sample populations are maintained across time (Glasgow, 2002; Glasgow et al., 2003; Glasgow et al., 2001; Merrell & Buchan, 2006). The design of the study may have benefited from collecting data several weeks following the administration of the posttest measure to determine whether the type of homework assigned showed enduring effects on students’ math calculation achievement despite the passage of time. Consequently, the collection of ‘maintenance’ data may have provided additional information pertaining to homework type and the retention of skills.

#### *Fixed Curriculum Schedule*

The design of the study consisted of participants receiving homework assignments three days per week for 6 weeks. The curriculum covered in the study included 3 math objectives broken down and presented in 17 concepts (see Table 1). Consequently, 17 complex math calculation concepts were presented across 18 homework assignments over a 6 week period. This period of time was held constant due to state and district curriculum requirements and did not consider individual rates of skill acquisition or learning. Participants were expected to maintain progress with the previously established

math curriculum calendar. Because some participants may have needed more opportunities to respond to fully acquire the different math calculation skills and procedures, the results may have been impacted.

### *Study Limitations and Directions for Future Research*

#### *Sample Population Size and Demographics*

Limitations to the study may influence the utility of the information found and the corresponding conclusions. For example, the data for the study was collected from a small sample population consisting of 90 fifth grade participants at a Mid-Atlantic, suburban, elementary school. The present study also consisted of a few school specific components, such as blocked schedules, the use of direct instruction, and the curriculum. As a result, the degree to which the study's results would apply, or generalize, to students enrolled in other elementary schools with varying racial or ethnic characteristics, economic backgrounds, and English language learning needs is unclear. Future research in the area of homework, especially in comparing homework types with varying levels of academic achievement is needed with larger sample populations from different geographical locations, different racial, ethnic, and economic backgrounds, varying English language learning needs, and varying ages and grades. The purpose of this future research is to document the impact of varying homework types as an instructional strategy or intervention on the academic achievement of students showing varying levels of performance (Glasgow, 2002; Glasgow, Lichtenstein, & Marcus, 2003; Glasgow, McKay, Piette, & Reynolds, 2001; Merrell & Buchan, 2006). A future study consisting of a larger sample population could also allow for greater flexibility of the statistical

techniques used (e.g., ANOVA, ANCOVA, etc.) and may permit an exploration of interaction effects between independent variables.

#### *Design Limitations*

*A 'no homework' condition.* The findings formulated from the current study did not establish a causal relationship between different homework types and academic achievement because the design did not include a 'no homework' control group. It is unclear whether students not receiving any homework would have shown similar academic growth after receiving instruction on the calculation concepts covered in the study. As a result, future research may want to incorporate a 'no homework' control group in the design.

*Limited data collection on homework assignments.* Although feedback was provided to the participants on their homework assignments, data collection on the accuracy, the number of digits placed correctly, and the percentage correct on each homework assignment was not included in the design. This data may have provided further information on the effectiveness of both homework assignments and participants' academic achievement. Future research may benefit from data collection on the accuracy and percentage correct on each homework assignment.

*Level of achievement groupings.* The blocking procedure for this study was selected after a review of the research literature did not uncover any documentation of blocking procedures for the purpose of investigating the effectiveness of homework on participants showing varying levels of academic achievement. In the present study, participants were blocked into thirds based on their pretest score for the purpose of creating homogeneous subgroups (see Figure 1). Yet, the participants in these three

subgroups may have been heterogeneous. For example, some participants blocked into the lower third achievement group showed considerable academic progress from the pretest to the posttest, while some of these participants showed limited academic progress. Other future research considerations may include different blocking methods for the level of achievement groups. In future studies, specific blocking procedures could be determined after reviewing the pretest scores in order to see if natural blocks in the data exist to form homogenous subgroups. Another possibility is to evaluate other blocking procedures, such as blocking the participants into four groups.

### *Student Learning and Motivation*

Both educational researchers and professionals have judiciously contemplated the role of motivation in student achievement and learning (Graham & Weiner, 1996). Reportedly, early research on school achievement and learning segregated cognitive and motivational factors; yet, throughout the last thirty years research has explored the interaction between cognition and motivation and the joint impact of cognition and motivation on student achievement and learning (Linnenbrink & Pintrich, 2002). Needless to say, most researchers acknowledge that students need a combination of cognitive skill and motivation in order to perform academically well in school (Pintrich & Schunk, 2002). Student motivation as measured by interest in the academic tasks presented or self-efficacy was not included in the study's design and may be considered a limitation. Because student motivation drives student engagement and study skills, which impacts academic achievement, future research designs involving varying types of homework, such as practice and working-practice homework, and varying levels of achievement may benefit from including the measurement, analysis, and evaluation of

motivation through, for instance, student self-reports and classroom observations designed to enhance self-reported information (Linnenbrink & Pintrich, 2002).

### *Conclusion*

Both educators and educational professionals are expected to focus on improving academic achievement for all students regardless of prior levels of achievement and current levels of achievement using evidenced-based instructional strategies and interventions (Ysseldyke & Bolt, 2007). Although the generally positive effect of homework as an instructional strategy or intervention on academic achievement has been documented in the literature and for the most part supported by homework researchers for upper elementary school students, the current study attempted to further the research literature by examining the influence of different homework types on academic achievement. Moreover, the current study furthered the research literature pertaining to homework by examining the impact of homework on participants showing varying levels of achievement in mathematics.

Several conclusions can be summarized from the present study. First, academic growth was observed on average for all participants overall as well as within each achievement level in the presence of instruction and the assignment of homework. Second, upon examination of the practice homework and working-practice homework, neither of these homework types proved more effective in increasing the academic achievement of the participants overall or within each achievement level. Finally, within the level of achievement groups, the participants appeared to respond differently to the instruction and the homework assignments (regardless of homework type) from an educational perspective. Participants blocked into the lower third achievement group on

average showed failing outcomes on the posttest measure, despite the observed academic growth from the pretest measure. As a result, these students may benefit from additional research supported instructional strategies and interventions in the presence of progress monitoring in order to promote math skill acquisition.



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**Appendix A**

**GRADE 5 CURRICULUM MATHEMATICS OBJECTIVES**

### Objective 5.1

The student will read, write, and identify the place values of decimals through thousandths. The student will round decimals to the nearest tenth or hundreds place. The student will compare the value of two decimals through thousands using the symbols  $>$ ,  $<$ , or  $=$ .

### Objective 5.2

The student will recognize and name commonly used fractions, halves, fourths, fifths, eighths, and tenths in their equivalent decimal form and vice versa. The student will order a given set of fractions and decimals from least to greatest. Fractions will include like and unlike denominators, limited to 12 or less, and mixed numbers.

### Objective 5.3

The student will solve problems, using paper and pencil and mental computation, involving:

- ▶ multiplication
- ▶ division

### Objective 5.4

The student will find the sum, difference, and product of two numbers expressed as decimals through thousandths, using an appropriate method of calculation, including paper and pencil, mental computation, and calculators.

### Objective 5.5

The student, given a dividend of four digits or fewer and a divisor of two digits or fewer, will find the quotient and remainders (if any).

### Objective 5.6

The student, given a dividend expressed as a decimal through thousandths and a single digit divisor, will find the quotient.

### Objective 5.7

The student will add and subtract with fractions and mixed numbers, with and without regrouping, and express answers in simplest form. Problems will include like and unlike denominators, limited to 12 or less.

### Objective 5.8

The student will describe and determine the perimeter of a polygon and the area of a square, rectangle, and right triangle, given the appropriate measures.

### Objective 5.9

The student will identify and describe the diameter, radius, chord, and circumference of a circle.

#### Objective 5.10

The student will differentiate between perimeter, area, and volume and identify whether the application of the concept of perimeter, area of volume is appropriate for given situation.

#### Objective 5.11

The student will choose an appropriate measuring device and unit of measure to solve problems involving the measurement of:

- ▶ Length-part of an inch ( $\frac{1}{2}$ ,  $\frac{1}{4}$ , and  $\frac{1}{8}$ ), inches, feet, yards, miles, millimeters, centimeters, meters, and kilometers
- ▶ Area-square units
- ▶ Weight and mass-ounces, pounds, tons, grams, and kilograms
- liquid volume-cups, pints, quarts, gallons, milliliters, and liters
- ▶ Temperature-Celsius and Fahrenheit units. Problems also will include estimating the conversion of Celsius and Fahrenheit units relative to familiar situations (water freezes at 0C and at 212F, normal body temperature is about 37C and 98.6F)

#### Objective 5.12

The student will determine an amount of elapsed time in hours and minutes within a 24-hour period.

#### Objective 5.13

The students will classify angles and triangles as right, acute, or obtuse.

#### Objective 5.14

The student will measure and draw right, acute, and obtuse angles and triangles, using appropriate tools.

#### Objective 5.15.

The student will recognize, identify, describe, and analyze the properties of two-dimensional (plane) figures (square, rectangle, triangle, parallelogram, rhombus, kite, and trapezoid) in order to develop definitions of these figures.

- ▶ The student will identify and explore congruent, noncongruent, and similar figures
- ▶ The student will investigate and describe the results of combining and subdividing shapes
- ▶ The student will identify and describe a line of symmetry
- ▶ The student will recognize the images of figures resulting from geometric transformations such as translations (slides), reflections (flips), or rotations (turns)

#### Objective 5.16

The student will identify, compare, and analyze properties of three-dimensional (solid) geometric shapes (cylinders, cones, cubes, square pyramids, and rectangular prisms).

#### Objective 5.17

The student will solve problems involving the probability of a single event by using tree diagrams or by constructing a sample space representing all possible results.

- ▶ The student will predict the probability of the outcome of a simple experiment, representing it with fractions or decimals from 0 to 1 and test this prediction
- ▶ The student will create a problem statement involving probability based on information from a given problem situation; students will not be required to solve the problem created

#### Objective 5.18

The student will, given a problem situation, collect, organize, and display a set of numerical data in a variety of forms, using bar graphs, stem-and-leaf plots, and line graphs, to draw conclusions and make predictions.

#### Objective 5.19

The student will find the mean, median, mode, and range of a set of data.

#### Objective 5.20

The student will analyze the structure of numerical and geometric patterns (how the change or grow) and express the relationship, using words, tables, graphs, or mathematical sentences. Concrete materials and calculators will be used.

#### Objective 5.21

The student will:

- ▶ Investigate and describe the concept of a variable
- ▶ Use a variable expression to represent a given verbal quantitative expression involving one operation
- ▶ Write an open sentence to represent a given mathematical relationship using a variable

#### Objective 5.22

The student will create a problem situation based on a given open sentence using a single variable.

#### Objective 5.23

The student will identify an ordered pair for a point on a graph and locate the point for an ordered pair in the first quadrant in a coordinate plane, or the x or y axis.



