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The Influence of Types of Homework on Opportunity to Learn and Students' Mathematics Achievement: Examples from the University of Chicago School Mathematics Project

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The Influence of Types of Homework on Opportunity to Learn and Students' Mathematics Achievement: Examples from the University of Chicago School Mathematics Project

by

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DEDICATION

I dedicate this dissertation to my dear parents who have given me full support throughout the years. They have provided me everything I have ever needed and taught me values I cannot possibly live without. Without them, I would not have had the opportunity to choose to become the person I am today. I cannot express my love enough for them both.

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ABSTRACT

Public views on assigning students mathematics homework have been controversial. Although homework is designed for students to complete during non-school hours (Cooper, 1989), many see homework as excessive pressure on students. Most research placed their focus on the influence of the time spent on homework or the amount of homework on student achievement. Few studies have addressed the impact of types of mathematics homework. The purpose of this study is to examine the role of homework types in influencing opportunity to learn (OTL) on student achievement.

This quantitative study used subsets of a large existing dataset collected by University of Chicago School Mathematics Project (UCSMP) in *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*. The findings showed that OTL measured by lesson coverage and by teachers' reported posttest OTL have significant impact. Each type of homework as a mediator might have significant, positive or negative mediating effects or no mediating effects at all. The findings from having OTL measured by lesson coverage as the independent variable were more consistent with each mathematics course. The differences of the mediating effects of types of homework on the impact of OTL measured by lesson coverage on student mathematics achievement and on the impact of teachers' reported posttest OTL on students' mathematics achievement may be explained through the nature of the types of homework as well as through limitations of the study. Recommendations for future research and implications of the study were presented in the discussion part of the study.

CHAPTER 1: INTRODUCTION

Homework is an issue that affects not only students and teachers, but also parents. Homework, defined as any tasks teachers assign to students to be done during non-school hours (Cooper, 1989), is a ubiquitous part of most schooling. The most common type of homework is instructional. At least three instructional purposes can be embedded in homework assignments: 1) To provide students with an opportunity to practice or review material presented in class (Becker & Epstein, 1982); 2) To introduce preparation materials to help students get ready for new materials teachers are going to cover in class (Muhlenbruck et al., 1999); 3) To extend students' previously learned knowledge and skills to new situations or to integrate separately learned skills and concepts (Lee & Pruitt, 1979).

Public views on assigning mathematics homework have been controversial at times. Parents tend to complain that there might be too much or too little homework. Students tend to complain that homework takes away too much of their leisure time. Even teachers often misunderstand the purpose for assigning homework (Cooper, Robinson, & Patall, 2006). Although research has supported homework as being an important supplement to in-school academic activities (Henderson, 1996), the popular press often documents conflicts between parents and schools relative to homework (Kralovec & Buell, 2000; Loveless, 2003). Regardless, mathematics teachers typically believe homework plays a major part in instructional practices and secondary school student learning. Research suggests that instructional practice can influence students' learning, and homework is a way teachers provide for students to engage with mathematics concepts (Cooper, Robinson, & Patall, 2006).

Given the different purposes for homework, it is natural to wonder if different types of homework assigned to students might impact student achievement in different ways. However, there are limited studies on the relationship of homework to achievement and even fewer studies that investigate different types of homework. Thus, I conducted the present study to investigate how the types of homework as a part of opportunity to learn impact student math achievement.

Conceptual Framework

The Mathematical Task Framework (MTF) developed by Stein and her colleagues in the Qualitative Understanding Amplifying Student Achievement and Reasoning (QUASAR) project (Henningsen & Stein, 1997; Stein, Grover, & Henningsen, 1996; Stein, Smith, Henningsen, & Silver, 2000; Silver & Stein, 1996) (See Figure 1) "underscores the important role that mathematical tasks play in influencing students' learning opportunities" (Silver & Herbst, 2007, p. 55). The framework reflects the important role that a mathematical task plays in influencing students' opportunity to learn as well as emphasizing the central role of teachers in setting up and implementing mathematics tasks. What teachers do with the mathematics tasks influences students' engagement with the tasks, and ultimately influences students' opportunity to learn mathematics through such tasks (Silver & Herbst, 2007). The framework highlights a difference between the influence of intended curriculum (the textbook or the tasks) and implemented curriculum (how the textbook or the tasks are used in the class) on student learning. Porter (2004) distinguished between the content of the two curricula: the *intended curriculum* is prewritten content intended to set standards for a particular subject and grade level, and the *implemented curriculum* is the content of instruction delivered by classroom teachers. Generally, researchers use the MTF as the basis for analyses of empirical data on the extent of opportunity to learn mathematics provided by teachers using mathematics tasks to achieve better student learning (Stein et al., 1996).

In this study, I used the MTF as the conceptual framework. The different types of homework assignments available in textbook lessons that comprise the curriculum refer to the tasks in curricular materials in the MTF figure. Lesson coverage refers to the lesson as set up by teachers. Homework assigned refers to tasks implemented by teachers and potentially by students. Student learning is reflected by achievement scores (See Figures 1 and 2).

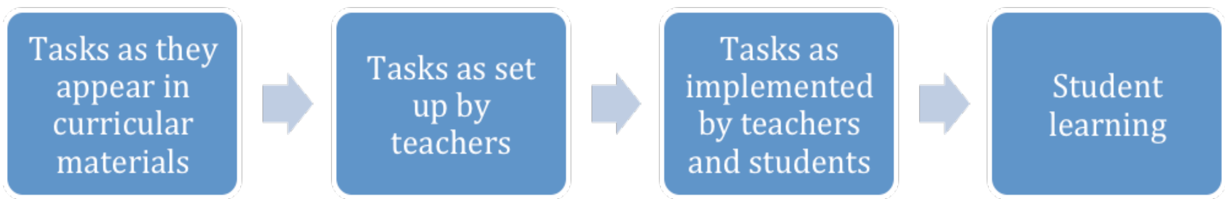

*Figure 1***.** The Mathematical Tasks Framework (Stein, Smith, Henningsen, & Silver, 2000)

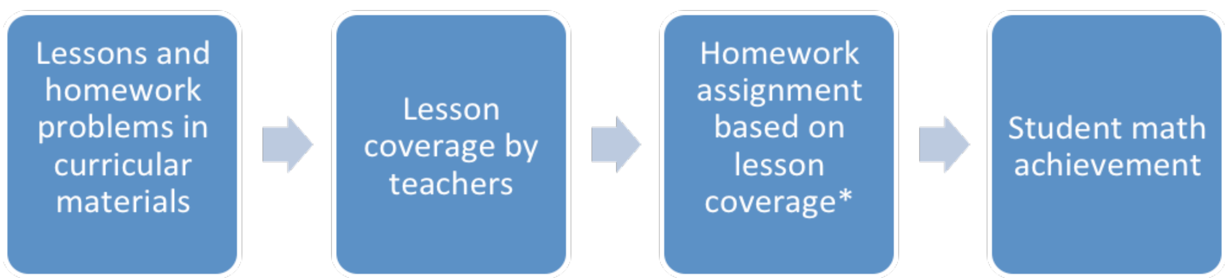

Figure 2. The Mathematical Tasks Framework as It Relates to Homework

Note. The Mathematical Tasks Framework as it relates to homework is adapted in a way so that the third phase is not one-to-one corresponding to the third phase in the original Mathematical Tasks Framework. For this study, the actual homework assignment completed by students is not known.

In this study, three different types of homework problems appeared in the curriculum and were examined, namely problems that cover basic understanding of the concepts, problems that apply the concepts, and review problems. Opportunity to learn (OTL) based on lesson coverage relates to teachers' decisions to assign different types of homework from chapters throughout the textbook; this is phase two (i.e., lesson coverage by teachers) of the MTF. Teachers may assign none, some, or all of the problems from the lessons taught. The percent of each type of homework problems assigned to students from the available problems refers to phase three (i.e., homework assignment based on lesson coverage) of the MTF. Phase four (i.e., student mathematics achievement) in the MTF refers to student mathematics learning.

Rationale

Since *An Agenda for Action* (National Council of Teachers of Mathematics, 1980) called for changes in student mathematics, the design of curriculum has focused on developing students' mathematics problem-solving skills. The *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) provided a set of recommendations for including specific content in school mathematics, mathematics skills expected of students, and learning goals for each grade band. The publication of *Principles and Standards for School Mathematics* (PSSM) (NCTM, 2000) refined and clarified the previous standards. In 2001, the passing of the *No Child Left Behind* (NCLB) legislation emphasized the importance of closing the achievement gap and enhancing achievement for all students. Since the release of PSSM and the passing of NCLB, many school mathematics curricula have been developed and implemented based on the recommendations of these standards to enhance student achievement.

To achieve the goal of enhancing student achievement, teachers must use their curriculum materials effectively. The assignment of homework is closely related to the implementation of the curriculum materials and yet is an area that is highly debated and understudied. This is true not only for how much homework is assigned but also for the nature of the homework assigned.

Homework is an important part of secondary school students' lives. However, many see homework as excessive pressure on students (Cooper, Robinson, & Patall, 2006); some even question the value of homework assignments and raise concerns that homework might affect students' mental health and discourage students from being motivated to learn. Taking such views into consideration, studies that have related student mathematics achievement and homework have shown a generally positive relationship between the two (Cooper, Robinson, & Patall, 2006). However, further investigations on factors related to homework assignments that can enhance student learning are needed.

Opportunity to learn (OTL) is widely considered "the single most important predictor of student achievement" (National Research Council, 2001, p. 334). Research has also shown that homework provides an opportunity for learning mathematics beyond classroom instruction (Cooper, Robinson, & Patell, 2006). Because of the complex nature of homework, positive and negative effects can occur simultaneously. The negative concerns about homework suggest the need to investigate the role of and types of homework in forming homework policies and practices, yet, to date, such research has been minimal. Among the available research, most researchers use amount of homework assigned or completed as measures of homework related to student achievement and rarely consider the possible impact of different types of homework on achievement.

Numerous definitions of homework have been used in the few available studies. Some included in-school guided studies, some included homework study courses, and some referred to non-instructional activities. In this study, I restrict the definition of homework to be only tasks assigned by teachers intended for students to carry out during non-school hours (Cooper, 1989). Most research interests have examined the relationship between amount of time spent on completed or assigned homework and achievement through the lens of the broad definitions of homework (Omlin-Ruback, 2009). Fewer studies have considered the influence of OTL on student achievement in terms of the implementation of the curriculum through lesson coverage and homework assigned by teachers. Therefore, there is a need to better understand the relationship between types of homework assigned and mathematics achievement as an aspect of OTL. Comparing the strengths of any effects can help teachers and schools make better instructional decisions relative to curriculum and homework.

I conducted a pilot study in 2012 to investigate the role of homework in achievement, in particular, the influence of homework types on opportunity to learn (OTL) and student mathematics achievement. The research question in this pilot study was: *To what extent do different types of homework influence the correlation between teachers' reported opportunity to learn and students' achievement?* In this study, I used OTL to refer to instructional practices, including teacher lesson coverage and amount of each of the types of homework assigned based on the lesson taught in one curriculum, specifically the *Transition Mathematics* (Third Edition, Field Trial Version) curriculum from the University of Chicago School Mathematics Project (UCSMP).

The sample for the pilot study consisted of 5 teachers and their 165 7^{th} grade students from ages 12 to 13 using the *Transition Mathematics* curriculum. I performed several multiple regression models and tested correlations between OTL and student mathematics achievement as well as the influence of the three different types of homework in this curriculum (covering the ideas, applying the mathematics, and review) on this correlation. The extent of such influence on OTL and achievement was represented using percentages calculated by Sobel's (1982) test.

The findings of the pilot study showed, overall, that all three homework types had positive influence on the correlation between OTL and student mathematics achievement. In particular, homework with the purpose of applying mathematics or review significantly increased the impact of OTL on student achievement.

Results from the pilot study were presented at the International Congress on Mathematics Education (ICME) in Seoul, South Korea, 2012. The presentation raised questions and interest from researchers and participants of the conference. Hence, this study examined some of these questions and determined the robustness of the findings from the pilot study.

Data analysis in the pilot study used homework as a mediating factor between lesson coverage and student achievement. Although the findings from the pilot study were positive, further examination about mediation analysis raised some concerns about the data analysis. The original sample was small and limited to one mathematics course. So there is a need to test the mediation using a larger sample size and more courses. Also the pilot study considered lesson coverage as the only measure of OTL, so it is important to consider other aspects of OTL. In this study, a multiple mediation model will replace the mediation approach used in the pilot study to allow investigations of the mediation effects of all three types of homework in the curriculum simultaneously and increase the accuracy of the original results.