**Appendix B**

**PRACTICE HOMEWORK ASSIGNMENTS**

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.5

1)  $3 \overline{)9}$       2)  $6 \overline{)102}$       3)  $5 \overline{)185}$       4)  $3 \overline{)18}$       5)  $1 \overline{)1395}$

6)  $2 \overline{)32}$       7)  $8 \overline{)560}$       8)  $4 \overline{)2208}$       9)  $2 \overline{)8}$       10)  $5 \overline{)30}$

11)  $4 \overline{)8}$       12)  $7 \overline{)4921}$       13)  $3 \overline{)375}$       14)  $5 \overline{)95}$       15)  $8 \overline{)8}$

16)  $3 \overline{)6}$       17)  $7 \overline{)490}$       18)  $4 \overline{)6004}$       19)  $5 \overline{)2580}$       20)  $9 \overline{)164}$

21)  $9 \overline{)81}$       22)  $8 \overline{)784}$       23)  $5 \overline{)210}$       24)  $9 \overline{)2016}$       25)  $2 \overline{)4}$

26)  $7 \overline{)42}$       27)  $6 \overline{)60}$       28)  $4 \overline{)6436}$       29)  $6 \overline{)5766}$       30)  $7 \overline{)7}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.5

1)  $7 \overline{)9}$     2)  $8 \overline{)87}$     3)  $26 \overline{)520}$     4)  $4 \overline{)3379}$     5)  $11 \overline{)99}$

6)  $3 \overline{)7}$     7)  $7 \overline{)757}$     8)  $46 \overline{)92}$     9)  $50 \overline{)8600}$     10)  $83 \overline{)747}$

11)  $3 \overline{)8798}$     12)  $5 \overline{)726}$     13)  $28 \overline{)84}$     14)  $29 \overline{)6960}$     15)  $6 \overline{)75}$

16)  $5 \overline{)31}$     17)  $50 \overline{)100}$     18)  $24 \overline{)288}$     19)  $8 \overline{)9201}$     20)  $71 \overline{)568}$

21)  $35 \overline{)315}$     22)  $10 \overline{)7030}$     23)  $9 \overline{)124}$     24)  $2 \overline{)5}$     25)  $12 \overline{)96}$

26)  $4 \overline{)9}$     27)  $9 \overline{)69}$     28)  $44 \overline{)9196}$     29)  $2 \overline{)997}$     30)  $19 \overline{)76}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.5

1)  $15 \overline{)90}$     2)  $19 \overline{)227}$     3)  $40 \overline{)60}$     4)  $53 \overline{)954}$     5)  $10 \overline{)70}$

6)  $83 \overline{)7719}$     7)  $18 \overline{)9913}$     8)  $25 \overline{)570}$     9)  $12 \overline{)48}$     10)  $20 \overline{)4380}$

11)  $60 \overline{)77}$     12)  $30 \overline{)150}$     13)  $56 \overline{)758}$     14)  $10 \overline{)134}$     15)  $33 \overline{)1688}$

16)  $34 \overline{)7936}$     17)  $18 \overline{)4896}$     18)  $16 \overline{)672}$     19)  $22 \overline{)97}$     20)  $24 \overline{)57}$

21)  $23 \overline{)6808}$     22)  $97 \overline{)582}$     23)  $88 \overline{)2375}$     24)  $14 \overline{)95}$     25)  $46 \overline{)92}$

26)  $35 \overline{)7525}$     27)  $50 \overline{)4212}$     28)  $39 \overline{)78}$     29)  $38 \overline{)955}$     30)  $76 \overline{)2812}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.6

1)  $7 \overline{)0.7}$     2)  $5 \overline{)388.0}$     3)  $3 \overline{)26.4}$     4)  $3 \overline{)19.2}$     5)  $2 \overline{)78.2}$

6)  $9 \overline{)38.7}$     7)  $6 \overline{)18.6}$     8)  $2 \overline{)1.8}$     9)  $5 \overline{)2.5}$     10)  $9 \overline{)40.5}$

11)  $2 \overline{)0.2}$     12)  $8 \overline{)352.8}$     13)  $7 \overline{)14.0}$     14)  $4 \overline{)482.4}$     15)  $9 \overline{)441.9}$

16)  $7 \overline{)2.1}$     17)  $3 \overline{)332.1}$     18)  $2 \overline{)35.2}$     19)  $5 \overline{)99.5}$     20)  $9 \overline{)9.9}$

21)  $6 \overline{)92.7}$     22)  $4 \overline{)116.8}$     23)  $8 \overline{)247.2}$     24)  $5 \overline{)20.8}$     25)  $9 \overline{)285.3}$

26)  $1 \overline{)0.8}$     27)  $6 \overline{)60}$     28)  $3 \overline{)83.7}$     29)  $6 \overline{)9.6}$     30)  $2 \overline{)4.6}$

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Teacher: \_\_\_\_\_ Directions: Practice dividing. SOL 5.6

1)  $6 \overline{)9.6}$     2)  $4 \overline{)333.2}$     3)  $8 \overline{)965.6}$     4)  $5 \overline{)264.5}$     5)  $6 \overline{)46.8}$

6)  $3 \overline{)0.9}$     7)  $8 \overline{)3.2}$     8)  $5 \overline{)17.5}$     9)  $9 \overline{)490.5}$     10)  $1 \overline{)314.7}$

11)  $5 \overline{)66.0}$     12)  $7 \overline{)53.6}$     13)  $3 \overline{)490.8}$     14)  $2 \overline{)143.8}$     15)  $6 \overline{)27.0}$

16)  $8 \overline{)93.6}$     17)  $2 \overline{)927.0}$     18)  $4 \overline{)214.4}$     19)  $7 \overline{)857.5}$     20)  $5 \overline{)697.5}$

21)  $2 \overline{)30.4}$     22)  $8 \overline{)461.6}$     23)  $7 \overline{)147.7}$     24)  $5 \overline{)364.0}$     25)  $3 \overline{)134.7}$

26)  $6 \overline{)4.2}$     27)  $9 \overline{)15.3}$     28)  $4 \overline{)14.0}$     29)  $1 \overline{)2.9}$     30)  $8 \overline{)370.4}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.6

1)  $3 \overline{) 3.48}$     2)  $9 \overline{) 945.0}$     3)  $5 \overline{) 4.55}$     4)  $2 \overline{) 8.08}$     5)  $7 \overline{) 34.09}$

6)  $5 \overline{) 7.00}$     7)  $3 \overline{) 15.18}$     8)  $8 \overline{) 5.12}$     9)  $1 \overline{) 7.14}$     10)  $7 \overline{) 9.24}$

11)  $6 \overline{) 0.72}$     12)  $4 \overline{) 47.52}$     13)  $9 \overline{) 0.45}$     14)  $3 \overline{) 13.23}$     15)  $2 \overline{) 68.94}$

16)  $2 \overline{) 9.96}$     17)  $5 \overline{) 96.60}$     18)  $7 \overline{) 17.71}$     19)  $8 \overline{) 0.08}$     20)  $3 \overline{) 0.24}$

21)  $4 \overline{) 5.08}$     22)  $6 \overline{) 4.44}$     23)  $9 \overline{) 2.52}$     24)  $8 \overline{) 91.84}$     25)  $7 \overline{) .77}$

26)  $5 \overline{) 0.30}$     27)  $8 \overline{) 17.28}$     28)  $1 \overline{) 2.73}$     29)  $3 \overline{) 65.40}$     30)  $3 \overline{) 5.34}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.6

1)  $4 \overline{)56.36}$     2)  $7 \overline{)9.80}$     3)  $6 \overline{)33.06}$     4)  $1 \overline{)9.05}$     5)  $3 \overline{)70.11}$

6)  $7 \overline{)2.10}$     7)  $5 \overline{)5.65}$     8)  $9 \overline{)44.55}$     9)  $4 \overline{)0.68}$     10)  $5 \overline{)7.25}$

11)  $8 \overline{)43.04}$     12)  $9 \overline{)42.21}$     13)  $3 \overline{)8.46}$     14)  $4 \overline{)97.2}$     15)  $5 \overline{)7.20}$

16)  $6 \overline{)13.38}$     17)  $9 \overline{)39.06}$     18)  $1 \overline{)27.29}$     19)  $6 \overline{)89.40}$     20)  $2 \overline{)0.32}$

21)  $2 \overline{)50.20}$     22)  $9 \overline{)1.98}$     23)  $8 \overline{)1.92}$     24)  $5 \overline{)2.20}$     25)  $4 \overline{)0.68}$

26)  $6 \overline{)4.74}$     27)  $7 \overline{)93.03}$     28)  $4 \overline{)12.16}$     29)  $2 \overline{)61.24}$     30)  $9 \overline{)0.18}$



Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.6

1)  $7 \overline{)25.123}$     2)  $2 \overline{)2.248}$     3)  $6 \overline{)58.374}$     4)  $9 \overline{)0.387}$     5)  $8 \overline{)0.680}$

6)  $1 \overline{)0.889}$     7)  $4 \overline{)7.092}$     8)  $3 \overline{)1.827}$     9)  $3 \overline{)5.376}$     10)  $6 \overline{)9.084}$

11)  $5 \overline{)3.980}$     12)  $9 \overline{)46.341}$     13)  $4 \overline{)0.792}$     14)  $8 \overline{)8.040}$     15)  $6 \overline{)28.356}$

16)  $8 \overline{)78.072}$     17)  $2 \overline{)30.804}$     18)  $7 \overline{)8.652}$     19)  $5 \overline{)0.375}$     20)  $4 \overline{)44.776}$

21)  $5 \overline{)8.610}$     22)  $7 \overline{)0.707}$     23)  $3 \overline{)2.991}$     24)  $9 \overline{)8.910}$     25)  $5 \overline{)89.200}$

26)  $2 \overline{)6.904}$     27)  $3 \overline{)0.405}$     28)  $8 \overline{)83.704}$     29)  $3 \overline{)0.651}$     30)  $6 \overline{)7.656}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.6

1)  $4 \overline{)70.132}$     2)  $8 \overline{)26.864}$     3)  $7 \overline{)17.948}$     4)  $9 \overline{)7.695}$     5)  $3 \overline{)3.345}$

6)  $5 \overline{)9.460}$     7)  $5 \overline{)0.800}$     8)  $6 \overline{)0.978}$     9)  $2 \overline{)0.588}$     10)  $4 \overline{)10.428}$

11)  $6 \overline{)6.462}$     12)  $8 \overline{)74.896}$     13)  $9 \overline{)9.458}$     14)  $2 \overline{)40.774}$     15)  $4 \overline{)0.196}$

16)  $6 \overline{)27.924}$     17)  $5 \overline{)91.805}$     18)  $3 \overline{)86.400}$     19)  $8 \overline{)4.680}$     20)  $5 \overline{)87.555}$

21)  $7 \overline{)0.938}$     22)  $4 \overline{)5.492}$     23)  $7 \overline{)41.370}$     24)  $2 \overline{)25.354}$     25)  $9 \overline{)14.211}$

26)  $3 \overline{)2.196}$     27)  $4 \overline{)45.204}$     28)  $9 \overline{)40.320}$     29)  $9 \overline{)32.049}$     30)  $8 \overline{)5.144}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference. Simplify.  
SOL 5.7

1)  $\frac{2}{5} + \frac{1}{5} =$

2)  $\frac{7}{11} + \frac{4}{11} =$

3)  $\frac{4}{5} - \frac{2}{5} =$

4)  $\frac{2}{2} - \frac{1}{2} =$

5)  $\frac{3}{9} - \frac{1}{9} =$

6)  $\frac{1}{12} + \frac{6}{12} =$

7)  $\frac{3}{6} - \frac{2}{6} =$

8)  $\frac{1}{9} + \frac{4}{9} =$

9)  $\frac{3}{7} + \frac{3}{7} =$

10)  $\frac{1}{12} + \frac{4}{12} =$

11)  $\frac{3}{4} - \frac{0}{4} =$

12)  $\frac{9}{10} - \frac{2}{10} =$

13)  $\frac{6}{6} - \frac{1}{6} =$

14)  $\frac{3}{5} + \frac{1}{5} =$

15)  $\frac{11}{11} - \frac{9}{11} =$

16)  $\frac{1}{1} + \frac{0}{1} =$

17)  $\frac{5}{7} - \frac{3}{7} =$

18)  $\frac{2}{4} + \frac{1}{4} =$

$$19) \frac{6}{11} + \frac{2}{11} =$$

$$20) \frac{2}{3} - \frac{0}{3} =$$

$$21) \frac{5}{11} - \frac{1}{11} =$$

$$22) \frac{11}{12} - \frac{7}{12} =$$

$$23) \frac{1}{3} + \frac{1}{3} =$$

$$24) \frac{2}{9} + \frac{2}{9} =$$

$$25) \frac{1}{8} + \frac{6}{8} =$$

$$26) \frac{1}{2} + \frac{0}{2} =$$

$$27) \frac{12}{12} - \frac{7}{12} =$$

$$28) \frac{7}{9} - \frac{3}{9} =$$

$$29) \frac{5}{10} + \frac{4}{10} =$$

$$30) \frac{8}{8} - \frac{7}{8} =$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum. Simplify. SOL 5.7