Hence, the purpose of this study is to examine the role of homework types in influencing OTL on student achievement. The study used a larger dataset and more courses to investigate the robustness of the results from the pilot study. The results of the study suggested recommendations for teachers on how to assign mathematics homework with the goal of improving achievement. This study also served as a reference for future investigations of influence of types of mathematics homework and achievement.

Research Questions

The purpose of this study is to examine whether there is a correlation between opportunity to learn (OTL) and student mathematics achievement, and if so, to determine the extent to which different types of homework influence such correlation. Opportunity to learn here is measured by the actual lesson coverage provided by teachers and from teachers' reports of the opportunity they provided students to learn the mathematics on the posttests, also referred to in this study as teachers' reported posttest OTL in the research questions.

The research questions are the following:

1. How does opportunity to learn influence mathematics achievement in different mathematics courses? In particular,
    a. How does OTL as measured by lesson coverage influence mathematics achievement in *Pre-Transition Mathematics, Transition Mathematics*, and *Algebra*?
    b. How does OTL as measured by posttest OTL influence mathematics achievement in *Pre-Transition Mathematics, Transition Mathematics*, and *Algebra*?
2. To what extent do different types of homework influence the impact of OTL measured by lesson coverage on student mathematics achievement measured by 3 posttests in each of *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*?
3. To what extent do different types of homework influence the impact of opportunity to learn mathematics measured by posttest OTL (i.e., teacher perceived opportunity to learn the content on each posttest) on student mathematics achievement measured by each

corresponding posttest in *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*?

4. What can we conclude from the difference of mediation effects of types of homework on the correlation of opportunity to learn measured by lesson coverage and mathematics achievement and on the correlation of opportunity to learn measured by posttest OTL and mathematics achievement?

With these research questions in mind, the next chapter synthesizes studies that examine the relationships between homework and achievement, opportunity to learn and achievement, and statistical methodologies that have been used for research related to homework and achievement.

Significance of the Study

Few studies have examined the relationship between types of homework problems and OTL or achievement. Research has shown that OTL is a significant predictor of student achievement. The lessons that teachers cover in their classroom instruction and the homework they assign also provide their students an opportunity to learn mathematics. The goal of the study was to determine whether different types of homework problems mediate the relationship between OTL and achievement as well as to explain the differences among their effects through several multiple mediation models for different mathematics courses.

The findings have the potential to provide insights that can guide classroom and policy related to homework. Instead of debating whether students should be assigned more or less homework problems, or no homework at all, educators can approach the issue from the angle of assigning homework strategically when they understand positive and negative effects of assigning different types of homework.

Definitions

Homework: defined as any tasks teachers assign to students to be completed during non-school hours (Cooper, 1989).

Intended curriculum: is prewritten content intended to set standards for a particular subject and grade level.

Implemented curriculum: is the content of instruction delivered by classroom teachers.

Lesson Coverage: refers to the lessons as taught by teachers.

Opportunity to Learn: refers to instructional practices, including teacher lesson coverage and amount of each of the types of homework assigned based on the lessons taught in the curriculum.

Posttest opportunity to learn: refers to teachers' reports of whether they taught or reviewed the content needed for their students to answer each posttest item.

CHAPTER 2: LITERATURE REVIEW

Homework has always been an essential part of teachers' instructional practice, yet it also has been the most debatable topic especially among parents and schools. To better understand homework and its influences in order to help determine which types of homework to assign to students, it is necessary to understand the historical research perspectives about the role of homework in the school curriculum. From synthesizing studies that examine the relationship between homework and achievement, homework types as a factor of opportunity to learn and how it affects achievement, I determine the definitions of the variables used in this study and how the relationships are investigated. The definition and history of mediation and statistical methods and modern mediation approach are also introduced in this chapter.

Historical Perspectives on Homework

Homework is not only the most common instructional practice in school mathematics, but is also a subject of constant debate among parents, educators, and policy makers regarding its necessity, frequency, and the quantity assigned to students. Not only do these concerns need to be addressed in present and future studies, it is also important to understand reasons that led to such concerns in the first place and what educators have studied in the past about the impact of mathematics homework regarding these concerns. Hence, this literature review provides a historical perspective related to research on homework.

In the early 1900s, research on homework assignments argued that homework increased time on academic tasks, which resulted in the sculpting of good study habits such as selfdiscipline (Bryan & Nelson, 1994; Gill & Schlossman, 2000). Such discipline developed through memorization and was believed to help students' knowledge acquisition. Homework was encouraged as a strong learning strategy because it was believed that memorization could be easily accomplished through doing homework without teachers' instructions outside of the classroom (Cooper, Lindsay, Nye, & Greathouse, 1998; Gill & Schlossman, 2000). This perspective was soon challenged by researchers who emphasized the development of problem solving skills and opposed learning through memorization. These views on homework led to two new perspectives on homework in the 1920s: the homework abolitionists and the homework reformers. The homework abolitionists suggested homework be abolished completely from school. The reformers focused on seeking ways to reform homework to focus on developing students' conceptual understanding and interest in learning (Cooper, Lindsay, Nye, & Greathouse, 1998; Gill & Scholssman, 2000).

In the 1930s and 1940s, many school districts abolished homework in grades K-6 because it was considered to be ineffective and took time from students' other activities. After World War II, homework reformers raised issues related to students' academic achievement compared to students in other countries. They asserted that U.S. students were academically behind students in other countries, especially in the subject of mathematics, and the abolishment of homework played a role in this decline. Because of this, homework reformers focused their research on shaping educational discourse on homework by defining its new pedagogical purposes (Gill & Schlossman, 2000). Gill and Schlossman (2000) recommended teachers and educators go beyond simple memorization of textbook materials in designing homework problems and make the nature of the problems more activity based. Instead of suggesting that homework is either all good or all bad, the reformers also worked on redefining the rationale and content for a new look of homework instead of using repetitious drill on lessons already presented in the classrooms. In addition, reforms on the impact of such changes in homework on policy and scheduling were also taking place, designed to "control the organization, quantity, and pacing of homework assignments and the burdens they placed on students and their family" (Gill & Schlossman, 2000, p. 33). The central mission of such reform called for "learning by doing", "educating the whole child", and "child-centered learner driven education" (Gill & Schlossman, 2000). This perspective directly resulted in an increase in the amount of homework assigned (Cooper & Valentine, 2001).

In the 1960s and 1970s, psychologists began to view homework as putting pressure on students, potentially affecting their mental health because homework took time away from students' other social, recreational and creative activities (Wildman, 1968). The result was a decrease in homework assignments in schools. In 1983, *A Nation at Risk* identified lack of homework as one of the major causes for poor mathematics performance in the US (National Commission on Excellence in Education, 1983), which led to a new educational focus on achievement by setting higher standards for educational practices. Many schools started to require more homework at early grades, even in kindergarten (Gill & Schlossman, 2000; Kohn, 2006). In 2001, *No Child Left Behind* called for mandatory annual testing to close the achievement gap in schools which also resulted in increased homework assignments (Kohn, 2006), especially mathematics homework. Nevertheless, public concerns from parents and social media about homework being a stress factor for students still remain a challenge for schools and educators (Cooper et al., 2006).

Historical views of homework indicate that the place of homework has changed through influences from the public and perspectives related to reform. It is clear that homework is still a topic for heated debate among educators and parents. Thus, it is important for researchers to have a full understanding of the nature of the homework assignment and its direct and indirect effect on student achievement. Such understanding is essential for proper structuring of school policies and instructional practices because ultimately homework assignment should be designed to enhance student mathematics achievement.

Homework and Achievement

As one aspect of opportunity to learn, research on homework has generally shown a correlation between homework and student achievement (Cooper, 1989; Cooper, Robinson, & Patall, 2006). Although measures of homework vary, some using amount and others using frequency or types of homework, such correlation between homework and achievement is generally found to be positive.

Cooper (1989) conducted a meta-analysis of 120 empirical studies on the effects of homework using studies conducted between 1960 and 1987. He concluded that there were three different types of studies on homework and achievement. The first type investigated the achievement level of students who were given homework with those who were not given homework to determine if the existence of homework is a factor in achievement. Such studies were normally conducted in a controlled environment with predetermined students of similar background and similar levels of prior knowledge being randomly assigned to two groups. Most studies of this type showed that homework being assigned generally had a positive influence on student achievement (Foyle, 1984, 1990; McGrath, 1992; Finstad, 1987, Meloy, 1987; Townsend, 1995). In addition, there were also significant grade level differences on the relationship between homework and achievement outcomes as measured by standardized tests. High school students with homework assigned scored significantly higher than those of the same grade with no homework. Middle grade students with homework performed moderately higher than those with no homework.

Cooper, Robinson and Patall (2006) also analyzed studies on homework and achievement conducted between 1987 and 2003. By grouping experimental studies using random assignment of students and controlling whether homework was assigned, they discovered that most studies found a positive effect of homework assignment on mathematics or language arts achievement (Finstad, 1987; Foyle, 1990; McGrath, 1992; Townsend, 1995). These studies, however, have limitations. Cooper, Robinson and Patall (2006) revealed that studies conducted in controlled environments with homework being assigned mostly used similar questions to those on the tests used to measure achievement; hence students who were not assigned any homework did not have a chance to practice these questions. Consequently, the results are somewhat compromised. The studies using standardized assessments as posttest scores can only measure the immediate effect of homework, but cannot measure the long-term effect without considering other factors that might compromise the controlled environment. The second type of studies identified by Cooper, Robinson and Patall (2006) compared homework completed outside of schools with homework completed in class. These studies found that supervised homework had a stronger influence on achievement than homework completed alone, especially when homework and in-class work were compared in elementary schools. Students who completed more supervised homework had better achievement scores on posttests than those who only completed homework outside of schools with no supervision. However, this correlation was not significant with students in middle and high schools. Once again this type of research showed a strong grade-level influence. The last type of studies examined the amount of time students spent on homework with their achievement outcomes and showed a significant correlation between the two. These studies often focused on either attempting to establish a causal relationship between homework and mathematics achievement or used homework as one of the factors that correlated with student achievement. Cooper's (1989) analysis of these studies indicated a correlation between homework and achievement but none of these studies investigated the role of types of homework on student achievement.

More recent studies (Davis & Jordan, 1994; Hill, 2003; Peng & Wright, 1994; Thomas, 2001; Thomas, 2002) have investigated homework's role in achievement along with consideration of other factors using multivariate analyses models. Using data from the National Education Longitudinal Study of 1988 (NELS) or NELS follow-up studies on the same group of middle school and high school students in later years, these studies provide more insights on various factors that might affect achievement, homework being one of these factors. The most frequently used measure of homework assignment in these studies is the amount of homework assigned, either frequency or length of homework completed by students or assigned by teachers. Most of these studies revealed a positive effect of the amount of homework on achievement. These studies did not include exogenous factors such as socio-economic status or gender in their analysis because the data were not collected in a controlled environment.

Other studies that controlled for variables such as prerequisite knowledge also used multivariate analysis to examine the relationship between the amount of homework and achievement (Brookhart, 1997; Cool & Keith, 1991; Fehrmann, Keith & Reimers, 1987; Foyle, 1990; Cooper, Lindsay, Nye & Greathouse, 1998; Hendrix, Sederberg & Miller, 1990; Olson, 1988; Smith, 1990; Smith, 1992; Wynn, 1996; Portes & MacLeod, 1996). Results from these studies generally revealed a positive correlation between the amount of homework assigned and student achievement, but indicated such relationships are not causal (Cooper et al., 2006). These studies normally calculated a simple bivariate correlation between the amount of homework and scores from an achievement assessment and did not consider other variables that might affect such correlations. These studies revealed a significant correlation between the time spent on homework and achievement, although such correlations were not significant for elementary students.

In summary, although many studies have examined the relationship between homework and achievement, researchers have not reached an agreement on how teachers assign homework and its effectiveness on improving student achievement. There is a lack of literature on homework types and their effect on student achievement. However, homework is often seen as an aspect of opportunity teachers provide for students to learn mathematics. It is also important to look at related literature on opportunity to learn considering homework assignment.

Homework and Opportunity to Learn

Opportunity to learn (OTL), as an explanation for differences in achievement among students (Floden, 2002), was first introduced by Carroll (1963) as one of the five critical constructs in his model of school learning. Carroll (1996) defined OTL as the amount of time that is available to a student to learn a specific task. In contrast to Carroll's model, Husén (1967) considered OTL as the overlap of mathematics taught and mathematics content actually tested. The combination of Carroll's and Husén's models was adapted by other researchers into various OTL frameworks for purposes of their studies (Robitaille & Travers, 1992; Winfield, 1987, 1993).

Stevens (1993) identified variables related to teacher instructional practices and student learning which form an OTL framework that was widely recognized by educators. These variables include *content exposure and coverage variables*, *content emphasis variables,* and *quality of instructional delivery variables*. *Content exposure and coverage variables* measure not only the amount of time students spend on learning but also the depth of the instructions they are provided. *Content emphasis variables* connect the content coverage provided by teachers within the implemented curriculum and the selection of assessment for purpose of basic skills instruction or beyond, hence, the types of homework assigned. *Quality of instructional delivery variables* are basically variables that describe how instructional practices affect students' academic achievement.

The construct of OTL has also appeared in studies organized by the International Association for the Evaluation of Education Achievement. OTL was initially defined to be opportunity that students have to learn the content of the test items. This definition was later broadened to "…criteria for, and the basis of, assessing the sufficiency or quality of the resources, practices, and conditions necessary at each level of the education system (schools, local educational agencies, and States) to provide all students with an opportunity to learn the material…" (Goal 2000: Educate America Act, 1994, Section 3a(7)). The OTL addressed but was not limited to dimensions such as curricula, instructional material, teacher capability, alignment of curriculum, instructional practices, and assessment with content standards. Schmidt and Maier (2009) measured opportunity to learn using content coverage, content exposure variables considering time and depth of teaching, and content emphasis variables such as lower versus higher order skills.

NRC (2001) clarified that OTL is not solely provided by teachers. The curriculum the teacher uses influences students' opportunity to learn (Stein et al., 1996). The way the teacher teaches and the expectations that teachers have also play a major role in shaping students' learning opportunities. In particular, research has shown that homework provides an OTL for mathematics beyond classroom instruction (Cooper, Robinson, & Patall, 2006).

Similarly, in the National Education Longitudinal Study of 1988 (NELS), researchers collected achievement test scores in mathematics, reading, science, and social studies from 24,500 eighth grade students; students and their teachers also completed questionnaires. The questionnaires included items on homework, such as the total minutes of homework completed or assigned in different subject areas. Using data collected from NELS reports, Lam (1996) used regression equations to examine the effect of mathematics homework on achievement. Students who reported doing homework always performed better than those who did not do homework. Among students who did homework, students who did 7 to 12 hours of homework per week had higher achievement scores than those who did 1-6 hours, 13-19 hours, or 20 hours and more per week. This result suggested a curvilinear relationship between homework and achievement. However, Lam (1996) restricted the sample of students to only Asian Americans and Caucasian Americans. Thus, this result cannot be generalized to all student populations.

Research has suggested many positive as well as negative consequences of homework in learning various subjects and more recent studies on the effect of homework and achievement use the amount or the frequency of homework assignment as a component of OTL (Cooper, 1989; Epstein, 1989; Warton, 2001). Such studies only consider the significance of the homework effect as an additive effect with other factors on achievement. Few studies have emphasized the effects of different types of homework assignments and further examined the extent of such effects specifically within the context of mathematics learning. Potential positive effects of homework for improving immediate achievement and learning include better retention of factual knowledge, increased understanding, and better critical thinking, concept formation, information processing and curriculum enrichment (Warton, 2001).

Omlin-Ruback (2009) was among the few researchers who examined the types of homework assignments that related to student performance. She investigated the types of homework assigned to fifth-grade students, their interaction with the assigned homework, and the relationship between homework and achievement using a convenience sample of fifth-grade students from a school district in the Pacific Northwest. Her findings show that homework with the purpose of developing conceptual understanding, and not just memorization or practicing procedural skills, is the main type of homework associated with higher student mathematics achievement scores. Because of her small sample, she mentioned that findings should not be generalized and recommended similar studies with larger samples. Her study was limited to elementary school students, hence also not generalizable to other grade level students.

Given the ongoing studies on the importance of homework related to student mathematics achievement and lack of literature on types of homework relating to student achievement, there is a need for studies on types of homework. It is also necessary to look the pros and cons of statistical methods that have been used to study homework and determine the most appropriate statistical method that should be used to examine mediating effects of types of homework in mathematics education.

Statistical Mediation Methods

The importance of mediation in statistical methods has been long recognized and statistical mediation analysis has been a part of educational studies in recent years. Mediation enables researchers to explain how and how much factors influence one another.

Baron and Kenny (1986) proposed a four-step mediation analysis approach involving regression analyses for each of the steps and testing the significance of the coefficients. This approach first requires that zero-order relationship among the variables exists in the first three steps; a zero-order relationship would be a relationship between two variables while ignoring influences of other variables that might have effect on this relation. If one of the three relationships in the first three steps is not significant, then a mediation effect is not possible or likely. Assuming there are significant relationships for the first three steps, a multiple regression analysis is conducted with the independent variable and proposed mediating variable predicting the dependent variable. Some level of mediation is then concluded if the effect of the mediating variable remains significant after controlling for the independent variable. If the relationship between the independent variable and the dependent variable is no longer significant when the mediator is controlled, then one can proceed to the conclusion that the mediator supports full mediation. If the independent variable is still significant when the mediator is controlled, then the mediator partially mediates the relationship between the independent variable and the dependent variable.

Baron's four-step approach has dominated mediational studies for many years. However, there are many limitations of this approach. First, because the independent variable is assumed to cause the mediator, a correlation is required between the two variables. Recent studies (MacKinnon, Fairchild, & Fritz, 2007) have found that this is not always true. Hence, the first step of Baron's approach is not necessary. Second, the four step approach does not support multiple mediators. In educational studies, it is essential to consider many factors when trying to explain the differences of the indirect effects of these factors as well as explaining how the indirect effect differs when considered individually or as part of the total effect. Third, the mediator variable tested here is required to be continuous while many factors that could potentially mediate a relationship are categorical, such as gender. Finally, Baron's four-step approach to mediation requires a sample size larger than 200 to achieve a reliable estimate.

Baron's approach remains popular among researchers because it is easy to understand and follow. However, modern methodological studies (Cerin & MacKinnon, 2009; Hayes, 2009; Rucker et al., 2011) suggest that researchers should not focus on testing the significance of paths in a mediation model by a hypothesis test, but "explicitly estimating the indirect effect and making an inference about its size in the population irrespective of the size of significance of the total effect" (Hayes & Preacher, 2012, p. 10).

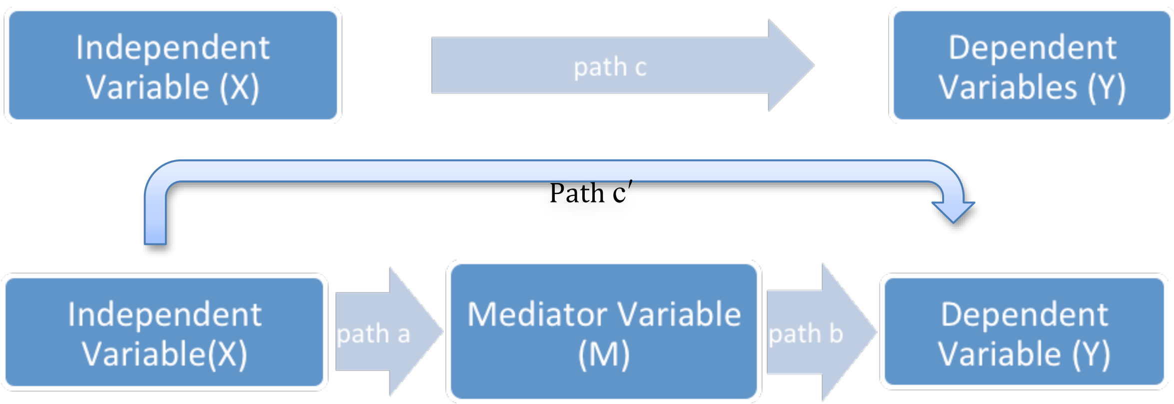

Figure 3. Schematic Illustrating Mediation Model

Figure 3 illustrates the model with the indirect effects that are to be tested. In particular, the significance of path c′ (a direct effect) is determined when it is mediated by the variables indicated within the mediation process. The indirect effect represents how the changes in the dependent variable for every unit change in the independent variable are mediated by the indicated variables.

Sobel (1982) proposed a hypothesis testing procedure for indirect effects that has been widely used by researchers to estimate the standard errors of the indirect effect and to calculate the estimated indirect effect. Although this testing procedure was acknowledged by Baron and

Kenny (1986), it is not recommended in samples with sizes less than 200. Modern approaches to mediation analysis focus on estimation and inference about the indirect effect of the independent variable on the dependent variable through proposed mediating variables. The concept of mediation is for researchers who are interested in understanding how things work. In order to accomplish such understanding, Hayes and Preacher (2012) point out that the key is to be able to explain the indirect effect of the mediator and its strength convincingly after establishing some causal relationship between the independent variable and dependent variable through a mediator. The mediating effects can be tested more accurately using testing methods such as bootstrapping (MacKinnon, Lockwood, & Williams, 2004; Preacher & Hayes, 2004, 2008; Shout & Bolger, 2002), the distribution of the product methods (MacKinnon, Fritz, Williams, & Lockwood, 2007), and the Monte Carlo confidence intervals (Preacher & Selig, 2012; MacKinnon et al., 2004) that do not have a strict requirement of sample size to ensure a close estimation of the indirect effect. Application of these approaches is easy by statistical software such as SPSS or SAS.

Summary

In summary, historical perspectives on the place of homework in the school curriculum have shown different opinions on the effect of homework. Studies conducted on homework and achievement have mostly shown positive correlations but often using the amount of homework as a measurement. Few studies have considered homework type as a factor of opportunity to learn and how it affects achievement.

CHAPTER 3: METHODS

In this chapter, I describe the research design, sample, and measures used to analyze the mediation effects of types of homework on the influence of opportunity to learn measured by lesson coverage on students' mathematics achievement and on the influence of teacher perceived opportunity to learn (OTL) measured by posttest opportunity to learn on students' mathematics achievement. This research examines the extent to which types of homework mediate the influence of OTL on student mathematics achievement. For the purpose of the present study, I consider OTL as "circumstances that allow students to engage in and spend time on academic tasks…" (National Research Council, 2001, p. 333). Opportunity to learn here is examined through teachers' actual lesson coverage and teachers' reported item coverage on the posttests.

Research Questions

The purpose of the study was to examine the extent to which types of homework mediate the impact of OTL on student mathematics achievement. The term OTL is approached from two perspectives: the actual lesson coverage and teachers' perceived opportunity provided to learn the mathematics assessed on the posttest. The research questions examined in this study were:

1. How does OTL influence mathematics achievement in different mathematics courses? In particular,
    a. How does OTL as measured by lesson coverage influence mathematics achievement in *Pre-Transition Mathematics, Transition Mathematics*, and *Algebra*?

b. How does OTL as measured by posttest OTL influence mathematics achievement in *Pre-Transition Mathematics, Transition Mathematics*, and *Algebra*?

2. To what extent do different types of homework influence the impact of OTL measured by lesson coverage on student mathematics achievement measured by 3 posttests in each of *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*?
3. To what extent do different types of homework influence the impact of OTL measured by posttest OTL (i.e., teacher perceived OTL measured by each posttest) on student mathematics achievement measured by each corresponding posttest in *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*?
4. What can we conclude from the difference of mediation effects of types of homework on the correlation of OTL measured by lesson coverage and mathematics achievement and on the correlation of OTL measured by posttest OTL and mathematics achievement?