1)  $\frac{3}{10} + \frac{2}{5} =$

2)  $\frac{1}{6} + \frac{1}{8} =$

3)  $\frac{1}{3} + \frac{5}{9} =$

4)  $\frac{4}{10} + \frac{1}{2} =$

5)  $\frac{1}{8} + \frac{3}{4} =$

6)  $\frac{1}{2} + \frac{2}{5} =$

7)  $\frac{2}{9} + \frac{1}{12} =$

8)  $\frac{3}{4} + \frac{2}{12} =$

9)  $\frac{1}{6} + \frac{1}{9} =$

10)  $\frac{1}{2} + \frac{3}{8} =$

11)  $\frac{1}{5} + \frac{5}{10} =$

12)  $\frac{8}{11} + \frac{1}{2} =$

13)  $\frac{5}{8} + \frac{1}{4} =$

14)  $\frac{1}{8} + \frac{7}{12} =$

15)  $\frac{1}{4} + \frac{3}{10} =$

16)  $\frac{1}{3} + \frac{2}{5} =$

17)  $\frac{3}{12} + \frac{1}{12} =$

18)  $\frac{2}{3} + \frac{1}{6} =$

$$19) \frac{1}{4} + \frac{1}{3} =$$

$$20) \frac{2}{7} + \frac{2}{5} =$$

$$21) \frac{1}{2} + \frac{1}{4} =$$

$$22) \frac{3}{12} + \frac{1}{6} =$$

$$23) \frac{1}{3} + \frac{2}{9} =$$

$$24) \frac{4}{9} + \frac{1}{3} =$$

$$25) \frac{1}{12} + \frac{1}{2} =$$

$$26) \frac{2}{4} + \frac{1}{12} =$$

$$27) \frac{1}{4} + \frac{2}{3} =$$

$$28) \frac{1}{5} + \frac{1}{10} =$$

$$29) \frac{1}{3} + \frac{1}{2} =$$

$$30) \frac{1}{8} + \frac{4}{6} =$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each difference. Simplify. SOL 5.7

1)  $\frac{5}{7} - \frac{1}{2} =$

2)  $\frac{8}{11} - \frac{1}{2} =$

3)  $\frac{7}{8} - \frac{8}{12} =$

4)  $\frac{5}{12} - \frac{2}{9} =$

5)  $\frac{2}{7} - \frac{1}{4} =$

6)  $\frac{3}{4} - \frac{1}{6} =$

7)  $\frac{6}{10} - \frac{1}{2} =$

8)  $\frac{3}{5} - \frac{2}{9} =$

9)  $\frac{1}{3} - \frac{3}{10} =$

10)  $\frac{1}{6} - \frac{1}{9} =$

11)  $\frac{6}{10} - \frac{1}{4} =$

12)  $\frac{5}{12} - \frac{1}{3} =$

13)  $\frac{2}{3} - \frac{1}{9} =$

14)  $\frac{7}{10} - \frac{2}{5} =$

15)  $\frac{1}{2} - \frac{1}{3} =$

16)  $\frac{7}{12} - \frac{1}{2} =$

17)  $\frac{11}{12} - \frac{1}{6} =$

18)  $\frac{5}{9} - \frac{1}{3} =$

$$19) \frac{3}{8} - \frac{1}{6} =$$

$$20) \frac{5}{9} - \frac{1}{2} =$$

$$21) \frac{2}{5} - \frac{2}{7} =$$

$$22) \frac{3}{6} - \frac{3}{10} =$$

$$23) \frac{2}{2} - \frac{1}{8} =$$

$$24) \frac{3}{4} - \frac{2}{3} =$$

$$25) \frac{4}{5} - \frac{1}{3} =$$

$$26) \frac{6}{7} - \frac{2}{3} =$$

$$27) \frac{8}{9} - \frac{2}{9} =$$

$$28) \frac{7}{7} - \frac{3}{4} =$$

$$29) \frac{8}{9} - \frac{1}{5} =$$

$$30) \frac{7}{9} - \frac{2}{3} =$$



Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum. Simplify. SOL 5.7

1)  $\frac{4}{7} + \frac{2}{6} =$

2)  $\frac{1}{2} + \frac{3}{10} =$

3)  $\frac{1}{3} + \frac{1}{6} =$

4)  $\frac{4}{10} + \frac{3}{5} =$

5)  $\frac{2}{3} + \frac{2}{8} =$

6)  $\frac{1}{6} + \frac{1}{10} =$

7)  $\frac{7}{12} + \frac{1}{6} =$

8)  $\frac{4}{9} + \frac{1}{12} =$

9)  $\frac{2}{4} + \frac{3}{9} =$

10)  $\frac{2}{4} + \frac{2}{5} =$

11)  $\frac{1}{2} + \frac{2}{8} =$

12)  $\frac{5}{11} + \frac{4}{6} =$

13)  $\frac{5}{10} + \frac{1}{3} =$

14)  $\frac{2}{3} + \frac{2}{12} =$

15)  $\frac{4}{11} + \frac{2}{4} =$

16)  $\frac{1}{3} + \frac{2}{8} =$

17)  $\frac{2}{3} + \frac{3}{9} =$

18)  $\frac{2}{8} + \frac{5}{9} =$

$$19) \frac{3}{6} + \frac{3}{12} =$$

$$20) \frac{2}{4} + \frac{4}{10} =$$

$$21) \frac{1}{6} + \frac{1}{9} =$$

$$22) \frac{4}{8} + \frac{2}{7} =$$

$$23) \frac{2}{4} + \frac{2}{8} =$$

$$24) \frac{3}{5} + \frac{2}{12} =$$

$$25) \frac{2}{8} + \frac{3}{10} =$$

$$26) \frac{1}{3} + \frac{3}{9} =$$

$$27) \frac{2}{4} + \frac{4}{8} =$$

$$28) \frac{3}{5} + \frac{2}{8} =$$

$$29) \frac{2}{8} + \frac{3}{6} =$$

$$30) \frac{1}{3} + \frac{2}{4} =$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each difference. Simplify. SOL 5.7

1)  $\frac{4}{6} - \frac{1}{3} =$

2)  $\frac{3}{5} - \frac{2}{8} =$

3)  $\frac{2}{4} - \frac{4}{11} =$

4)  $\frac{7}{7} - \frac{1}{2} =$

5)  $\frac{8}{9} - \frac{1}{3} =$

6)  $\frac{6}{8} - \frac{5}{11} =$

7)  $\frac{9}{12} - \frac{1}{2} =$

8)  $\frac{2}{2} - \frac{2}{10} =$

9)  $\frac{4}{6} - \frac{2}{7} =$

10)  $\frac{8}{10} - \frac{2}{4} =$

11)  $\frac{2}{3} - \frac{2}{6} =$

12)  $\frac{3}{5} - \frac{2}{4} =$

13)  $\frac{3}{4} - \frac{5}{12} =$

14)  $\frac{5}{6} - \frac{1}{4} =$

15)  $\frac{6}{8} - \frac{1}{2} =$

16)  $\frac{4}{5} - \frac{3}{6} =$

17)  $\frac{2}{5} - \frac{2}{10} =$

18)  $\frac{2}{4} - \frac{1}{3} =$

$$19) \frac{6}{8} - \frac{3}{9} =$$

$$20) \frac{6}{8} - \frac{1}{10} =$$

$$21) \frac{7}{9} - \frac{2}{6} =$$

$$22) \frac{7}{8} - \frac{7}{12} =$$

$$23) \frac{3}{6} - \frac{2}{10} =$$

$$24) \frac{4}{5} - \frac{8}{12} =$$

$$25) \frac{6}{9} - \frac{1}{2} =$$

$$26) \frac{3}{4} - \frac{6}{8} =$$

$$27) \frac{5}{9} - \frac{6}{12} =$$

$$28) \frac{6}{8} - \frac{3}{7} =$$

$$29) \frac{4}{6} - \frac{2}{3} =$$

$$30) \frac{6}{9} - \frac{3}{6} =$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum. Simplify. SOL 5.7

$$1) \quad 1 \frac{2}{8} + 2 \frac{8}{8} =$$

$$2) \quad 7 \frac{11}{12} + 8 \frac{5}{12} =$$

$$3) \quad 12 \frac{10}{5} + 7 \frac{6}{5} =$$

$$4) \quad 1 \frac{4}{7} + 1 \frac{3}{7} =$$

$$5) \quad 12 \frac{2}{3} + 10 \frac{4}{3} =$$

$$6) \quad 7 \frac{4}{8} + 6 \frac{2}{8} =$$

$$7) \quad 5 \frac{7}{9} + 3 \frac{5}{9} =$$

$$8) \quad 11 \frac{2}{4} + 11 \frac{1}{4} =$$

$$9) \quad 9 \frac{3}{8} + 6 \frac{3}{8} =$$

$$10) \quad 10 \frac{3}{7} + 6 \frac{6}{7} =$$

$$11) \quad 10 \frac{1}{3} + 8 \frac{1}{3} =$$

$$12) \quad 12 \frac{2}{6} + 8 \frac{2}{6} =$$

$$13) \quad 9 \frac{3}{5} + 4 \frac{1}{5} =$$

$$14) \quad 8 \frac{2}{4} + 2 \frac{3}{4} =$$

$$15) \quad 8 \frac{6}{9} + 6 \frac{5}{9} =$$

$$16) \quad 2 \frac{3}{10} + 9 \frac{2}{10} =$$

$$17) 3 \frac{4}{12} + 6 \frac{6}{12} =$$

$$18) 1 \frac{4}{6} + 1 \frac{2}{6} =$$

$$19) 4 \frac{59}{9} + 2 \frac{1}{9} =$$

$$20) 3 \frac{1}{8} + 2 \frac{6}{8} =$$

$$21) 5 \frac{57}{7} + 5 \frac{3}{7} =$$

$$22) 3 \frac{1}{2} + 4 \frac{1}{2} =$$

$$23) 6 \frac{6}{11} + 7 \frac{3}{11} =$$

$$24) 7 \frac{4}{10} + 4 \frac{5}{10} =$$

$$25) 8 \frac{1}{6} + 4 \frac{2}{6} =$$

$$26) 9 \frac{7}{12} + 5 \frac{1}{12} =$$

$$27) 6 \frac{8}{10} + 9 \frac{8}{10} =$$

$$28) 7 \frac{10}{11} + 3 \frac{10}{11} =$$

$$29) 8 \frac{5}{8} + 9 \frac{5}{8} =$$

$$30) 11 \frac{5}{10} + 9 \frac{3}{10} =$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each difference. Simplify. SOL 5.7

$$1) \quad 4 \frac{1}{2} - 2 \frac{1}{2} =$$

$$2) \quad 10 \frac{8}{9} - 4 \frac{5}{9} =$$

$$3) \quad 12 \frac{9}{11} - 6 \frac{7}{11} =$$

$$4) \quad 9 \frac{4}{4} - 3 \frac{2}{4} =$$

$$5) \quad 8 \frac{6}{9} - 6 \frac{3}{9} =$$

$$6) \quad 10 \frac{6}{11} - 9 \frac{5}{11} =$$

$$7) \quad 11 \frac{2}{3} - 9 \frac{2}{3} =$$

$$8) \quad 12 \frac{4}{7} - 2 \frac{3}{7} =$$

$$9) \quad 8 \frac{4}{8} - 3 \frac{4}{8} =$$

$$10) \quad 12 \frac{4}{5} - 5 \frac{2}{5} =$$

$$11) \quad 11 \frac{9}{10} - 4 \frac{1}{10} =$$

$$12) \quad 10 \frac{2}{3} - 7 \frac{1}{3} =$$

$$13) \quad 8 \frac{7}{8} - 4 \frac{3}{8} =$$

$$14) \quad 9 \frac{7}{9} - 4 \frac{4}{9} =$$

$$15) \quad 12 \frac{10}{12} - 7 \frac{1}{12} =$$

$$16) \quad 9 \frac{4}{6} - 3 \frac{1}{6} =$$

$$17) \quad 7 \frac{5}{8} - 6 \frac{3}{8} =$$

$$18) \quad 7 \frac{10}{12} - 4 \frac{4}{12} =$$

$$19) \quad 12 \frac{9}{10} - 4 \frac{4}{10} =$$

$$20) \quad 11 \frac{3}{4} - 8 \frac{1}{4} =$$

$$21) \quad 8 \frac{6}{7} - 2 \frac{4}{7} =$$

$$22) \quad 12 \frac{4}{5} - 1 \frac{2}{5} =$$

$$23) \quad 4 \frac{7}{10} - 2 \frac{3}{10} =$$

$$24) \quad 7 \frac{6}{8} - 5 \frac{2}{8} =$$

$$25) \quad 6 \frac{10}{12} - 3 \frac{2}{12} =$$

$$26) \quad 10 \frac{6}{6} - 2 \frac{2}{6} =$$

$$27) \quad 9 \frac{2}{2} - 8 \frac{1}{2} =$$

$$28) \quad 10 \frac{3}{6} - 1 \frac{1}{6} =$$

$$29) \quad 7 \frac{8}{10} - 3 \frac{6}{10} =$$

$$30) \quad 12 \frac{11}{12} - 1 \frac{8}{12} =$$



Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference. Simplify.  
SOL 5.7

$$1) \quad 2 \frac{2}{3} + 4 \frac{1}{2} =$$

$$2) \quad 3 \frac{5}{12} + 8 \frac{2}{3} =$$

$$3) \quad 9 \frac{1}{4} - 6 \frac{1}{6} =$$

$$4) \quad 5 \frac{2}{3} + 9 \frac{6}{9} =$$

$$5) \quad 11 \frac{6}{8} - 6 \frac{3}{7} =$$

$$6) \quad 12 \frac{4}{6} - 10 \frac{1}{3} =$$

$$7) \quad 11 \frac{4}{8} - 9 \frac{2}{6} =$$

$$8) \quad 1 \frac{6}{8} + 7 \frac{1}{2} =$$

$$9) \quad 2 \frac{2}{4} + 2 \frac{4}{10} =$$

$$10) \quad 9 \frac{2}{5} - 4 \frac{2}{7} =$$

$$11) \quad 12 \frac{3}{4} - 4 \frac{4}{8} =$$

$$12) \quad 11 \frac{2}{2} + 1 \frac{3}{5} =$$

$$13) \quad 12 \frac{5}{11} + 5 \frac{4}{6} =$$

$$14) \quad 3 \frac{4}{11} + 2 \frac{2}{4} =$$

$$15) \quad 6 \frac{4}{6} - 3 \frac{1}{5} =$$

$$16) \quad 8 \frac{7}{9} - 8 \frac{2}{6} =$$

$$17) \quad 10 \frac{3}{4} - 7 \frac{5}{12} =$$

$$18) \quad 11 \frac{2}{3} + 7 \frac{2}{8} =$$

$$19) \quad 12 \frac{2}{8} + 4 \frac{3}{6} =$$

$$20) \quad 9 \frac{2}{4} - 7 \frac{2}{3} =$$

$$21) \quad 6 \frac{2}{4} - 2 \frac{2}{11} =$$

$$22) \quad 9 \frac{7}{10} + 8 \frac{8}{12} =$$

$$23) \quad 2 \frac{8}{12} - 1 \frac{4}{9} =$$

$$24) \quad 10 \frac{1}{2} - 7 \frac{3}{9} =$$

$$25) \quad 4 \frac{3}{5} + 3 \frac{5}{10} =$$

$$26) \quad 1 \frac{4}{7} + 1 \frac{4}{6} =$$

$$27) \quad 5 \frac{2}{4} + 10 \frac{5}{9} =$$

$$28) \quad 4 \frac{2}{5} - 4 \frac{2}{10} =$$

$$29) \quad 10 \frac{68}{5} - 1 \frac{2}{5} =$$

$$30) \quad 8 \frac{4}{7} + 9 \frac{1}{2} =$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference. Simplify.  
SOL 5.7

$$1) \quad 3 \frac{5}{7} - 1 \frac{1}{2} =$$

$$2) \quad 3 \frac{3}{7} + 2 \frac{1}{2} =$$

$$3) \quad 8 \frac{4}{10} + 8 \frac{3}{5} =$$

$$4) \quad 11 \frac{7}{12} + 1 \frac{1}{6} =$$

$$5) \quad 9 \frac{1}{2} - 8 \frac{1}{3} =$$

$$6) \quad 12 \frac{9}{12} - 8 \frac{1}{2} =$$

$$7) \quad 6 \frac{1}{6} + 3 \frac{1}{9} =$$

$$8) \quad 3 \frac{3}{4} - 1 \frac{1}{2} =$$

$$9) \quad 12 \frac{6}{8} - 9 \frac{1}{2} =$$

$$10) \quad 4 \frac{8}{9} - 3 \frac{2}{3} =$$

$$11) \quad 5 \frac{2}{4} + 1 \frac{3}{6} =$$

$$12) \quad 3 \frac{1}{2} + 3 \frac{2}{5} =$$

$$13) \quad 11 \frac{8}{12} - 4 \frac{3}{10} =$$

$$14) \quad 9 \frac{4}{5} - 3 \frac{8}{12} =$$

$$15) \quad 9 \frac{1}{3} + 2 \frac{6}{9} =$$

$$16) \quad 8 \frac{1}{3} + 4 \frac{1}{6} =$$

$$17) \quad 11 \frac{1}{2} - 6 \frac{3}{10} =$$

$$18) \quad 6 \frac{5}{6} + 5 \frac{3}{9} =$$

$$19) \quad 9 \frac{4}{8} + 3 \frac{5}{4} =$$

$$20) \quad 5 \frac{3}{4} - 2 \frac{5}{12} =$$

$$21) \quad 10 \frac{2}{8} + 3 \frac{5}{9} =$$

$$22) \quad 7 \frac{1}{3} + 8 \frac{2}{8} =$$

$$23) \quad 7 \frac{7}{9} - 4 \frac{1}{5} =$$

$$24) \quad 11 \frac{5}{6} - 3 \frac{1}{3} =$$

$$25) \quad 9 \frac{4}{5} - 5 \frac{2}{8} =$$

$$26) \quad 11 \frac{7}{10} + 12 \frac{4}{5} =$$

$$27) \quad 8 \frac{5}{6} - 1 \frac{1}{9} =$$

$$28) \quad 9 \frac{8}{12} + 5 \frac{3}{6} =$$

$$29) \quad 4 \frac{3}{4} + 6 \frac{7}{12} =$$

$$30) \quad 6 \frac{2}{4} - 2 \frac{2}{9} =$$

**Appendix C**

**WORKING-PRACTICE HOMEWORK ASSIGNMENTS**

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing and multiplying. SOL 5.5 and 5.3.

1)  $3 \overline{)9}$

2)  $\begin{array}{r} 60 \\ \times 2 \\ \hline \end{array}$

3)  $5 \overline{)185}$

4)  $\begin{array}{r} 22 \\ \times 1 \\ \hline \end{array}$

5)  $\begin{array}{r} 9 \\ \times 4 \\ \hline \end{array}$

6)  $2 \overline{)32}$

7)  $\begin{array}{r} 13 \\ \times 11 \\ \hline \end{array}$

8)  $\begin{array}{r} 860 \\ \times 3 \\ \hline \end{array}$

9)  $2 \overline{)8}$

10)  $\begin{array}{r} 35 \\ \times 5 \\ \hline \end{array}$

11)  $4 \overline{)8}$

12)  $\begin{array}{r} 31 \\ \times 18 \\ \hline \end{array}$

13)  $3 \overline{)375}$

14)  $\begin{array}{r} 7 \\ \times 3 \\ \hline \end{array}$

15)  $\begin{array}{r} 80 \\ \times 33 \\ \hline \end{array}$

16)  $3 \overline{)6}$

17)  $\begin{array}{r} 126 \\ \times 26 \\ \hline \end{array}$

18)  $\begin{array}{r} 17 \\ \times 7 \\ \hline \end{array}$

19)  $5 \overline{)2580}$

20)  $\begin{array}{r} 77 \\ \times 60 \\ \hline \end{array}$

21)  $9 \overline{)81}$

22)  $\begin{array}{r} 216 \\ \times 90 \\ \hline \end{array}$

23)  $5 \overline{)210}$

24)  $\begin{array}{r} 4 \\ \times 2 \\ \hline \end{array}$

25)  $\begin{array}{r} 86 \\ \times 3 \\ \hline \end{array}$

26)  $7 \overline{)42}$

27)  $\begin{array}{r} 100 \\ \times 5 \\ \hline \end{array}$

28)  $\begin{array}{r} 45 \\ \times 33 \\ \hline \end{array}$

29)  $6 \overline{)5766}$

30)  $\begin{array}{r} 52 \\ \times 19 \\ \hline \end{array}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing and multiplying. SOL 5.5 and 5.3.

1)  $7 \overline{)9}$       2)  $3 \overline{)9}$       3)  $26 \overline{)520}$       4)  $5 \overline{)185}$       5)  $\begin{array}{r} 161 \\ \times 46 \\ \hline \end{array}$

6)  $3 \overline{)7}$       7)  $2 \overline{)32}$       8)  $2 \overline{)8}$       9)  $50 \overline{)8600}$       10)  $\begin{array}{r} 9 \\ \times 0 \\ \hline \end{array}$

11)  $3 \overline{)8798}$       12)  $4 \overline{)8}$       13)  $28 \overline{)84}$       14)  $3 \overline{)375}$       15)  $\begin{array}{r} 166 \\ \times 12 \\ \hline \end{array}$

16)  $5 \overline{)31}$       17)  $3 \overline{)6}$       18)  $5 \overline{)2580}$       19)  $8 \overline{)9201}$       20)  $\begin{array}{r} 17 \\ \times 6 \\ \hline \end{array}$

21)  $35 \overline{)315}$       22)  $9 \overline{)81}$       23)  $9 \overline{)124}$       24)  $5 \overline{)210}$       25)  $\begin{array}{r} 42 \\ \times 38 \\ \hline \end{array}$

26)  $4 \overline{)9}$       27)  $7 \overline{)42}$       28)  $6 \overline{)5766}$       29)  $2 \overline{)997}$       30)  $\begin{array}{r} 9 \\ \times 6 \\ \hline \end{array}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.5.

1)  $15 \overline{)90}$     2)  $5 \overline{)185}$     3)  $40 \overline{)60}$     4)  $2 \overline{)32}$     5)  $7 \overline{)9}$

6)  $83 \overline{)7719}$     7)  $4 \overline{)8}$     8)  $26 \overline{)520}$     9)  $12 \overline{)48}$     10)  $50 \overline{)8600}$

11)  $60 \overline{)77}$     12)  $3 \overline{)375}$     13)  $56 \overline{)758}$     14)  $5 \overline{)2580}$     15)  $3 \overline{)8798}$

16)  $34 \overline{)7936}$     17)  $9 \overline{)81}$     18)  $28 \overline{)84}$     19)  $22 \overline{)97}$     20)  $5 \overline{)31}$

21)  $23 \overline{)6808}$     22)  $5 \overline{)210}$     23)  $88 \overline{)2375}$     24)  $7 \overline{)42}$     25)  $35 \overline{)315}$

26)  $35 \overline{)7525}$     27)  $6 \overline{)5766}$     28)  $9 \overline{)124}$     29)  $38 \overline{)955}$     30)  $4 \overline{)9}$



Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing and multiplying. SOL 5.6 and 5.3.