Background of Study

The research reported in this study is based on a secondary analysis of data collected as part of the evaluations of the University of Chicago School Mathematics Project (UCSMP) secondary mathematics curricula, specifically *Pre-Transition Mathematics* (PTM) during the 2006-2007 school year (1st Edition, Field Trial Version)*, Transition Mathematics* during the 2005-2006 school year (3rd Edition, Field Trial Version), and *Algebra* (3rd Edition, Field Trial Version) during the 2005-2006 school year. *Pre-Transition Mathematics* (Year 1) "integrates arithmetic with work in statistics, geometry, and algebraic thinking" and "explores algebra to describe generalizations, solve simple equations, and write formulas" (Thompson, Senk, & Yu, 2012, p. 6). *Transition Mathematics* (Year 2) "serves as a pre-algebra text, but with significant geometric work integrated with algebra" (p. 6). *Algebra* (Year 3) "explores a wide range of functions, including exponential functions, while also weaving statistics and geometry with algebra" (p. 7). These courses are designed for students who are at grade levels 6 to 8, with PTM students generally in grade 6; although *Algebra* is designed for grade 8 students, some students use this text in high school. The Third Edition of the secondary materials, developed from 2005 to 2008, maintained effective features from previous versions but also incorporated elements such as active learning, cooperative group work, and technology (Thompson, Senk & Yu, 2012).

All UCSMP curriculum materials contain the same basic lesson elements with a range of mathematics topics in terms of content, and with assumptions that students are required to learn mathematics through reading, and hence, to answer questions related to the reading. Problem-solving and applications are embedded throughout the material so that students are provided opportunity to relate mathematics and explore real-world problems, with technology as assistance to understanding and exploration. The materials use a modified mastery approach to instruction supported by problem sets designed to balance the practice of skills, properties, uses, and representations of concepts after each lesson (Thompson, Senk & Yu, 2012).

Each lesson of these three textbooks contains four types of homework problems for students to complete:

- *Covering the Ideas* questions focus on basic concepts within the lesson, with many problems being similar to those actually found within the lesson's examples.
- *Applying the Mathematics* questions extend the concepts or integrate them with previously learned concepts so students can apply ideas in new contexts.
- *Review* questions provide opportunities for students to continue working on important concepts in subsequent lessons and chapters, based on a modified mastery approach within the UCSMP curriculum.

- *Exploration* questions provide extensions and investigations beyond the essential concepts. (Thompson, Senk, & Yu, 2012, p. 6)

UCSMP recommends that teachers assign most, if not all, of the problems in these types of homework questions with the exception of the *exploration* questions (Thompson, Senk & Yu, 2012). For the purpose of this study, only *covering the ideas, applying the mathematics,* and *review* questions are investigated because these are the types of homework problems expected to be assigned by teachers on a regular basis.

Data Collection

The datasets used in this study are subsets of a large existing dataset collected as part of the evaluations of the secondary materials developed by UCSMP. Although the UCSMP evaluation studies included students using both UCSMP materials and comparison textbook materials, only the teachers and students using UCSMP textbooks were included in this study. By restricting the sample to teachers and students using the UCSMP curriculum, I controlled for the types of homework problems aligned with the most common instructional purposes for homework problems reviewed in the literature review section. Non-UCSMP materials were excluded because teachers and students who used these materials did not necessarily have access to homework problems with the same purposes as those in the UCSMP curriculum.

The samples for the three courses were distinct, meaning that students participated in only one evaluation study. The results from three studies were compared after data were analyzed in each sample to determine if the findings are consistent across studies. Standardized pretest scores were used to control for prerequisite mathematics knowledge before students started studying the curriculum. Posttest scores were used to measure achievement from standardized tests and tests made by UCSMP staff. The final sample size in each course was determined by including only UCSMP students in *PTM*, *TM*, or *Algebra* who took all pretests and posttests in these three courses and stayed with the same teacher along with the teachers of these students.

Teacher data were collected from teacher questionnaires, teacher posttest opportunity to learn forms, and teachers' chapter evaluation forms. Opportunity to learn is based on two perspectives separately: teacher reported lesson coverage and teacher reported opportunity to learn the content of the posttest items. I expected there to be differences in the final results of the mediating effects of homework types using opportunity to learn based on the independent variables of lesson coverage or posttest opportunity to learn analyzed individually.

The mediating variables were homework types: *covering the ideas, applying the mathematics* and *review.* These mediators were measured by the percent of available problems of each type teachers assigned to their students, with the calculated percentage of problems assigned based only on problems in lessons taught. Unfortunately information about students' completion of these homework problems was not available which was one limitation of the study.

Participants

Ten schools participated in the *Pre-Transition Mathematics* study. At eight of these schools, students were in sixth grade; at two schools, students were in seventh grade. Six schools participated in the *Transition Mathematics* evaluation study, with students at two schools in sixth grade and students at four schools in seventh grade. Six schools participated in the *Algebra* evaluation study, four of which were middle schools and two of which were high schools. The only students included were those who took all assessments including the two pretests and three posttests for each mathematics course and who had the same teacher and stayed in the same class for the duration of the study. For *Pre-Transition Mathematics*, there were 287 students in the final sample for *Transition Mathematics*, there were 237 students and for *Algebra*, there were 232 students.

Instrumentation

Tests to Access Achievement

Pre-Transition Mathematics. The two pretests used to assess students' prerequisite knowledge for *Pre-Transition Mathematics* (see Appendix A) at the beginning of the year were: the *TerraNova CAT Survey 16*, which was a standardized 31-item multiple-choice test (CTB McGraw-Hill, 2001) assessing prerequisite knowledge of arithmetic, algebra readiness, and geometry; and the *Entering Mathematics Test* which contained 29 questions developed by UCSMP that also focused on prerequisite knowledge on arithmetic, algebra readiness, and geometry. Calculators were not permitted on either of the pretests. The three posttests (see Appendix A) used to assess students' mathematics achievement at the end of the school year were: the Terra Nova CAT Survey 17, which was a standardized 32-item test focusing on decimal and fraction arithmetic, algebraic items or patterns, geometric concepts, measurement and data; the *Mathematics Test One*, a 36-item multiple-choice test constructed by UCSMP to provide additional insight on the content of the Terra Nova CAT Survey 17 and to provide measures of growth from the pretest; and a *Problem-Solving and Understanding Test* which was a 16-item test that required short answers in which students were expected to share their thinking about arithmetic, algebraic, or geometric concepts and for which calculators were permitted.

Transition Mathematics. The two pretests (see Appendix B) for the purpose of assessing students' prerequisite knowledge at the beginning of the year were: the *TerraNova CAT Survey 17C*, which was a standardized 32-item multiple-choice test (CTB McGraw-Hill, 2001) that assesses prerequisite knowledge for *Transition Mathematics*, including number concepts, algebraic ideas or patterns, geometric concepts, measurement, and data analysis; and *Middle School Mathematics Test* which was a 28-item multiple-choice test developed by UCSMP assessing knowledge of equations or inequalities, measurement formulas, and transformations, with a number of items expected to be repeated on the posttest for purposes of assessing growth over the year. Calculators were not permitted on either of the pretests. The three posttests (see Appendix B) used at the end of the year were: the *Iowa Algebra Aptitude Test: Form 1 Fourth Edition* which is a 63-item multiple choice standardized test (Schoen & Ansley, 1993a) that assessed readiness for algebra; *Algebra/Geometry Readiness Test: Part One* developed by UCSMP which contained 40 multiple-choice questions focusing on variables and their uses, equations and inequalities, measurement, transformations, and geometric figures and their properties; and *Algebra/Geometry Readiness Test: Part Two* which contained 12 constructed response items developed by UCSMP project staff (Thompson, Senk, & Yu, 2012) for which students needed to explain their thinking when solving the arithmetic or algebraic problems. Calculators were not permitted on the *Iowa Algebra Aptitude Test* (IAAT) or the *Algebra/Geometry Readiness Test: Part One* but were allowed on *Part Two.*

Algebra. There were two pretests (see Appendix C) for the purposes of assessing students' prerequisite knowledge at the beginning of the year. One pretest was the *Iowa Algebra Aptitude Test: Form 1* (Fourth edition) which was a standardized test containing 63 items that assess students' algebra readiness (Schoen & Ansley, 1993); and the *Entering Algebra Test: Part One* which was a 30-item multiple-choice test developed by UCSMP assessing solving equations and inequalities, functional relationships, equivalent expressions and equations, and real number arithmetic, with a number of these items expected to be repeated on the posttest to assess growth over the year. (Thompson & Senk, in preparation).

Three posttests (see Appendix C) were used at the end of the school year. The first posttest was the *TerraNova Algebra I* (CTB-McGraw Hill, 2005), which was a standardized test containing 32 multiple-choice items assessing knowledge of first-year algebra and for which the use of calculators was not permitted. The second posttest, the *Algebra Test: Part One*, was a 38-item multiple-choice test developed by UCSMP staff assessing equations and inequalities, functional relationships, equivalent expressions and equations, and real number arithmetic and for which calculators were not permitted. The third posttest was the *Algebra Test: Part Two* which contains 11 constructed-response items developed by UCSMP project staff to assess the ability of students to explain their thinking when solving more complex algebraic problems and for which calculators were permitted.

Teacher Chapter Evaluation Form

For each chapter of the textbook, teachers completed a chapter evaluation form (see Appendix D) in which they rated the lesson text and problems, indicated the length of time spent on each lesson, and recorded the homework problems assigned. In addition, they provided constructed-response comments to specific questions about each chapter. The homework problems assigned were classified as covering the ideas, applying the mathematics, or review to determine a percentage of available problems of each type that students had an opportunity to complete from only the lessons taught by their teachers.

Teacher Opportunity-to-Learn (OTL) Form

The Posttest Opportunity-to-Learn Form completed by teachers at the end of the year provided an opportunity for teachers to indicate whether they taught or reviewed the content for every item on all posttests, whether teachers taught or reviewed the content needed for their students to answer each of the items on the posttests (Thompson, Senk, & Yu, 2012).

For each item on all three posttests, the following questions were asked:

1. During this school year, did you teach or review the mathematics needed for your students to answer this item correctly?
    a. Yes, it is part of the text I used.
    b. Yes, although it is not part of the text I used.
    c. No, because it is not part of the text I used.
    d. No, although it is part of the text I used.
2. If your students take a state assessment at the grade level in which this course is being taught, is the content addressed by this item tested on the state assessment?
    a. Yes
    b. No

Responses to this form provided information on the extent to which students had an opportunity to learn the mathematics assessed on posttest items, at least from the teacher perspective (Thompson, Senk, & Yu, 2012). The percent of items for which teachers reported *yes* was used to obtain the teachers' perceived OTL percent on the posttest in the mediation models.

Data Analysis

Multiple mediation models, developed by Preacher and Hayes (2008) using bootstrapping in SPSS, were used to test the indirect effect of different homework types as mediators on the effect that opportunity to learn mathematics has on students' achievement for each of the three courses, controlling for prerequisite knowledge. In this present study, I examined multiple mediators using a macro *indirect* written by Preacher and Hayes (2008) in SPSS with bootstrapping tests because of the moderate size of the sample.

The results were then compared to the indirect effect of these homework types as mediators on the effect that teachers' reported opportunity to learn had on students' achievement for all three courses as well.

Bootstrapped tests were used to calculate the differences between the indirect effects of the mediators by calculating the total and indirect effects as well as bias-corrected confidence intervals for the indirect effects. The benefit of using bootstrapping is that it is based on random sampling processes, so by resampling the original dataset, I can generate comparable data to see if the results are similar by comparing the contrasts between the mediators that are created during the process.

The variables for each of the courses were as follows:

Dependent Variables:

Achievement scores on all three posttests for each course.

Independent Variables:

Teachers' lesson coverage reported as the percentage of the lessons in the book that the teacher taught.

Teachers' reported opportunity to learn based on posttest items.

Mediators:

Percent of *Covering the Ideas* exercises assigned based on lessons taught.

Percent of *Applying the Mathematics* exercises assigned based on lessons taught.

Percent of *Review* exercises assigned based on lessons taught.

Covariates:

Achievement on adjusted pretest percentage for all three courses.

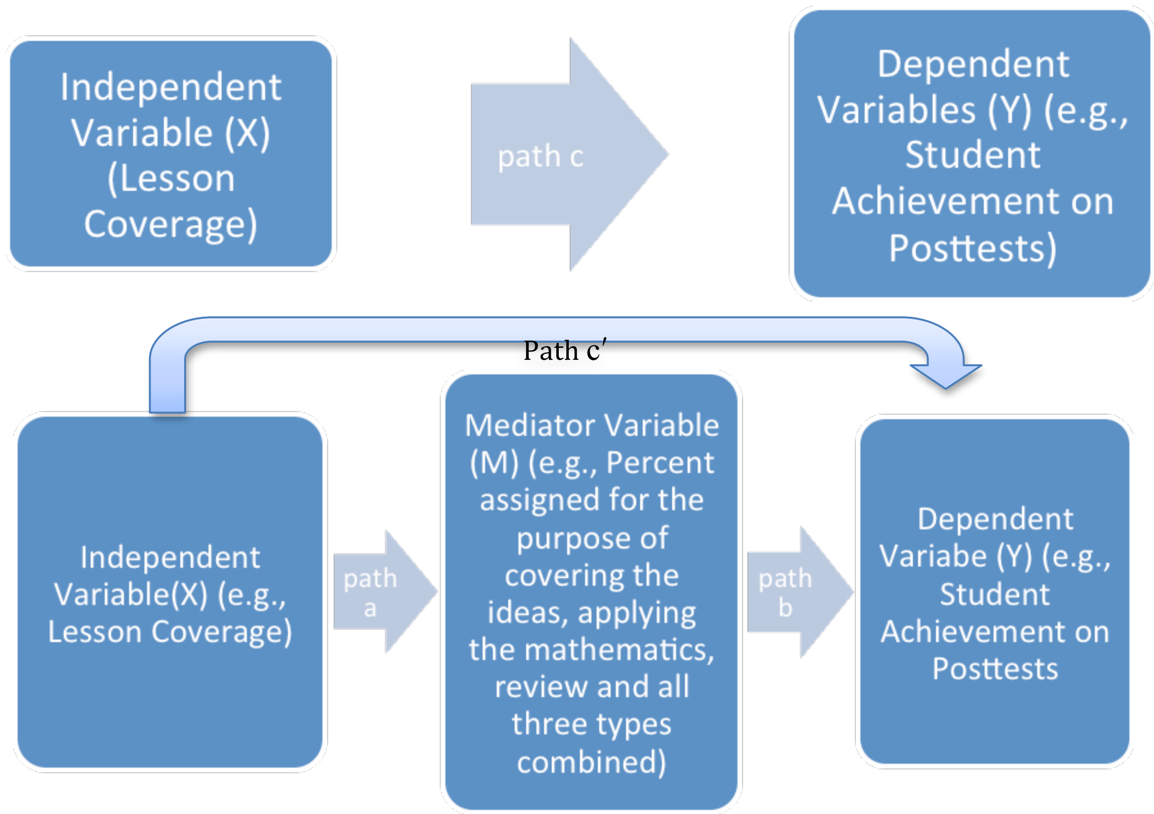

Figure 4. Schematic illustrating mediation model as used in this study

Figure 4 illustrates the model that was tested with the relationships among variables, especially significance of path c′ (a direct effect) when it was mediated by the variables indicated within the mediation process. True indirect effects and estimated indirect effects representing the changes in the dependent variable for every unit change in the independent variable were the emphasis of this study and verified by bootstrapping to see if the influence of OTL on student mathematics achievement was indeed mediated by the indicated variables, and if so, by how much.

CHAPTER 4: RESULTS

Providing students the opportunity to learn mathematics has been a main emphasis in improving student achievement in school mathematics. The purpose of this research study was to investigate the extent to which types of homework influence the impact of opportunity to learn mathematics on student achievement. Subsets of data taken from the University of Chicago School Mathematics Project (UCSMP) were used in this study with students who studied from *Pre-Transition Mathematics, Transition Mathematics,* and *Algebra* taken as the sample. Homework types that cover the ideas, apply the mathematics, or review were examined as the mediators of the influence of opportunity to learn measured by either teachers' lesson coverage or teachers' perceived opportunity to learn the content on posttest items from the three mathematics courses.

The study was a quantitative study using path analysis to investigate mediation effects of three types of homework problems proposed as mediators. Bootstrapping was performed to validate the true indirect effect by creating 10,000 samples to obtain an estimated indirect effect and significance was determined by bias corrected confidence intervals.

Opportunity to Learn Measured by Lesson Coverage, Questions Assigned, and Opportunity to Learn Content on Posttest Items

For *Pre-Transition Mathematics*, 13 teachers participated in the study. The opportunity to learn measured by lesson coverage and measured by teachers' reported posttest OTL is reported in Table 1. The data show that OTL measured by lesson coverage in *Pre-Transition Mathematics* had more variability, ranging from 41% to 90%; OTL percentages measured by posttest OTL were consistent among teachers, ranging from about 80% to 100% for all three posttests.

Table 1

Teacher Provided OTL Measured by Lesson Coverage and by Teachers' Reported Posttest OTL for Pre-Transition Mathematics

Teacher	OTL Measured by Lesson Coverage (%)	OTL Measured by Posttest 1 (%)	OTL Measured by Posttest 2 (%)	OTL Measured by Posttest 3 (%)
T4114U2	41	75	75	81
T4114U1	51	75	75	81
T4115U1	70	88	94	100
T4116U1	80	75	92	94
T4118U1	89	84	100	100
T4119U1	90	100	100	100
T4120U1	79	97	100	100
T4121U1	80	100	100	94
T4123U1	53	94	92	81
T4124U2	69	81	75	88
T4124U1	70	81	86	88
T4101U1	78	97	97	94

The homework coverage of each teacher is reported in Table 2. The data show noticeable variability in the nature of the types of homework problems assigned by *PTM* teachers with review homework considerably lower than covering the ideas homework or applying the mathematics homework.

For *Transition Mathematics*, 7 teachers participated in the study. The OTL measured by lesson coverage and teachers' reported posttest OTL is reported in Table 3. The data showed that OTL measured by lesson coverage for *TM* ranged from 56% to 92%, and OTL percentages measured by *TM* posttest OTL had more variability with reported coverage of the content on the two multiple choice posttests ranging from 70% to 92% for posttest 1 (IAAT) and 55% to 100%

for posttest 2 (Algebra/Geometry Readiness Test) but only 41% to 76% for the problem solving test.

Table 2

Number and Percent of Question Types Assigned by UCSMP Pre-Transition Mathematics Teachers Based on Lessons Taught

Teacher	Covering (#/%)	Applying (#/%)	Review (#/%)
T4114U2	406/84	184/63	86/51
T4114U1	588/88	297/74	156/42
T4115U1	776/97	456/93	224/49
T4116U1	699/79	309/57	210/40
T4118U1	940/99	557/96	241/43
T4119U1	886/93	537/91	516/91
T4120U1	845/97	518/98	492/96
T4121U1	787/100	489/100	440/97
T4123U1	639/88	293/67	131/32
T4124U2	481/60	353/72	283/62
T4124U1	800/100	490/100	439/95
T4101U1	761/98	367/77	259/59

Note: The percent was calculated by dividing the actual number of homework problems assigned of each type by the total number of possible problems of each type of homework in the lessons taught.

The homework coverage of each teacher is reported in Table 4. The data show noticeable variability in the nature of the types of homework problems assigned by *TM* teachers with review homework considerably lower than covering the ideas homework or applying the mathematics homework, with one teacher only assigning 27% of the review homework and another assigning 91% of the review homework.

There were 6 teachers who participated in the *Algebra* study. The variability of OTL measured by lesson coverage and teachers' reported posttest OTL are reported in Table 5. OTL measured by lesson coverage for *Algebra* is ranged from 47% to 100%. With the exception of two teachers, teachers generally reported posttest OTL for at least 90% of posttest 1 items. And teachers' reported posttest 2 OTL ranged from 67% to 100% and from 7% to 100% for the problem-solving test.

Table 3

Teacher Provided OTL Measured by Lesson Coverage and by Posttest OTL for Transition Mathematics

Teacher	OTL Measured by Lesson Coverage (%)	OTL Measured by Posttest 1 (%)	OTL Measured by Posttest 2 (%)	OTL Measured by Posttest 3(%)
T2102U1	84	83	100	71
T2103U1	80	79	95	65
T2104U1	92	79	93	65
T2105U1	69	70	55	47
T2106U1	70	92	95	76
T2106U2	56	92	95	76
T2107U1	80	90	100	41

Table 4

Number and Percent of Question Types Assigned by UCSMP Transition Mathematics Teachers Based on Lesson Taught

Teacher	Covering (#/%)	Applying (#/%)	Review (#/%)
T2102U1	966/94	470/73	160/27
T2103U1	905/91	491/83	271/48
T2104U1	1107/98	625/91	500/78
T2105U1	802/92	344/61	237/50
T2106U1	812/93	553/97	233/48
T2106U2	703/96	462/96	314/82
T2107U1	960/99	615/99	518/91

Note: The percent was calculated by dividing the actual number of homework problems assigned of each type by the total number of possible problems of each type of homework in the lessons taught.

The homework coverage of each teacher is reported in Table 6. The data showed again that teachers assigned the least amount of review homework. One teacher assigned 83% of review problems but another only assigned 2% of such problems. The assignment of covering the ideas problems ranged from 48% to 100% and applying the mathematics problems ranged from 25% to 99%.

Table 5

Teacher Provided Opportunity to Learn Measured by Lesson Coverage and Teachers' Reported Posttest OTL for Algebra

Teacher	OTL Measured by Lesson Coverage (%)	OTL Measured by Posttest 1 (%)	OTL Measured by Posttest 2 (%)	OTL Measured by Posttest 3 (%)
T3107U1	84	97	89	100
T3108U1	47	72	84	67
T3110U1	75	94	97	100
T3112U1	100	91	100	100
T3111U1	80	97	100	100
T3109U1	58	59	74	67

Table 6

Number and Percent of Question Types Assigned by UCSMP Algebra Teachers Based on Lesson Taught

Teacher	Covering (#/%)	Applying (#/%)	Review (#/%)
T3107U1	963/100	552/99	581/83
T3108U1	430/86	232/79	219/54
T3110U1	795/94	432/89	367/58
T3112U1	982/87	450/68	377/45
T3111U1	887/95	511/95	466/71
T3109U1	313/48	379/25	10/2

Note: The percent was calculated by dividing the actual number of homework problems assigned of each type by the total number of possible problems of each type of homework in the lessons taught.

Impact of Two Types of OTL and Achievement (Research Question 1)

The first research question examined how opportunity to learn influences mathematics achievement within different mathematics courses, respectively,

a. How does opportunity to learn (OTL) as measured by lesson coverage influence mathematics achievement in *Pre-Transition Mathematics, Transition Mathematics*, and *Algebra*?

b. How does teachers' reported posttest opportunity to learn influence mathematics achievement in *Pre-Transition Mathematics, Transition Mathematics*, and *Algebra*?

The Impact of Lesson Coverage as OTL (Part A)

Part a of research question 1 examined how OTL as measured by lesson coverage influenced mathematics achievement in *Pre-Transition Mathematics, Transition Mathematics*, and *Algebra*. This was answered by conducting 9 sets of regressions using OTL as measured by lesson coverage to predict mathematics achievement measured by 3 posttests in each of three mathematics courses (*Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra)*. A standardized pretest score was used in each regression as a covariate.

Pre-Transition Mathematics. There were 287 students who took all the pretests and posttests, who used the UCSMP *Pre-Transition Mathematics* curriculum, and who stayed in the same class with the same teacher throughout the study.

In the first regression model, I used posttest 1 (CAT 17 Survey) percent correct as the dependent variable, OTL measured by teachers' reported lesson coverage as the independent variable, and standardized pretest (CAT Survey 16) percent correct as the covariate. The coefficient of determination, R^2 = .71, and the adjusted coefficient of determination, R^2 = .70, indicated that the OTL measured by teachers' reported lesson coverage explained 70% of the variability in the posttest 1 achievement scores as the dependent variable. The regression coefficient was .31, $F(2, 284) = 294.55$, $t = 4.93$, $p < .001$, showed that the OTL measured by lesson coverage significantly predicted the posttest 1 achievement. Therefore, *Pre-Transition Mathematics* achievement measured by posttest 1 (CAT 17 Survey) from OTL measured by lesson coverage with pretest scores as the covariate was statistically significant with $p < .001$.

In the second regression model, I used posttest 2 (UCSMP constructed multiple-choice test) percent correct as the dependent variable, OTL measured by teacher reported lesson coverage as the independent variable, and standardized pretest (CAT Survey 16) percent correct as the covariate. The coefficient of determination, R^2 = .67, and the adjusted coefficient of determination, R^2 = .66, indicated that the OTL measured by teachers' reported lesson coverage explained 66% of the variability in posttest 2 achievement scores as the dependent variable. The regression coefficient was .18, F (2, 284) = 262.81, t = 3.23, p < .001 showed that the OTL measured by lesson coverage statistically significantly predicted the posttest 2 achievement. Therefore, the result for the second regression used to predict *Pre-Transition Mathematics* achievement measured by posttest 2 achievement from OTL measured by lesson coverage with pretest score as the covariate was statistically significant with p < .001.