1)  $7 \overline{)0.7}$

2)  $\begin{array}{r} 207 \\ \times 76 \\ \hline \end{array}$

3)  $3 \overline{)26.4}$

4)  $\begin{array}{r} 62 \\ \times 14 \\ \hline \end{array}$

5)  $\begin{array}{r} 57 \\ \times 3 \\ \hline \end{array}$

6)  $9 \overline{)38.7}$

7)  $\begin{array}{r} 7 \\ \times 4 \\ \hline \end{array}$

8)  $\begin{array}{r} 60 \\ \times 2 \\ \hline \end{array}$

9)  $5 \overline{)2.5}$

10)  $\begin{array}{r} 11 \\ \times 9 \\ \hline \end{array}$

11)  $2 \overline{)0.2}$

12)  $\begin{array}{r} 57 \\ \times 25 \\ \hline \end{array}$

13)  $7 \overline{)14.0}$

14)  $\begin{array}{r} 35 \\ \times 34 \\ \hline \end{array}$

15)  $\begin{array}{r} 425 \\ \times 6 \\ \hline \end{array}$

16)  $7 \overline{)2.1}$

17)  $\begin{array}{r} 87 \\ \times 6 \\ \hline \end{array}$

18)  $\begin{array}{r} 4 \\ \times 3 \\ \hline \end{array}$

19)  $5 \overline{)99.5}$

20)  $\begin{array}{r} 15 \\ \times 5 \\ \hline \end{array}$

21)  $6 \overline{)92.7}$

22)  $\begin{array}{r} 160 \\ \times 40 \\ \hline \end{array}$

23)  $8 \overline{)247.2}$

24)  $\begin{array}{r} 70 \\ \times 9 \\ \hline \end{array}$

25)  $\begin{array}{r} 85 \\ \times 2 \\ \hline \end{array}$

26)  $1 \overline{)0.8}$

27)  $\begin{array}{r} 10 \\ \times 10 \\ \hline \end{array}$

28)  $\begin{array}{r} 9 \\ \times 5 \\ \hline \end{array}$

29)  $6 \overline{)9.6}$

30)  $\begin{array}{r} 183 \\ \times 88 \\ \hline \end{array}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing and multiplying. SOL 5.6 and 5.3.

1)  $6 \overline{)9.6}$     2)  $7 \overline{)0.7}$     3)  $8 \overline{)965.6}$     4)  $3 \overline{)26.4}$     5)  $\begin{array}{r} 413 \\ \times 1 \\ \hline \end{array}$

6)  $3 \overline{)0.9}$     7)  $9 \overline{)38.7}$     8)  $5 \overline{)2.5}$     9)  $9 \overline{)490.5}$     10)  $\begin{array}{r} 59 \\ \times 9 \\ \hline \end{array}$

11)  $5 \overline{)66.0}$     12)  $2 \overline{)0.2}$     13)  $3 \overline{)490.8}$     14)  $7 \overline{)14.0}$     15)  $\begin{array}{r} 273 \\ \times 15 \\ \hline \end{array}$

16)  $8 \overline{)93.6}$     17)  $7 \overline{)2.1}$     18)  $5 \overline{)99.5}$     19)  $7 \overline{)857.5}$     20)  $\begin{array}{r} 8 \\ \times 8 \\ \hline \end{array}$

21)  $2 \overline{)30.4}$     22)  $6 \overline{)92.7}$     23)  $7 \overline{)147.7}$     24)  $8 \overline{)247.2}$     25)  $\begin{array}{r} 70 \\ \times 70 \\ \hline \end{array}$

26)  $6 \overline{)4.2}$     27)  $1 \overline{)0.8}$     28)  $6 \overline{)9.6}$     29)  $1 \overline{)2.9}$     30)  $\begin{array}{r} 48 \\ \times 7 \\ \hline \end{array}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.6.

1)  $3 \overline{)3.48}$       2)  $7 \overline{)0.7}$       3)  $5 \overline{)4.55}$       4)  $3 \overline{)26.4}$       5)  $8 \overline{)965.6}$

6)  $5 \overline{)7.00}$       7)  $9 \overline{)38.7}$       8)  $3 \overline{)0.9}$       9)  $1 \overline{)7.14}$       10)  $9 \overline{)490.5}$

11)  $6 \overline{)0.72}$       12)  $5 \overline{)2.5}$       13)  $9 \overline{)0.45}$       14)  $7 \overline{)14.0}$       15)  $5 \overline{)66.0}$

16)  $2 \overline{)9.96}$       17)  $5 \overline{)99.5}$       18)  $3 \overline{)490.8}$       19)  $8 \overline{)0.08}$       20)  $7 \overline{)857.5}$

21)  $4 \overline{)5.08}$       22)  $6 \overline{)92.7}$       23)  $9 \overline{)2.52}$       24)  $8 \overline{)247.2}$       25)  $2 \overline{)30.4}$

26)  $5 \overline{)0.30}$       27)  $6 \overline{)9.6}$       28)  $7 \overline{)147.7}$       29)  $3 \overline{)65.40}$       30)  $4 \overline{)4.2}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing and multiplying. SOL 5.6 and 5.3.

1)  $4 \overline{) 56.36}$

2)  $\begin{array}{r} 86 \\ \times 69 \\ \hline \end{array}$

3)  $6 \overline{) 33.06}$

4)  $\begin{array}{r} 40 \\ \times 0 \\ \hline \end{array}$

5)  $\begin{array}{r} 8 \\ \times 3 \\ \hline \end{array}$

6)  $7 \overline{) 2.10}$

7)  $\begin{array}{r} 351 \\ \times 55 \\ \hline \end{array}$

8)  $\begin{array}{r} 233 \\ \times 4 \\ \hline \end{array}$

9)  $4 \overline{) 0.68}$

10)  $\begin{array}{r} 21 \\ \times 5 \\ \hline \end{array}$

11)  $8 \overline{) 43.04}$

12)  $\begin{array}{r} 90 \\ \times 16 \\ \hline \end{array}$

13)  $3 \overline{) 8.46}$

14)  $\begin{array}{r} 240 \\ \times 6 \\ \hline \end{array}$

15)  $\begin{array}{r} 8 \\ \times 7 \\ \hline \end{array}$

16)  $6 \overline{) 13.38}$

17)  $\begin{array}{r} 14 \\ \times 3 \\ \hline \end{array}$

18)  $\begin{array}{r} 6 \\ \times 3 \\ \hline \end{array}$

19)  $6 \overline{) 89.40}$

20)  $\begin{array}{r} 38 \\ \times 10 \\ \hline \end{array}$

21)  $2 \overline{) 50.20}$

22)  $\begin{array}{r} 6 \\ \times 4 \\ \hline \end{array}$

23)  $8 \overline{) 1.92}$

24)  $\begin{array}{r} 18 \\ \times 8 \\ \hline \end{array}$

25)  $\begin{array}{r} 17 \\ \times 13 \\ \hline \end{array}$

26)  $6 \overline{) 4.74}$

27)  $\begin{array}{r} 430 \\ \times 0 \\ \hline \end{array}$

28)  $\begin{array}{r} 871 \\ \times 6 \\ \hline \end{array}$

29)  $2 \overline{) 61.24}$

30)  $\begin{array}{r} 8 \\ \times 4 \\ \hline \end{array}$

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Teacher: \_\_\_\_\_ Directions: Practice dividing and multiplying. SOL 5.6 and 5.3.

1)  $7 \overline{) 25.123}$     2)  $4 \overline{) 56.36}$     3)  $6 \overline{) 58.374}$     4)  $6 \overline{) 33.06}$     5)  $\begin{array}{r} 412 \\ \times 70 \\ \hline \end{array}$

6)  $1 \overline{) 0.889}$     7)  $7 \overline{) 2.10}$     8)  $4 \overline{) 0.68}$     9)  $3 \overline{) 5.376}$     10)  $\begin{array}{r} 57 \\ \times 50 \\ \hline \end{array}$

11)  $5 \overline{) 3.980}$     12)  $8 \overline{) 43.04}$     13)  $4 \overline{) 0.792}$     14)  $3 \overline{) 8.46}$     15)  $\begin{array}{r} 218 \\ \times 3 \\ \hline \end{array}$

16)  $8 \overline{) 78.072}$     17)  $6 \overline{) 13.38}$     18)  $6 \overline{) 89.40}$     19)  $5 \overline{) 0.375}$     20)  $\begin{array}{r} 26 \\ \times 7 \\ \hline \end{array}$

21)  $5 \overline{) 8.610}$     22)  $2 \overline{) 50.20}$     23)  $3 \overline{) 2.991}$     24)  $8 \overline{) 1.92}$     25)  $\begin{array}{r} 60 \\ \times 2 \\ \hline \end{array}$

26)  $2 \overline{) 6.904}$     27)  $6 \overline{) 4.74}$     28)  $2 \overline{) 61.24}$     29)  $3 \overline{) 0.651}$     30)  $\begin{array}{r} 3 \\ \times 3 \\ \hline \end{array}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Practice dividing. SOL 5.6.

1)  $4 \overline{)70.132}$     2)  $7 \overline{)2.10}$     3)  $7 \overline{)17.948}$     4)  $4 \overline{)0.68}$     5)  $7 \overline{)25.123}$

6)  $5 \overline{)9.460}$     7)  $8 \overline{)43.04}$     8)  $1 \overline{)0.889}$     9)  $2 \overline{)0.588}$     10)  $4 \overline{)0.792}$

11)  $6 \overline{)6.462}$     12)  $3 \overline{)8.46}$     13)  $9 \overline{)9.458}$     14)  $6 \overline{)13.38}$     15)  $3 \overline{)0.651}$

16)  $6 \overline{)27.924}$     17)  $6 \overline{)89.40}$     18)  $2 \overline{)6.904}$     19)  $8 \overline{)4.680}$     20)  $5 \overline{)8.610}$

21)  $7 \overline{)0.938}$     22)  $2 \overline{)50.20}$     23)  $7 \overline{)41.370}$     24)  $6 \overline{)4.74}$     25)  $5 \overline{)0.375}$

26)  $3 \overline{)2.196}$     27)  $2 \overline{)61.24}$     28)  $5 \overline{)3.980}$     29)  $9 \overline{)32.049}$     30)  $8 \overline{)78.072}$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference. Practice multiplying. SOL 5.7 and 5.3.

1)  $\frac{2}{5} + \frac{1}{5} =$

2)  $93$

$\underline{\times 43}$

3)  $\frac{4}{5} - \frac{2}{5} =$

4)  $910$

$\underline{\times 9}$

5)  $7$

$\underline{\times 1}$

6)  $\frac{1}{12} + \frac{6}{12} =$

7)  $185$

$\underline{\times 16}$

8)  $31$

$\underline{\times 5}$

9)  $\frac{3}{7} + \frac{3}{7} =$

10)  $67$

$\underline{\times 53}$

11)  $\frac{3}{4} - \frac{0}{4} =$

12)  $28$

$\underline{\times 4}$

13)  $\frac{6}{6} - \frac{1}{6} =$

14)  $8$

$\underline{\times 5}$

15)  $12$

$\underline{\times 5}$

16)  $\frac{1}{1} + \frac{0}{1} =$

17)  $60$

$\underline{\times 2}$

18)  $60$

$\underline{\times 2}$

$$19) \frac{6}{11} + \frac{2}{11} =$$

$$20) \begin{array}{r} 100 \\ \times 96 \\ \hline \end{array}$$

$$21) \frac{5}{11} - \frac{1}{11} =$$

$$22) \begin{array}{r} 33 \\ \times 3 \\ \hline \end{array}$$

$$23) \frac{1}{3} + \frac{1}{3} =$$

$$24) \begin{array}{r} 50 \\ \times 3 \\ \hline \end{array}$$

$$25) \begin{array}{r} 20 \\ \times 6 \\ \hline \end{array}$$

$$26) \frac{1}{2} + \frac{0}{2} =$$

$$27) \begin{array}{r} 6 \\ \times 5 \\ \hline \end{array}$$

$$28) \begin{array}{r} 59 \\ \times 14 \\ \hline \end{array}$$

$$29) \frac{5}{10} + \frac{4}{10} =$$

$$30) \begin{array}{r} 189 \\ \times 6 \\ \hline \end{array}$$



Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference. Practice multiplying. SOL 5.7 and 5.3.