In the third regression model, I used posttest 3 (PSU) percent correct as the dependent variable, OTL measured by teacher reported lesson coverage as the independent variable, and the standardized pretest (CAT Survey 16) percent correct as the covariate. The coefficient of determination, R^2 = .68, and the adjusted coefficient of determination, R^2 = .67, indicated that OTL measured by lesson coverage explained 67% of the variability in posttest 3 achievement as the dependent variable. The regression coefficient was .34, F (2, 284) = 262.45, t = 4.79, p < .001, which showed OTL measured by lesson coverage statistically significantly predicted posttest 3 as the dependent variable. Therefore, *Pre-Transition Mathematics* achievement measured by posttest 3 (PSU) from OTL measured by lesson coverage with pretest score as the covariate was statistically significant with p < .001.

Transition Mathematics. There were 237 students in *Transition Mathematics* (3rd Ed.) who took all pretests and posttests and who stayed in the same class with the same teacher throughout the study.

In the first regression model, I used posttest 1 (IAAT) percent correct as the dependent variable, OTL measured by teacher reported lesson coverage as the independent variable, and standardized pretest (CAT Survey 17) percent correct as the covariate. The coefficient of determination, $R^2 = .43$, and the adjusted coefficient of determination, $R^2 = .42$, indicated that the independent variable explained 42% of the variability in the dependent variable. The regression coefficient was .47, $F\ (2, 234) = 176.59$, $t = 5.13$, $p < .001$, which showed that the OTL measured by lesson coverage statistically significantly predicted posttest 1 achievement as the dependent variable. Therefore, *Transition Mathematics* achievement measured by posttest 1 (IAAT) from OTL measured by lesson coverage with pretest score as the covariate is statistically significant with $p < .001$.

In the second regression model, I used posttest 2 (Algebra/Geometry Readiness) percent correct as the dependent variable, OTL measured by teachers' reported lesson coverage as the independent variable, and standardized pretest (CAT Survey 17) percent correct as the covariate. The coefficient of determination, $R^2 = .39$, and the adjusted coefficient of determination, $R^2 = .37$, indicated that the independent variable explained 37% of the variability of posttest 2 achievement as the dependent variable. The regression coefficient was .36, $F\ (2, 234) = 156.27$, $t = 4.00$, $p < .001$ which showed that OTL measured by lesson coverage statistically significantly predicted posttest 2 achievement. Therefore, *Transition Mathematics* achievement measured by posttest 2 (Algebra Geometry Readiness) from OTL measured by lesson coverage with pretest score as the covariate was statistically significant with $p < .001$.

In the third regression model I used posttest 3 (PSU) percent correct as the dependent variable, OTL measured by teachers' reported lesson coverage as the independent variable, and standardized pretest (CAT Survey 17) percent correct as the covariate. The coefficient of determination, R^2 = .64, and the adjusted coefficient of determination, R^2 = .64, indicated that the OTL measured by lesson coverage explained 64% of the variability in posttest 3 as the dependent variable. The regression coefficient was .55, $F(2, 234) = 90.60$, $t = 9.23$, $p < .001$, so the OTL measured by lesson coverage statistically significantly predicted the posttest 3 achievement as the dependent variable. Therefore, *Transition Mathematics* achievement measured by posttest 3 (PSU) from OTL measured by lesson coverage with pretest score as the covariate was statistically significant with $p < .001$.

Algebra. There were 232 students who used UCSMP *Algebra* (3rd Ed.) who took all pretests and posttests and who stayed in the same class with the same teacher throughout the study.

For the first regression model, I used posttest 1 (Terra Nova *Algebra*) percent correct as the dependent variable, OTL measured by teachers' reported lesson coverage as the independent variable, and standardized pretest (IAAT) percent correct as the covariate. The coefficient of determination, R^2 = .61, and the adjusted coefficient of determination, R^2 = .61, indicated that OTL measured by lesson coverage explained 61% of the variability in the posttest 1 achievement. The regression coefficient was .55, $F(2, 229) = 133.97$, $t = 9.23$, $p < .001$, which showed that it statistically significantly predicted the *Algebra* posttest 1 achievement. Therefore, *Algebra* achievement measured by posttest 1 (Terra Nova *Algebra*) from OTL measured by lesson coverage with pretest score as the covariate was statistically significant with $p < .001$.

In the second regression model, I used posttest 2 (UC) percent correct as the dependent variable, OTL measured by teachers' reported lesson coverage as the independent variable, and standardized pretest (IAAT) percent correct as the covariate. The coefficient of determination, R^2= .58, and the adjusted coefficient of determination, R^2 = .57, indicated that OTL measured by lesson coverage explained 57% of the variability in the posttest 2 achievement. The regression coefficient was .56, F (2, 229) = 268.36, t = 9.18, p < .001, which showed that it statistically significantly predicted the posttest 2 achievement. Therefore, *Algebra* achievement measured by posttest 2 (UC) from OTL measured by lesson coverage with pretest score as the covariate was statistically significant with p < .001.

In the third regression model, I used posttest 3 (PSU) percent correct as the dependent variable, OTL measured by teachers' reported lesson coverage as the independent variable, and standardized pretest (IAAT) percent correct as the covariate. The coefficient of determination, R^2= .65, and the adjusted coefficient of determination, R^2 = .64, indicated that OTL measured by lesson coverage explained 64% of the variability in the posttest 3 achievement. The regression coefficient was .56, F (2, 229) = 138.00, t = 9.26, p < .001, which showed that it statistically significantly predicted the posttest 3 achievement. Therefore, *Algebra* achievement measured by posttest 3 (PSU) from OTL measured by lesson coverage with pretest score as the covariate was statistically significant with p < .001.

Conclusion. In all 9 regression models, the dependent variable of mathematics achievement including different posttests was statistically significantly predicted by OTL measured by lesson coverage, controlling for prior knowledge measured by pretests. Therefore, OTL measured by lesson coverage significantly impacted student mathematics achievement measured by different posttests in *Pre-Transition Mathematics, Transition Mathematics,* and *Algebra*.

The Impact of Posttest OTL (Part B)

This part of the question was answered by conducting 9 regressions using OTL as measured by teachers' reported posttest OTL to predict mathematics achievement measured by 3 posttests in each of the three mathematics courses (*Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra)*. Standardized pretest scores were again used in each regression as covariates.

Pre-Transition Mathematics. As previously reported, the final sample size was 287.

In the first regression model, the posttest 1 (CAT 17 Survey) result was used as the dependent variable, with teachers' reported posttest OTL as the independent variable and standardized pretest (CAT Survey 16) percent correct as the covariate. The coefficient of determination, R^2 = .47, and the adjusted coefficient of determination, R^2 = .46, indicated that OTL measured by *PTM* posttest 1 explained 46% of the variability in the *PTM* posttest 1 achievement. The regression coefficient was 1.06, F (2, 284) = 290.77, t = 9.74, p < .001, which showed that the posttest 1 OTL statistically significantly predicted the posttest 1 achievement. Therefore, *Pre-Transition Mathematics* achievement measured by posttest 1 (CAT 17 Survey) from posttest 1 OTL with pretest score as the covariate was statistically significant with p < .001.

In the second regression model, the posttest 2 (UC) percent correct was used as the dependent variable, with posttest 2 OTL as the independent variable and standardized pretest (CAT Survey 16) percent correct as the covariate. The coefficient of determination, R^2 = .40, and the adjusted coefficient of determination, R^2 = .39, indicated that the *PTM* posttest 2 OTL explained 39% of the variability in posttest 2 achievement. The regression coefficient was .92, *F* (2, 284) = 273.18, $t = 7.85$, $p < .001$, which showed that the *PTM* posttest 2 OTL statistically significantly predicted the posttest 2 achievement. Therefore, *Pre-Transition Mathematics* achievement measured by posttest 2 (UC) from teachers' reported posttest 2 OTL with pretest scores as the covariate was statistically significant with $p < .001$.

In the third regression model, posttest 3 (PSU) percent correct was used as the dependent variable, and posttest 3 OTL as the independent variable and standardized pretest (CAT Survey 16) percent correct as the covariate. The coefficient of determination, $R^2 = .52$, and the adjusted coefficient of determination, $R^2 = .51$, indicated that *PTM* posttest 3 OTL explained 51% of the variability of the dependent variable. The regression coefficient was 1.52, F (2, 284) = 296.67, $t = 9.64$, $p < .001$, which showed that *PTM* posttest 3 OTL statistically significantly predicted the posttest 3 achievement. Therefore, *Pre-Transition Mathematics* achievement measured by posttest 3 (PSU) from posttest 3 OTL with pretest score as the covariate was statistically significant with $p < .001$.

Transition Mathematics. As previously reported, the final sample size was 237.

In the first regression model, I used posttest 1 (IAAT) percent correct as the dependent variable, posttest 1 OTL as the independent variable and standardized pretest (CAT Survey 17) percent correct as the covariate. The coefficient of determination, $R^2 = .43$, and the adjusted coefficient of determination, $R^2 = .42$, indicated that the *TM* posttest 1 OTL explained 43% of the variability in the posttest 1 achievement. The regression coefficient was .17, *F* (2, 234) = 154.08, $t = .99$, $p < .001$, which showed that posttest 1 OTL statistically significantly predicted the posttest 1 achievement. Therefore, *Transition Mathematics* achievement measured by posttest 1 (IAAT) from teachers' reported posttest 1 OTL with pretest score as the covariate was statistically significant with $p < .001$.

In the second regression model, I used posttest 2 (Algebra/Geometry Readiness) percent correct as the independent variable, with teachers' reported posttest 2 OTL as the independent variable and standardized pretest (CAT Survey 17) percent correct as the covariate. The coefficient of determination, $R^2 = .43$, and the adjusted coefficient of determination, $R^2 = .42$, indicated that *TM* posttest 2 OTL explained 42% of the variability of posttest 2 achievement. The regression coefficient was .78, F (2, 234) = 154.19, $t = 6.06$, $p < .001$, which showed that posttest 2 OTL statistically significantly predicted the posttest 2 achievement. Therefore, *Transition Mathematics* achievement measured by posttest 2 (Algebra/Geometry Readiness) from teachers' reported posttest 2 OTL measured with pretest score as the covariate was statistically significant with $p < .001$.

In the third regression model, I used posttest 3 (PSU) percent correct as the independent variable, with teachers' reported posttest 3 OTL as the independent variable and standardized pretest (CAT Survey 17) percent correct as the covariate. The coefficient of determination, $R^2 = .65$, and the adjusted coefficient of determination, $R^2 = .64$, indicated that the *TM* posttest 3 OTL explained 64% of the variability in the posttest 3 achievement. The regression coefficient was .13, F (2, 234) = 83.54, $t = 1.33$, $p < .001$, which showed that *TM* posttest 3 OTL statistically significantly predicted posttest 3 achievement. Therefore, *Transition Mathematics* achievement measured by posttest 3 (PSU) from teachers' reported posttest 3 OTL with pretest score as the covariate was statistically significant with $p < .001$.

Algebra. As previously reported, the final sample size was 232.

In the first regression model, I used posttest 1 (Terra Nova Algebra) percent correct as the independent variable, with posttest 1 OTL as the independent variable and standardized pretest (IAAT) percent as the covariate. The coefficient of determination, $R^2 = .62$, and the adjusted coefficient of determination, R^2 = .62, indicated that *Algebra* posttest 1 OTL explained 62% of the variability in the posttest 1 achievement. The regression coefficient was .83, F (2, 229) = 139.38, t = 11.33, p < .001, which showed that posttest 1 OTL statistically significantly predicted the posttest 1 achievement. Therefore, *Algebra* achievement measured by posttest 1 (Terra Nova Algebra) from teacher reported posttest 1 OTL with pretest score as the covariate was statistically significant with p < .001.

In the second regression model, I used posttest 2 (UC) percent correct as the independent variable, with posttest 2 OTL as the independent variable and standardized pretest (IAAT) percent correct as the covariate. The coefficient of determination, R^2 = .50, and the adjusted coefficient of determination, R^2 = .49, indicated that the *Algebra* posttest 2 OTL explained 49% of the variability in posttest 2 OTL. The regression coefficient was .76, F (2, 229) = 272.32, t = 5.39, p < .001, which showed that *Algebra* posttest 2 OTL statistically significantly predicted the posttest 2 achievement. Therefore, *Algebra* achievement measured by posttest 2 (UC) from teacher reported posttest 2 OTL with pretest scores as the covariate was statistically significant with p < .001.

In the third regression model, I used posttest 3 (PSU) percent correct as the independent variable, with posttest 3 OTL as the independent variable, and with standardized pretest (IAAT) percent as the covariate. The coefficient of determination, R^2 = .67, and the adjusted coefficient of determination, R^2 = .66, indicated that *Algebra* posttest 3 OTL explained 66% of the variability in posttest 3 achievement. The regression coefficient was .74, F (2, 229) = 154.38, t = 11.96, p < .001, which showed that posttest 3 OTL statistically significantly predicted posttest 3 achievement. Therefore, *Algebra* achievement measured by posttest 3 (PSU) from teachers' reported posttest 3 OTL with pretest score as the covariate was statistically significant (p < .001).

Conclusion. In all 9 regression models, the dependent variable of mathematics achievement including different posttests was statistically significantly predicted by teachers' reported OTL (the percent of the posttest items for which they reported teaching or reviewing the content needed to answer the item) with all $p < .001$, and with consideration of prior knowledge measured by pretests. Therefore, teachers' reported posttest OTL also significantly impacted student mathematics achievement in *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*.

The Extent to which Three Types of Homework Impact OTL Measured by Lesson Coverage and Achievement (Research Question 2)

The second research question focused on the relationship between homework and opportunity to learn mathematics measured by lesson coverage: To what extent do different types of homework influence the impact of OTL measured by lesson coverage on student mathematics achievement measured by 3 posttests in each of *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*?

To calculate the extent to which different types of homework influence the impact of opportunity to learn mathematics on student mathematics achievement, the custom dialog indirect.spd created by Preacher and Hayes (2008) was used. This dialog measured the total, direct, and single-step indirect effects of opportunity to learn (measured by lesson coverage and teachers' reported posttest OTL) on student achievement (measured by 3 posttests in each of 3 mathematics courses) mediated through homework types (covering the ideas, applying the mathematics, and review). In this analysis, a gain score (the difference between each posttest and pretest) was used in the regression analysis as a covariate. Bias-corrected bootstrap confidence intervals were calculated for the indirect effects as well as bootstrap tests of the difference between the indirect effects that homework types have on the influence of opportunity to learn on student mathematics achievement (Preacher & Hayes, 2008). Because gain scores are used as covariates, the total effect of the student achievement is corrected for the effect of the pretest as well.

As discussed in the literature review, bootstrap confidence intervals were used in this study because the Sobel tests generally make unrealistic assumptions about the shape of the sampling distribution of the indirect effect. In the output provided to answer research question 2, “Data” represents the indirect effect calculated in the original sample, and the mean of the indirect effect estimates calculated through bootstrap samples are represented by “Boot”. Here I used Bootstrap sample 10,000 for each model and 95% for the level of confidence for the confidence intervals. (See the statistics for each model in Appendix E)

Each output (see Appendix E) provided the indirect effect of each mediator (covering the ideas, applying the mathematics, and review) as well as the indirect effect for all three of the mediators combined. C1, C2, and C3 are the contrasts of the three indirect effects against each other to determine if any of the mediators have stronger indirect effects than the others. Hence, C1 represents the contrast between homework that covers the ideas and homework that applies the mathematics; C2 represents the contrast between homework that covers the ideas and review homework. C3 represents the contrast between homework that applies the mathematics and review homework. The output also provided a 95% bias corrected bootstrap confidence interval; if zero does not lie between the upper and lower boundaries of the interval, then mediation exists.

The three different variables investigated as mediators here are homework *covering the ideas, applying the mathematics,* and *review* based on lessons taught. I used OTL measured by lesson coverage and teachers’ reported posttest OTL as the independent variables.

Pre-Transition Mathematics

Using *PTM* posttest 1 achievement as dependent variable. Overall, the whole model showed that OTL measured by lesson coverage as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *PTM* posttest 1, (F (5, 281) = 135.91, $p < .001$). The R^2 was .71 and adjusted R^2 was .70, indicating that 70% of variance in the *PTM* posttest 1 was accounted for by OTL measured by lesson coverage through the three mediators.

The total effect (i.e., direct and indirect effects) of the OTL measured by lesson coverage on the impact of the posttest 1 achievement (c path) was significant, $t = 4.93$, $p < .001$. The direct effect of OTL measured by lesson coverage (c′ path) to *PTM* posttest 1 achievement was significant $t = 3.04$, $p < .05$. The partial effect of OTL measured by lesson coverage on *PTM* posttest 1 achievement after controlling for pretest score was significant, $t = 17.52$, $p < .001$. The direct effects of OTL measured by lesson coverage on the mediators (Covering, Applying, and Review) and of the three mediators on posttest 1 achievement were significant at the level of at least .005. All the coefficients and significant levels of the direct effects are presented in Figure 5.

Table 7 reports indirect effects of the homework types on student achievement measured by *Pre-Transition Mathematics* posttest 1.

Total indirect effect refers to combining indirect effects of all three mediators. Total indirect effect was .10 (.01 for covering + .19 for applying + (-.10) for review). The 95% confidence interval of the total effect ranged from .03 to .18. Because 0 did not occur between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators had significant impact on posttest 1 achievement.

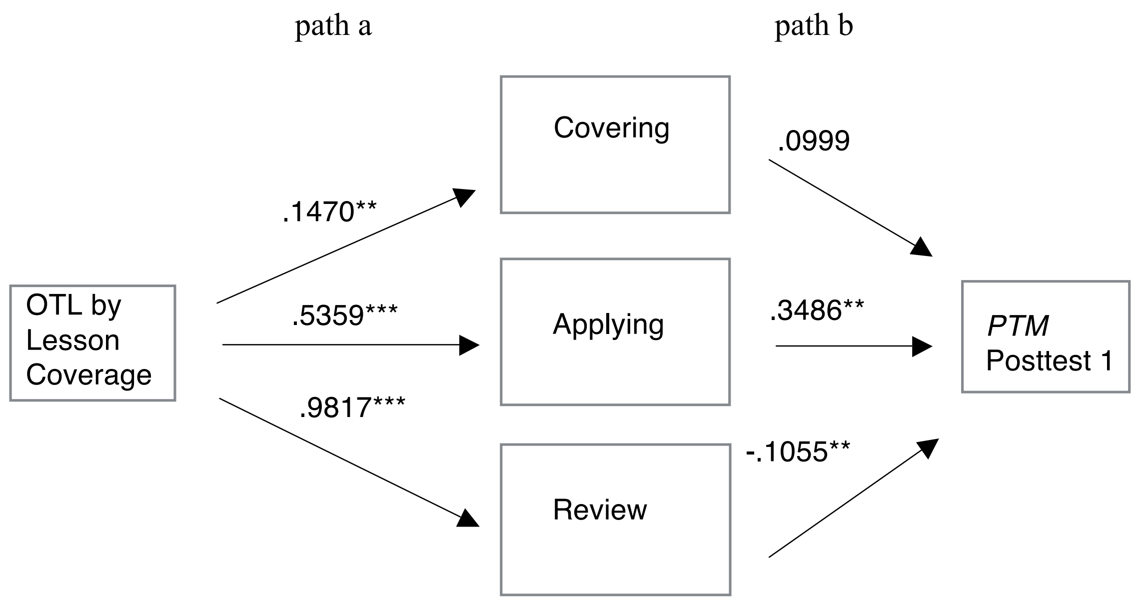

Figure 5. Coefficients and significance test for path a and path b using OTL measured by lesson coverage as the independent variable and *PTM* posttest 1 achievement as the dependent variable. *Note*: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 7

Total and Individual Indirect Effects for Homework Types as Mediators for Pre-Transition Mathematics Posttest 1

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.0979	.0966	-.0013	.0370	(.0294, .1750)
Covering	.0147	.0146	.0000	.0140	(-.0109, .0454)
Applying	.1868	.1865	-.0003	.0507	(.0955, .2941)
Review	-.1036	-.1045	-.0009	.0461	(-.2026, -.0185)
C1	-.1721	-.1718	.0003	.0591	(-.3005, .2175)
C2	.1182	.1191	.0009	.0459	(.0333, .2175)
C3	.2904	.2910	.0006	.0878	(.1297, .4778)

Notes: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL measured by lesson coverage only through covering the ideas was .01 (.15 from IV to covering * .10 from covering to DV) and confidence interval ranged from -.01 to .05. Because 0 was between the lower and the upper limits of the bias corrected confidence interval, homework covering the ideas as a mediator had no significant impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement.

The true indirect effect of the OTL measured by lesson coverage only through applying the mathematics was .19 (.54 from IV to applying * .35 from applying to DV) and confidence interval ranged from .10 to .29. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics as a mediator had a positively significant impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement.

The true indirect effect of the OTL measured by lesson coverage only through review homework was -.10 (.98 from IV to review * -.11 from review to DV) and confidence interval ranged from -.20 to -.02. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, the homework that reviews had a significant, but negative impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement.

Table 7 also showed the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. From the estimates of the 95% confidence interval, C2 and C3 all showed significant differences because 0 was not in the 95% confidence interval, but not C1. This finding occurred because the mediator of applying the mathematics had the largest positive impact than the indirect effect of review. The mediator of review had large impact but in a negative way, the indirect effect of covering the idea was not significant.

Conclusion. In this path analysis I used a sample of 287 students. Overall, OTL measured by lesson coverage as predictor and the three mediators used in the path analysis were valid. Approximately 70% of the variance in the *PTM* posttest 1 was accounted for by the predictor through these three mediators. The total indirect effect of the OTL measured by lesson coverage on student mathematics achievement measured by *Pre-Transition Mathematics* posttest 1 achievement was significant (.10). The specific effects for covering the ideas, applying the mathematics, and review were .01, .19, and -.10, respectively. Homework applying the mathematics had significant, positive impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement and the effect of review was significant, but negative. However, covering the ideas had no significant effect. This led to the significantly different effect between covering the ideas and review, between covering the ideas and applying the mathematics, and applying the mathematics and review.

Using *PTM* posttest 2 achievement as dependent variable. Overall, the whole model showed that OTL measured by lesson coverage as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *PTM* posttest 2, (F (5, 281) = 111.60, $p < .001$). The R^2 was .67 and adjusted R^2 was .66, indicating that 66% of variance in the *PTM* posttest 2 was accounted for by OTL measured by lesson coverage through the three mediators.

The total effect (i.e., direct and indirect effects) of the OTL measured by lesson coverage on the impact of the posttest 2 achievement (c path) was significant, $t = 3.23$, $p < .001$. The direct effect of OTL measured by lesson coverage (c′ path) to *PTM* posttest 2 achievement was not significant, $t = 1.76$, $p = .08$. The partial effect of OTL measured by lesson coverage on *PTM* posttest 2 achievement after controlling for pretest score was significant, $t = 17.18$,

$p < .001$. The direct effects of OTL measured by lesson coverage on all three mediators (Covering, Applying and Review) were all significant ($p < .05$). The direct effects of homework applying the mathematics on posttest 2 achievement were significant ($p < .001$), however homework covering the ideas or review were not significant ($p = .33$ and $p = .39$, respectively). All the coefficients and significant levels of the direct effects are presented in Figure 6.

Table 8 reports indirect effect of the homework types on student achievement measured by *Pre-Transition Mathematics* posttest 2.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .07 (.01 for covering + .09 for applying + (-.03) for review). The 95% confidence interval of the total effect ranged from -.01 to .14. Because 0 does occur between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators had no significant impact on the posttest 2 achievement.

The true indirect effect of the OTL measured by lesson coverage only through covering the ideas was .01 (.15 from IV to covering * .09 from covering to DV) and confidence interval ranged from -.01 to .04. Because 0 lies between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas had no significant impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement.

The true indirect effect of the OTL measured by lesson coverage only through applying the mathematics was .09 (.54 from IV to applying * .16 from applying to DV) and confidence interval ranged from .01 to .18. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics was a mediator that had a positive significant impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement.