1)  $\frac{3}{10} + \frac{2}{5} =$

2)  $\frac{2}{5} + \frac{1}{5} =$

3)  $\frac{1}{3} + \frac{5}{9} =$

4)  $\frac{4}{5} - \frac{2}{5} =$

5) 
$$\begin{array}{r} 87 \\ \times 51 \\ \hline \end{array}$$

6)  $\frac{1}{2} + \frac{2}{5} =$

7)  $\frac{1}{12} + \frac{6}{12} =$

8)  $\frac{3}{4} + \frac{2}{12} =$

9)  $\frac{1}{6} + \frac{1}{9} =$

10) 
$$\begin{array}{r} 46 \\ \times 3 \\ \hline \end{array}$$

11)  $\frac{1}{5} + \frac{5}{10} =$

12)  $\frac{3}{4} - \frac{0}{4} =$

13)  $\frac{5}{8} + \frac{1}{4} =$

14)  $\frac{6}{6} - \frac{1}{6} =$

15) 
$$\begin{array}{r} 2 \\ \times 2 \\ \hline \end{array}$$

16)  $\frac{1}{3} + \frac{2}{5} =$

17)  $\frac{1}{1} + \frac{0}{1} =$

18)  $\frac{6}{11} + \frac{2}{11} =$

19)  $\frac{1}{4} + \frac{1}{3} =$

20) 
$$\begin{array}{r} 724 \\ \times 7 \\ \hline \end{array}$$

21)  $\frac{1}{2} + \frac{1}{4} =$

$$22) \frac{5}{11} - \frac{1}{11} =$$

$$23) \frac{1}{3} + \frac{2}{9} =$$

$$24) \frac{1}{3} + \frac{1}{3} =$$

$$25) \begin{array}{r} 952 \\ \times 10 \\ \hline \end{array}$$

$$26) \frac{2}{4} + \frac{1}{12} =$$

$$27) \frac{1}{2} + \frac{0}{2} =$$

$$28) \frac{5}{10} + \frac{4}{10} =$$

$$29) \frac{1}{3} + \frac{1}{2} =$$

$$30) \begin{array}{r} 71 \\ \times 21 \\ \hline \end{array}$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference.  
SOL 5.7.

1)  $\frac{5}{7} - \frac{1}{2} =$

2)  $\frac{2}{5} + \frac{1}{5} =$

3)  $\frac{7}{8} - \frac{8}{12} =$

4)  $\frac{5}{11} - \frac{1}{11} =$

5)  $\frac{1}{3} + \frac{1}{2} =$

6)  $\frac{3}{4} - \frac{1}{6} =$

7)  $\frac{3}{4} - \frac{0}{4} =$

8)  $\frac{5}{8} + \frac{1}{4} =$

9)  $\frac{1}{3} - \frac{3}{10} =$

10)  $\frac{1}{2} + \frac{2}{5} =$

11)  $\frac{6}{10} - \frac{1}{4} =$

12)  $\frac{1}{12} + \frac{6}{12} =$

13)  $\frac{2}{3} - \frac{1}{9} =$

14)  $\frac{1}{1} + \frac{0}{1} =$

15)  $\frac{1}{4} + \frac{1}{3} =$

16)  $\frac{7}{12} - \frac{1}{2} =$

17)  $\frac{4}{5} - \frac{2}{5} =$

18)  $\frac{1}{2} + \frac{1}{4} =$

19)  $\frac{3}{8} - \frac{1}{6} =$

20)  $\frac{1}{3} + \frac{1}{9} =$

21)  $\frac{2}{5} - \frac{2}{7} =$

22)  $\frac{1}{3} + \frac{1}{3} =$

23)  $\frac{2}{2} - \frac{1}{8} =$

24)  $\frac{1}{2} + \frac{0}{2} =$

25)  $\frac{1}{3} + \frac{2}{5} =$

26)  $\frac{6}{7} - \frac{2}{3} =$

27)  $\frac{3}{7} + \frac{3}{7} =$

28)  $\frac{1}{3} + \frac{2}{9} =$

29)  $\frac{8}{9} - \frac{1}{5} =$

30)  $\frac{2}{4} + \frac{1}{12} =$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum. Practice multiplying. SOL 5.7 and 5.3.

1)  $\frac{4}{7} + \frac{2}{6} =$

2)  $\begin{array}{r} 640 \\ \times 46 \\ \hline \end{array}$

3)  $\frac{1}{3} + \frac{1}{6} =$

4)  $\begin{array}{r} 80 \\ \times 55 \\ \hline \end{array}$

5)  $\begin{array}{r} 10 \\ \times 4 \\ \hline \end{array}$

6)  $\frac{1}{6} + \frac{1}{10} =$

7)  $\begin{array}{r} 3 \\ \times 2 \\ \hline \end{array}$

8)  $\begin{array}{r} 90 \\ \times 35 \\ \hline \end{array}$

9)  $\frac{2}{4} + \frac{3}{9} =$

10)  $\begin{array}{r} 736 \\ \times 29 \\ \hline \end{array}$

11)  $\frac{1}{2} + \frac{2}{8} =$

12)  $\begin{array}{r} 24 \\ \times 15 \\ \hline \end{array}$

13)  $\frac{5}{10} + \frac{1}{3} =$

14)  $\begin{array}{r} 485 \\ \times 0 \\ \hline \end{array}$

15)  $\begin{array}{r} 20 \\ \times 3 \\ \hline \end{array}$

16)  $\frac{1}{3} + \frac{2}{8} =$

17)  $\begin{array}{r} 7 \\ \times 6 \\ \hline \end{array}$

18)  $\begin{array}{r} 62 \\ \times 61 \\ \hline \end{array}$

$$19) \frac{3}{6} + \frac{3}{12} =$$

$$20) \begin{array}{r} 13 \\ \times 4 \\ \hline \end{array}$$

$$21) \frac{1}{6} + \frac{1}{9} =$$

$$22) \begin{array}{r} 806 \\ \times 6 \\ \hline \end{array}$$

$$23) \frac{2}{4} + \frac{2}{8} =$$

$$24) \begin{array}{r} 80 \\ \times 40 \\ \hline \end{array}$$

$$25) \begin{array}{r} 18 \\ \times 4 \\ \hline \end{array}$$

$$26) \frac{1}{3} + \frac{3}{9} =$$

$$27) \begin{array}{r} 907 \\ \times 60 \\ \hline \end{array}$$

$$28) \begin{array}{r} 19 \\ \times 8 \\ \hline \end{array}$$

$$29) \frac{2}{8} + \frac{3}{6} =$$

$$30) \begin{array}{r} 20 \\ \times 20 \\ \hline \end{array}$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference. Practice multiplying. SOL 5.7 and 5.3.

1)  $\frac{4}{6} - \frac{1}{3} =$

2)  $\frac{4}{7} + \frac{2}{6} =$

3)  $\frac{2}{4} - \frac{4}{11} =$

4)  $\frac{1}{3} + \frac{1}{6} =$

5) 
$$\begin{array}{r} 72 \\ \times 18 \\ \hline \end{array}$$

6)  $\frac{6}{8} - \frac{5}{11} =$

7)  $\frac{1}{6} + \frac{1}{10} =$

8)  $\frac{2}{4} + \frac{3}{9} =$

9)  $\frac{4}{6} - \frac{2}{7} =$

10) 
$$\begin{array}{r} 17 \\ \times 5 \\ \hline \end{array}$$

11)  $\frac{2}{3} - \frac{2}{6} =$

12)  $\frac{1}{2} + \frac{2}{8} =$

13)  $\frac{3}{4} - \frac{5}{12} =$

14)  $\frac{5}{10} + \frac{1}{3} =$

15) 
$$\begin{array}{r} 7 \\ \times 4 \\ \hline \end{array}$$

16)  $\frac{4}{5} - \frac{3}{6} =$

17)  $\frac{1}{3} + \frac{2}{8} =$

18)  $\frac{3}{6} + \frac{3}{12} =$

$$19) \frac{6}{8} - \frac{3}{9} =$$

$$20) \begin{array}{r} 937 \\ \times 5 \\ \hline \end{array}$$

$$21) \frac{7}{9} - \frac{2}{6} =$$

$$22) \frac{1}{6} + \frac{1}{9} =$$

$$23) \frac{3}{6} - \frac{2}{10} =$$

$$24) \frac{2}{4} - \frac{2}{8} =$$

$$25) \begin{array}{r} 301 \\ \times 27 \\ \hline \end{array}$$

$$26) \frac{3}{4} - \frac{6}{8} =$$

$$27) \frac{1}{3} + \frac{3}{9} =$$

$$28) \frac{2}{8} + \frac{3}{6} =$$

$$29) \frac{4}{6} - \frac{2}{3} =$$

$$30) \begin{array}{r} 967 \\ \times 98 \\ \hline \end{array}$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference.  
SOL 5.7.

$$1) \quad 1 \frac{2}{8} + 2 \frac{8}{8} =$$

$$2) \quad \frac{5}{10} + \frac{1}{3} =$$

$$3) \quad 12 \frac{10}{5} + 7 \frac{6}{5} =$$

$$4) \quad \frac{2}{8} + \frac{3}{6} =$$

$$5) \quad \frac{4}{6} - \frac{2}{3} =$$

$$6) \quad 7 \frac{4}{8} + 6 \frac{2}{8} =$$

$$7) \quad \frac{1}{3} + \frac{2}{8} =$$

$$8) \quad \frac{3}{4} - \frac{5}{12} =$$

$$9) \quad 9 \frac{3}{8} + 6 \frac{3}{8} =$$

$$10) \quad \frac{4}{5} - \frac{3}{6} =$$

$$11) \quad 10 \frac{1}{3} + 8 \frac{1}{3} =$$

$$12) \quad \frac{1}{3} + \frac{3}{9} =$$

$$13) \quad 9 \frac{3}{5} + 4 \frac{1}{5} =$$

$$14) \quad \frac{1}{6} + \frac{1}{10} =$$

$$15) \quad \frac{4}{6} - \frac{1}{3} =$$

$$16) \quad 2 \frac{3}{10} + 9 \frac{2}{10} =$$

$$17) \quad \frac{3}{6} + \frac{3}{12} =$$

$$18) \quad \frac{2}{4} - \frac{4}{11} =$$



$$19) \quad 4 \frac{5}{9} + 2 \frac{1}{9} =$$

$$20) \quad \frac{4}{6} - \frac{2}{7} =$$

$$21) \quad 5 \frac{5}{7} + 5 \frac{3}{7} =$$

$$22) \quad \frac{1}{3} + \frac{1}{6} =$$

$$23) \quad 6 \frac{6}{11} + 7 \frac{3}{11} =$$

$$24) \quad \frac{2}{4} + \frac{2}{8} =$$

$$25) \quad \frac{3}{4} - \frac{6}{8} =$$

$$26) \quad 9 \frac{7}{12} + 5 \frac{1}{12} =$$

$$27) \quad \frac{4}{7} + \frac{2}{6} =$$

$$28) \quad \frac{6}{8} - \frac{5}{11} =$$

$$29) \quad 8 \frac{5}{8} + 9 \frac{5}{8} =$$

$$30) \quad \frac{3}{6} - \frac{2}{10} =$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each difference. Simplify. Practice multiplying. SOL 5.7 and 5.3.

$$1) \quad 4 \frac{1}{2} - 2 \frac{1}{2} =$$

$$2) \quad \begin{array}{r} 875 \\ \times 7 \\ \hline \end{array}$$

$$3) \quad 12 \frac{9}{11} - 6 \frac{7}{11} =$$

$$4) \quad \begin{array}{r} 51 \\ \times 7 \\ \hline \end{array}$$

$$5) \quad \begin{array}{r} 5 \\ \times 2 \\ \hline \end{array}$$

$$6) \quad 10 \frac{6}{11} - 9 \frac{5}{11} =$$

$$7) \quad \begin{array}{r} 67 \\ \times 3 \\ \hline \end{array}$$

$$8) \quad \begin{array}{r} 250 \\ \times 7 \\ \hline \end{array}$$

$$9) \quad 8 \frac{48}{8} - 3 \frac{4}{8} =$$

$$10) \quad \begin{array}{r} 10 \\ \times 8 \\ \hline \end{array}$$

$$11) \quad 11 \frac{9}{10} - 4 \frac{1}{10} =$$

$$12) \quad \begin{array}{r} 458 \\ \times 4 \\ \hline \end{array}$$

$$13) \quad 8 \frac{7}{8} - 4 \frac{3}{8} =$$

$$14) \quad \begin{array}{r} 59 \\ \times 44 \\ \hline \end{array}$$

$$15) \quad \begin{array}{r} 9 \\ \times 9 \\ \hline \end{array}$$

$$16) \quad 9 \frac{4}{6} - 3 \frac{1}{6} =$$

$$17) \quad \begin{array}{r} 10 \\ \times 0 \\ \hline \end{array}$$

$$18) \quad \begin{array}{r} 420 \\ \times 3 \\ \hline \end{array}$$

$$19) \quad 12 \frac{9}{10} - 4 \frac{4}{10} =$$

$$20) \quad \begin{array}{r} 355 \\ \times 45 \\ \hline \end{array}$$

$$21) \quad 8 \frac{6}{7} - 2 \frac{4}{7} =$$

$$22) \quad \begin{array}{r} 68 \\ \times 24 \\ \hline \end{array}$$

$$23) \quad 4 \frac{7}{10} - 2 \frac{3}{10} =$$

$$24) \quad \begin{array}{r} 891 \\ \times 4 \\ \hline \end{array}$$

$$25) \quad \begin{array}{r} 84 \\ \times 9 \\ \hline \end{array}$$

$$26) \quad 10 \frac{6}{6} - 2 \frac{2}{6} =$$

$$27) \quad \begin{array}{r} 5 \\ \times 4 \\ \hline \end{array}$$

$$28) \quad \begin{array}{r} 193 \\ \times 92 \\ \hline \end{array}$$

$$29) \quad 7 \frac{8}{10} - 3 \frac{6}{10} =$$

$$30) \quad \begin{array}{r} 18 \\ \times 2 \\ \hline \end{array}$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference. Practice multiplying. SOL 5.7 and 5.3.

$$1) \quad 2 \frac{2}{3} + 4 \frac{1}{2} =$$

$$2) \quad 4 \frac{1}{2} - 2 \frac{1}{2} =$$

$$3) \quad 9 \frac{1}{4} - 6 \frac{1}{6} =$$

$$4) \quad 12 \frac{9}{11} - 6 \frac{7}{11} =$$

$$5) \quad \begin{array}{r} 75 \\ \times 6 \\ \hline \end{array}$$

$$6) \quad 12 \frac{4}{6} - 10 \frac{1}{3} =$$

$$7) \quad 10 \frac{6}{11} - 9 \frac{5}{11} =$$

$$8) \quad 8 \frac{4}{8} - 3 \frac{4}{8} =$$

$$9) \quad 2 \frac{2}{4} + 2 \frac{4}{10} =$$

$$10) \quad \begin{array}{r} 9 \\ \times 2 \\ \hline \end{array}$$

$$11) \quad 12 \frac{3}{4} - 4 \frac{4}{8} =$$

$$12) \quad 11 \frac{9}{10} - 4 \frac{1}{10} =$$

$$13) \quad 12 \frac{5}{11} + 5 \frac{4}{6} =$$

$$14) \quad 8 \frac{7}{8} - 4 \frac{3}{8} =$$

$$15) \quad \begin{array}{r} 60 \\ \times 2 \\ \hline \end{array}$$

$$16) \quad 8 \frac{7}{9} - 8 \frac{2}{6} =$$

$$17) \quad 9 \frac{4}{6} - 3 \frac{1}{6} =$$

$$18) \quad 12 \frac{9}{10} - 4 \frac{4}{10} =$$

$$19) \quad 12 \frac{2}{8} + 4 \frac{3}{6} =$$

$$20) \quad 15 \\ \underline{\times 4}$$

$$21) \quad 6 \frac{2}{4} - 2 \frac{2}{11} =$$

$$22) \quad 8 \frac{6}{7} - 2 \frac{4}{7} =$$

$$23) \quad 2 \frac{8}{12} - 1 \frac{4}{9} =$$

$$24) \quad 4 \frac{7}{10} - 2 \frac{3}{10} =$$

$$25) \quad 610 \\ \underline{\times 26}$$

$$26) \quad 1 \frac{4}{7} + 1 \frac{4}{6} =$$

$$27) \quad 10 \frac{6}{6} - 2 \frac{2}{6} =$$

$$28) \quad 7 \frac{8}{10} - 3 \frac{6}{10} =$$

$$29) \quad 10 \frac{6}{8} - 1 \frac{2}{5} =$$

$$30) \quad 93 \\ \underline{\times 55}$$

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Teacher: \_\_\_\_\_

Directions: Find each sum and difference.  
SOL 5.7.

$$1) \quad 3 \frac{5}{7} - 1 \frac{1}{2} =$$

$$2) \quad 4 \frac{7}{10} - 2 \frac{3}{10} =$$

$$3) \quad 8 \frac{4}{10} + 8 \frac{3}{5} =$$

$$4) \quad 10 \frac{6}{11} - 9 \frac{5}{11} =$$

$$5) \quad 12 \frac{2}{8} + 4 \frac{3}{6} =$$

$$6) \quad 12 \frac{9}{12} - 8 \frac{1}{2} =$$

$$7) \quad 10 \frac{6}{6} - 2 \frac{2}{6} =$$

$$8) \quad 2 \frac{8}{12} - 1 \frac{4}{9} =$$

$$9) \quad 12 \frac{6}{8} - 9 \frac{1}{2} =$$

$$10) \quad 10 \frac{6}{8} - 1 \frac{2}{5} =$$

$$11) \quad 5 \frac{2}{4} + 1 \frac{3}{6} =$$

$$12) \quad 9 \frac{4}{6} - 3 \frac{1}{6} =$$

$$13) \quad 11 \frac{8}{12} - 4 \frac{3}{10} =$$

$$14) \quad 4 \frac{1}{2} - 2 \frac{1}{2} =$$

$$15) \quad 2 \frac{2}{3} + 4 \frac{1}{2} =$$

$$16) \quad 8 \frac{1}{3} + 4 \frac{1}{6} =$$

$$17) \quad 11 \frac{9}{10} - 4 \frac{1}{10} =$$

$$18) \quad 12 \frac{4}{6} - 10 \frac{1}{3} =$$

$$19) \quad 9 \frac{4}{8} + 3 \frac{5}{4} =$$

$$20) \quad 2 \frac{2}{4} + 2 \frac{4}{10} =$$

$$21) \quad 10 \frac{2}{8} + 3 \frac{5}{9} =$$

$$22) \quad 8 \frac{4}{8} - 3 \frac{4}{8} =$$

$$23) \quad 7 \frac{7}{9} - 4 \frac{1}{5} =$$

$$24) \quad 8 \frac{7}{8} - 4 \frac{3}{8} =$$

$$25) \quad 12 \frac{5}{11} + 5 \frac{4}{6} =$$

$$26) \quad 11 \frac{7}{10} + 12 \frac{4}{5} =$$

$$27) \quad 12 \frac{9}{11} - 6 \frac{7}{11} =$$

$$28) \quad 9 \frac{1}{4} - 6 \frac{1}{6} =$$

$$29) \quad 4 \frac{3}{4} + 6 \frac{7}{12} =$$

$$30) \quad 6 \frac{2}{4} - 2 \frac{2}{11} =$$

**Appendix D**

**PRETEST-POSTTEST MEASURE**



Name: \_\_\_\_\_  
Teacher: \_\_\_\_\_

Date: \_\_\_\_\_  
Score: \_\_\_\_\_

**Directions: Solve each problem and simplify.**

1.  $9 \overline{)8.316}$

Answer: .924  
Digits Correct: 3

2.  $5 \overline{)3000}$

Answer: 600  
Digits Correct: 3

3.  $\frac{11}{10} - \frac{1}{2} =$

Answer: 3/5  
Digits Correct: 2

4.  $\frac{9}{10} - \frac{6}{10} =$

Answer: 3/10  
Digits Correct: 3

5.  $8 \frac{5}{8} - 5 \frac{3}{6} =$

Answer: 3 1/8  
Digits Correct: 3

6.  $3 \overline{)0.18}$

Answer: .06  
Digits Correct: 2

7.  $10 \frac{7}{6} - 4 \frac{5}{6} =$

Answer: 6 1/3  
Digits Correct: 3

8.  $\frac{1}{3} + \frac{1}{6} =$

Answer: 1/2  
Digits Correct: 2

9.  $\frac{3}{4} - \frac{2}{12} =$

Answer: 7/12  
Digits Correct: 3

10.  $\frac{6}{8} - \frac{2}{6} =$

Answer: 5/12  
Digits Correct: 3

11.  $60 \overline{)480}$

Answer: 8  
Digits Correct: 1

12.  $\frac{2}{5} + \frac{2}{5} =$

Answer: 4/5  
Digits Correct: 2

13.  $5 \overline{)522}$

Answer: 104 R2  
Digits Correct: 4

14.  $6 \overline{)86.76}$

Answer: 14.46  
Digits Correct: 4

15.  $\frac{3}{8} + \frac{1}{4} =$

Answer: 5/8  
Digits Correct: 2

16.  $\frac{1}{3} + \frac{5}{12} =$

Answer: 3/4  
Digits Correct: 2

17.  $7 \overline{)19.6}$

Answer: 2.8  
Digits Correct: 2

18.  $3 \overline{)2518}$

Answer: 839 R1  
Digits Correct: 4

$$19. \quad 46 \overline{)4140}$$

Answer: 90  
 Digits Correct: 2

$$20. \quad \frac{4}{8} + \frac{3}{8} =$$

Answer: 7/8  
 Digits Correct: 2

$$21. \quad 17 \overline{)165}$$

Answer: 9 R12  
 Digits Correct: 3

$$22. \quad 3 \frac{1}{2} + 1 \frac{1}{2} =$$

Answer: 5  
 Digits Correct: 1

$$23. \quad 20 \overline{)99}$$

Answer: 4 R19  
 Digits Correct: 3

$$24. \quad 6 \frac{9}{8} - 5 \frac{1}{8} =$$

Answer: 2  
 Digits Correct: 1

$$25. \quad \frac{4}{5} - \frac{1}{3} =$$

Answer: 7/15  
 Digits Correct: 3

$$26. \quad \frac{6}{7} - \frac{2}{7} =$$

Answer: 4/7  
 Digits Correct: 2

$$27. \quad \frac{1}{4} + \frac{4}{6} =$$

Answer: 11/12  
 Digits Correct: 4

$$28. \quad 9 \frac{6}{9} - 3 \frac{1}{3} =$$

Answer: 6 1/3  
 Digits Correct: 3

$$29. \quad 7 \overline{)9.149}$$

Answer: 1.307  
 Digits Correct: 4

$$30. \quad 4 \frac{4}{9} + 5 \frac{2}{9} =$$

Answer: 9 2/3  
 Digits Correct: 3

$$31. \quad 2 \frac{3}{4} + 2 \frac{2}{3} =$$

Answer: 5 5/12  
 Digits Correct: 4

$$32. \quad 5 \frac{2}{3} + 3 \frac{3}{5} =$$

Answer: 9 4/15  
 Digits Correct: 4

$$33. \quad 3 \overline{)76.5}$$

Answer: 25.5  
 Digits Correct: 3

$$34. \quad 4 \overline{)824}$$

Answer: 206  
 Digits Correct: 3

**Appendix E**  
**LETTERS OF CONSENT**

September 2006

Dear Parent or Guardian:

My name is Jill Roper and I am a Nationally Certified School Psychologist, a doctoral student at the University of Missouri-Columbia, and a School Psychologist with Prince William County Schools. Presently, I am working on a research study under the supervision of Dr. Craig Frisby and Dr. Robbie Scholes. I have presented my research study to Prince William County School's superintendent and the principal at your child's elementary school and they have expressed an interest in participating. Your child is also invited to participate in this research study. Please read the following information carefully and discuss it with your child before giving consent.

The overall purpose of the study is to learn more about the effects of homework on classroom performance and academic achievement using fifth grade students. The assignment of homework includes many of the components needed for improving classroom academic performance, such as reviewing recently learned information. The goal of this research project is to see if students of different academic performances benefit from homework in mathematics achievement. In addition, the project will examine if differences exist between students of different academic performances when given mathematics homework. As a result, we are seeking permission from you to recruit your child to assist us with this study by allowing us to collect data on your child's homework performance and a pretest-posttest measure in math.

Certain risks and discomforts may be associated with this research. They include possible boredom with the homework. Benefits of participating in this study are increased academic achievement in mathematics and the knowledge that the data collected during this study are contributing to science. Nevertheless, participation is on a completely voluntary basis for you and your child. If you and your child give consent to participate, your child's homework in math will be managed throughout the course of the 6 week study. Homework will be assigned 3 days a week as a supplement to classroom instruction. Each homework assignment would not be expected to take more than 30 to 45 minutes for the participant to complete and must be returned the next school day. Finally, during the study the participant will be asked to complete a pretest-posttest measure in math, which would take about 60 to 90 minutes to complete for each.

All reasonable measures to protect the confidentiality of your child's records and your identity will be taken. Your child's identity will not be revealed in any publication that may result from this study. The confidentiality of all study related records will be maintained in accordance with State and Federal laws. Please note that an identification number will be assigned to each participant, and the homework assignments as well as chapter tests will be marked with the identification number. Identifying information about all participants will be kept separately, in a locked cabinet. Although you will have access to your child's homework and pretest-posttest performance through contact with his or her classroom teacher during the course of the study, Dr. Frisby, Dr. Scholes, and I are the only individuals who will have access to the information kept in the locked cabinet.

You are not only free to decline consent for your child to participate in the study, but also withdraw your child from the study at any time. Your child may also choose not to participate or withdraw from the study at any time. No penalty exists for not participating or withdrawing. Thank you for your time in considering your child's involvement in this study.

If you have any questions or concerns regarding this study, or if any problems arise, you may call Dr. Craig Frisby, at (573) 885-2561, or Dr. Robie Scholes, at (573)884-6269. You may also ask questions or state concerns to Michele Reznicek, Compliance Officer for the MU Campus IRB, at (573) 884-6512. It is not the policy of the University of Missouri to compensate human subjects in the event the research results in injury. The University of Missouri does have medical, professional, and general liability self-insurance coverage for any injury caused by the negligence of its faculty and staff. Within the limitations of the laws of the State of Missouri, the University of Missouri will also provide facilities and medical attention to participants who suffer injuries while participating in the research projects of the University of Missouri. In the event you have suffered injury as the result of participating in this research program, you are to contact the Risk Management Office at (573) 882-3735 who can review the matter and provide further information. This statement is not to be construed as an admission of liability.

If you are willing to help us, please sign below and return the form in the enclosed envelop to your child's classroom teacher.

Sincerely,

Jill Roper MS, Psy.S., NCSP  
School Psychologist

Craig Frisby, Ph.D.  
School Psychology Director  
University of Missouri-Columbia

Robbie Scholes, Ph.D.  
Clinical Assistant Professor  
University of Missouri-Columbia

**I have read this consent form and have been given the opportunity to ask questions. I will also be given a signed copy of this consent form for my records. I hereby consent to my child's participation in the research described above.**

Participant's Name: \_\_\_\_\_

Informed consent provided by: \_\_\_\_\_

Relationship to Participant \_\_\_\_\_

Date: \_\_\_\_\_

---

Parent or legal guardian's signature is required if participant is less than 18 years of age or not legally competent.

September 2006

Dear Fifth Grade Students:

My name is Jill Roper and I am a School Psychologist at your elementary school. Presently, I am working on a research study under the supervision of Dr. Craig Frisby and Dr. Robbie Scholes. I have presented my project to Prince William County School's superintendent, principal and fifth grade teachers at your school, and your parents or guardians. They have all expressed an interest in participating. You are also invited to participate in this research study. Please read the following information carefully.

We are interested in learning more about the effects of homework on classroom performance and academic achievement using fifth grade students. Homework includes many of the components needed for improving classroom performance and academic achievement, such as reviewing recent information. The goal of this project is to see if students of different academic performance benefit from homework in mathematics achievement. In addition, the project will examine if a difference exists between students of varying academic performance when assigned mathematics homework. As a result, we are seeking permission from you to assist us with this task by allowing us to collect data on your homework performance and pretest-posttest measure in math.

Certain risks and discomforts may be associated with this research. They include possible boredom with the homework. Benefits of participating in this study are increased academic achievement in mathematics and the knowledge that the data collected during this study are contributing to science. Nevertheless, participation is on a completely voluntary basis. If you agree to participate, your homework in math will be managed throughout the 6 week study. Homework will be assigned 3 days a week as a supplement to classroom instruction. Each homework assignment would not be expected to take more than 30 to 45 minutes for the participant to complete and must be returned the next school day. Finally, during the study the participant will be asked to complete a chapter pre-test and post-test in math, which would take about 60 to 90 minutes to complete for each.

If you do not wish to be in this study or you decide you do not want to continue after you have started, just tell your teacher or me. The study will be stopped and there will be no negative consequences. That is, no one will know that you decided to stop.

If you think of questions after you leave today, you should ask one of your parents to give me a call so that I can try and answer any questions you have. If you are willing to help us, please sign below.

Sincerely,

Jill Roper MS, Psy.S., NCSP

**I have read this form and have been given the opportunity to ask questions. I hereby agree to participate in the research described above.**

\_\_\_\_\_  
Participant's Signature

\_\_\_\_\_  
Date

Informed assent provided by: \_\_\_\_\_



**Appendix F**  
**LESSON PLAN**

Lesson Plan: Math Curriculum Objective 5.5

Objective: Dividing 2 digit numbers by 1 digit numbers, with remainders

Resources/Materials: Teacher Sourcebook; Student Textbook; Math Journal; Pencils; White Board; Dry Erase Marker; Place Value Chart; Multiplication Charts

Date: October 2006

Procedures and Activities:

1. State objective by writing it on the white board.
2. Review the terms used in division and how to set up a division problem on the white board. Students will copy this information into their math journal for notes.

$$\begin{array}{r} \text{Quotient} \quad \text{Remainder (R)} \\ \text{Divisor} \overline{) \text{Dividend}} \end{array}$$

3. Write

$$9 \overline{) 56}$$

on the white board. Have students copy the problems into their math journal.

4. **Write and state, “When the tens digit is less than the divisor-Step 1: Think of multiplication facts that have products close to 56.”** Have students copy Step 1 into their math journals. Draw students’ attention to Step 1. Point out to the students that the place-value chart shows the value of the digits in the dividend and in the quotient. **Ask: “In what column in the place-value chart will you put the quotient?” Answer: The ones column.**
5. Point out to the students the multiplication facts for 9. Students may use multiplication charts if necessary. **Ask: “What is the multiple of 9 nearest to, but not greater than, 56?” Answer: 54. Write and state: “9 x 5 = 45; 9 x 6 = 54; 9 x 7 = 63.”** Circle 9 x 6 = 54 on the white board. Have students write copy this into their math journals.

6. Write and state, “**Step 2: Write 5 in the ones place in the quotient. Multiply and record the product under the dividend. Subtract.**” Have students copy Step 2 into their math journals. Direct students’ attention to Step 2. Focus on the quotient. **Ask: “54 is the product of 9 and what other factor?” Answer: 6. Ask: “Where do you write the number 6?” Answer: In the ones place, in the quotient.** Explain that you write the product of 6 and 9, 54, in the division problem. Then you subtract. **Ask: “What is 56 minus 54?” Answer: 2.**

$$9 \times 6 = \begin{array}{r} 6 \text{ R}2 \\ 9 \overline{) 56} \\ \underline{- 54} \\ 2 \end{array}$$

7. Write and state, “**Step 3: Compare the remainder with the divisor. If the remainder is less than the divisor, write it next to the quotient. Check your work if the remainder is greater than the divisor.**” Have students copy Step 3 into their math journals.

$$9 \times 6 = \begin{array}{r} 6 \text{ R}2 \\ 9 \overline{) 56} \\ \underline{- 54} \\ 2 \end{array}$$

$2 < 9$

8. Continue with Step 3. Focus on the remainder. **Ask: “What is the remainder?” Answer: 2. Ask: “The remainder must be less than what number?” Answer: 9. Ask: “What letter is used to indicate the remainder?” Answer: R. Ask: “Where is the remainder written?” Answer: Next to the 6.**

9. Tell students that the remainder cannot be equal to or greater than 9. Explain to the students that if the remainder is greater than the divisor, then the number in the quotient should be greater.

10. Write

$$2 \overline{) 37}$$

on the white board. Have students copy the problems into their math journal.

11. Write and state, “**When the tens digit is greater than the divisor-Step 1: Divide the tens digit. Write 1 in the tens place in the quotient.**” Have students copy Step 1 into their math journals. Draw students’ attention to Step 1. Point out to the students that the place-value chart shows the value of the digits in the dividend and in the quotient. **Ask: “In what column in the place-value chart will you start this quotient?” Answer: The tens column.**

$$3 > 2 \text{ in } 2 \overline{) 37}$$

12. Write and state, “**Step 2: Multiply. Record. Subtract.**” Have students copy Step 2 into their math journals. Execute Step 2 on the white board. **Ask: “What is the product of 2 and 1?” Answer: 2. Ask: “What is 3 minus 2?” Answer: 1.**

$$2 \times 1 = \begin{array}{r} 1 \\ 2 \overline{) 37} \\ \underline{-2} \\ 1 \end{array}$$

13. Write and state, “**Step 3: Compare the remainder with the divisor.**” Point out if the remainder is less than the divisor to continue the problem or to check your work if the remainder is greater than the divisor.

$$2 \times 1 = \begin{array}{r} 1 \\ 2 \overline{) 37} \\ \underline{-2} \\ 1 \end{array}$$

14. Write and state, “**Step 4: Bring down the 7 in the ones place. Repeat Step 2.**” Have students copy Step 4 into their math journals. Execute Step 4 on the white board. **Ask: “What is the multiple of 2 nearest to, but not greater than, 17?” Answer: 16. Write and state: “2 x 6 = 12; 2 x 7 = 14; 2 x 8 = 18.”** Circle 2 x 8 = 16 on the white board. Have students write copy this into their math journals. **Ask: “16 is the product of 2 and what other factor?” Answer: 8. Ask: “Where do you write the number 8?” Answer: In the ones place, in the quotient.** Explain that you write the product of 2 and 8, 16, in the division problem. Then you subtract. **Ask: “What is 17 minus 16?” Answer: 1.**

$$\begin{array}{r} 18 \\ 2 \overline{) 37} \\ \underline{-2} \\ 17 \\ \underline{-16} \\ 1 \end{array}$$

15. Write and state, “**Step 5: Compare the remainder with the divisor. If the remainder is less than the divisor, write it next to the quotient. Check your work if the remainder is greater than the divisor.**”

16. Continue with Step 5. Focus on the remainder. **Ask: “What is the remainder?”**  
**Answer: 1.** **Ask: “The remainder must be less than what number?”** **Answer: 2.**  
**Ask: “What letter is used to indicate the remainder?”** **Answer: R.** **Ask: “Where is the remainder written?”** **Answer: Next to the 8.**

$$\begin{array}{r}
 18 \quad R1 \\
 2 \overline{) 37} \\
 \underline{2 \times 1 = 2} \phantom{0} \\
 17 \\
 \underline{2 \times 8 = 16} \\
 1
 \end{array}$$

17. Write and state, **“Practice on your own in your text on page 111, exercises 1 through 4; use a piece of paper.”**

18. Check to determine if the students can divide two digit by 1 digit numbers, with remainders, while they are working. When most students are finished, select students to demonstrate their work on the white board for the class.

19. Write and state, **“Practice on your own in your text on page 112, exercises 5 through 8.”**

20. Check. When most students are finished, select students to demonstrate their work on the white board for the class.

21. Write and state, **“Practice on your own in your text on page 112, exercises 9 through 16.”**

22. Check. When most students are finished, select students to demonstrate their work on the white board for the class.

23. Distribute homework and state it is due on the next school day.

## VITA

Jill Roper was born in Shakopee, Minnesota. After growing up in Minnesota, she received the following degrees: B.A. in English and Psychology from the College of Saint Benedict/St. John's University in 1998; M.S. in School Psychology from Minnesota State University at Moorhead in 2000; Psy.S. in School Psychology from Minnesota State University at Moorhead in 2001; Ph.D. in School Psychology from the University of Missouri-Columbia in 2008. She has worked as a Nationally Certified School Psychologist since 2000 in public school districts across the United States including Blue Earth, Minnesota, Prince William County (Washington D.C. area), and the Los Angeles Unified School District. Jill is married to Ronald Vaughan, Ph.D. Environmental Engineering, and currently lives in Los Angeles, California.