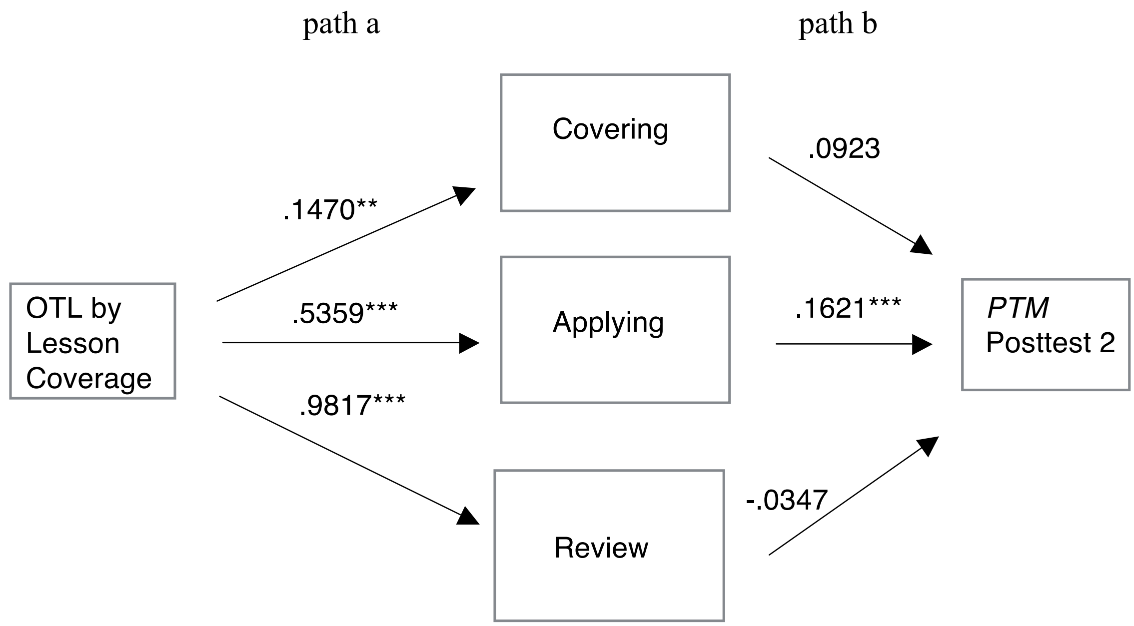

Figure 6. Coefficients and significance test for path a and path b using OTL measured by lesson coverage as the independent variable and *PTM* posttest 2 achievement as the dependent variable. *Note*: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 8

Total and Individual Indirect Effects for Homework Types as Mediators for Pre-Transition Mathematics Posttest 2

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.0663	.0659	-.0005	.0328	(-.0050, .1365)
Covering	.0136	.0136	.0000	.0125	(-.0082, .0423)
Applying	.0869	.0872	.0004	.0426	(.0080, .1756)
Review	-.0341	-.0350	-.0009	.0380	(-.1144, .0354)
C1	-.0733	-.0737	-.0004	.0505	(-.1776, .0219)
C2	.0477	.0485	.0009	.0382	(-.0228, .1282)
C3	.1209	.1222	.0012	.0718	(-.0139, .2685)

Note: C1 = Covering the ideas – Applying the mathematics; *C2* = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL measured by lesson coverage only through review homework was -.03 (.98 from IV to review * -.03 from review to DV) and confidence interval ranged from -.11 to .04. Because 0 was between the lower and upper limits of the bias corrected confidence interval, review homework did not have a significant impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement.

Table 8 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, none of C1, C2, and C3 showed significant effect differences because 0 was in the ranges of the 95% confidence interval. This finding occurred because covering the ideas and review had no significant indirect effects whereas only applying the mathematics had a significant, positive mediating effect and the effect was very small.

Conclusion. In this model I used a sample of 287 students. Overall, OTL measured by lesson coverage as predictor and the three mediators used in the path analysis were valid. Approximately 25% of the variance in the *PTM* posttest 2 was accounted for by the predictor through these three mediators. The total indirect effect of the OTL measured by lesson coverage on student mathematics achievement measured by *Pre-Transition Mathematics* posttest 1 achievement was significant (.07). The specific effects for covering the ideas, applying the mathematics, and review were .01, .09, and -.03, respectively. Homework covering the ideas and review had no significant impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement. However, applying the mathematics had statistically significant, positive indirect effect as a mediator but the size of the indirect effect was small. This led to no different effect between covering the ideas and review, between applying the mathematics and review, and covering the ideas and applying the mathematics.

Using *PTM* posttest 3 achievement as dependent variable. Overall, the whole model showed that OTL measured by lesson coverage as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *PTM* posttest 3, (F (5, 281) = 118.00, p < .001). The R^2 was .68 and adjusted R^2 was .67, indicating that 67% of variance in the *PTM* posttest 3 was accounted for by OTL measured by lesson coverage through the three mediators.

The total effect (i.e., direct and indirect effects) of the OTL measured by lesson coverage on the impact of the posttest 1 achievement (c path) was significant, t = .4.79, p < .001. The direct effect of OTL measured by lesson coverage (c′ path) to *PTM* posttest 3 achievement was significant, t = -2.54, p < .05. The partial effect of OTL measured by lesson coverage on *PTM* posttest 3 achievement after controlling for pretest score was significant, t = 16.48, p < .001. The direct effect of OTL measured by lesson coverage on all three homework types as mediators were significant at the level of at least .05. The direct effects of homework covering the ideas and review on *PTM* posttest 3 achievement were not significant (p = .22 and p = .78, respectively), but the direct effect of homework applying the mathematics on *PTM* posttest 3 was significant (p < .05). All the coefficients and significant levels of the direct effects are presented in Figure 7.

Table 9 reports the indirect effect of the homework types on student achievement measured by *Pre-Transition Mathematics* posttest 3.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .14 (.02 for covering + .13 for applying + (-.02) for review). The 95% confidence interval of the total effect ranged from .06 to .22. Because 0 did not occur between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators had significant impact on the posttest 3 achievement.

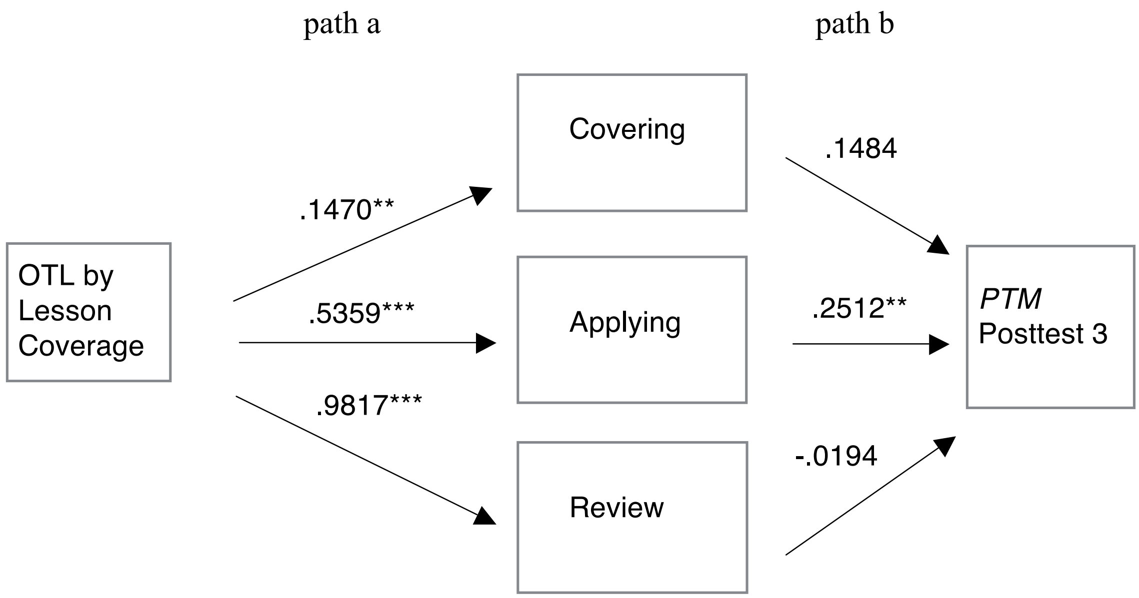

Figure 7. Coefficients and significance test for path a and path b using OTL measured by lesson coverage as the independent variable and *PTM* posttest 3 as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 9

Total and Individual Indirect Effects for Homework Types as Mediators for Pre-Transition Mathematics Posttest 3

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.1374	.1366	-.0008	.0406	(.0628, .2225)
Covering	.0218	.0214	-.0004	.0140	(-.0026, .0532)
Applying	.1346	.1352	.0006	.0529	(.0348, .2444)
Review	-.0190	-.0200	-.0010	.0505	(-.1211, .0789)
C1	-.1128	-.1138	-.0009	.0608	(-.2384, .0046)
C2	.0408	.0415	.0006	.0501	(-.0560, .1413)
C3	.1537	.1552	.0015	.0937	(-.0233, .3423)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL measured by lesson coverage only through covering the ideas was .02 (.15 from IV to covering * .15 from covering to DV) and confidence interval ranged from -.00 to .05. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas had no significant impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement.

The true indirect effect of the OTL measured by lesson coverage only through applying the mathematics was .13 (.54 from IV to applying * .25 from applying to DV) and confidence interval ranged from .03 to .24. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics was a mediator and had significant, positive impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement.

The true indirect effect of the OTL measured by lesson coverage only through review homework was -.02 (.98 from IV to review * -.02 from review to DV) and confidence interval ranged from -.12 to .08. Because 0 was between the lower and upper limits of the bias corrected confidence interval, review homework did not have a significant impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement.

Table 9 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, none of C1, C2, and C3 showed significant effect differences because 0 was in the ranges of the 95% confidence intervals. This finding occurred because covering the ideas and review had no significant indirect effects whereas only applying the mathematics had a significant, positive mediating effect and the effect was very small.

Conclusion. In this path analysis I used a sample of 287 students. Overall, OTL measured by lesson coverage as predictor and the three mediators used in the path analysis were valid. Approximately 67% of the variance in the *PTM* posttest 3 was accounted for by the predictor through these three mediators. The total indirect effect of the OTL measured by lesson coverage on student mathematics achievement measured by *Pre-Transition Mathematics* posttest 3 achievement was significant (.14). The specific effects for covering the ideas, applying the mathematics, and review were .02, .13, and -.02, respectively. Homework covering the ideas and review did not have significant impacts on the relationship between OTL measured by lesson coverage and posttest 3 achievement. However, applying the mathematics had a significant, positive indirect effect but the effect was very small. This led to no significantly different effects between covering the ideas and applying, between applying the mathematics and review, and between covering the ideas and review.

Transition Mathematics

Using *TM* posttest 1 achievement as dependent variable. Overall, the whole model showed that OTL measured by lesson coverage as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *TM* posttest 1, (F (5, 231) = 35.23, p < .001). The R^2 was .43 and adjusted R^2 was .42, indicating that 42% of variance in the *TM* posttest 1 was accounted for by OTL measured by lesson coverage through the three mediators.

The total effect (i.e., direct and indirect effects) of the OTL measured by lesson coverage on the impact of the posttest 1 achievement (c path) was significant, t = 5.13, p < .001. The direct effect of OTL measured by lesson coverage (c′ path) to *TM* posttest 1 achievement was not significant, t = 1.49, p = .14. The partial effect of OTL measured by lesson coverage on *TM* posttest 1 achievement after controlling for pretest score was significant, $t = 6.77$, $p < .001$. The direct effects of OTL measured by lesson coverage on homework covering the ideas and applying the mathematics were significant ($p < .05$), however review homework was not significant ($p = .71$). The direct effects of the three mediators (Covering, Applying, and Review) on the posttest 1 achievement were all significant at the level of at least .05. All the coefficients and significant levels of the direct effects are presented in Figure 8.

Table 10 reports the indirect effect of the homework types on student achievement measured by *Transition Mathematics* posttest 1.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .33 (.42 for covering + (-.06) for applying + (-.03) for review). The 95% confidence interval of the total effect ranged from .21 to .46. Because 0 did not occur between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators had significant impact on the posttest 1 achievement.

The true indirect effect of the OTL measured by lesson coverage only through covering the ideas was .42 (.09 from IV to covering * 4.50 from covering to DV) and confidence interval ranged from .26 to .64. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a positive significant impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement.

The true indirect effect of the OTL measured by lesson coverage only through applying the mathematics was -.06 (-.14 from IV to applying * .41 from applying to DV) and confidence interval ranged from -.12 to -.01. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics was a mediator that had a negative significant impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement.

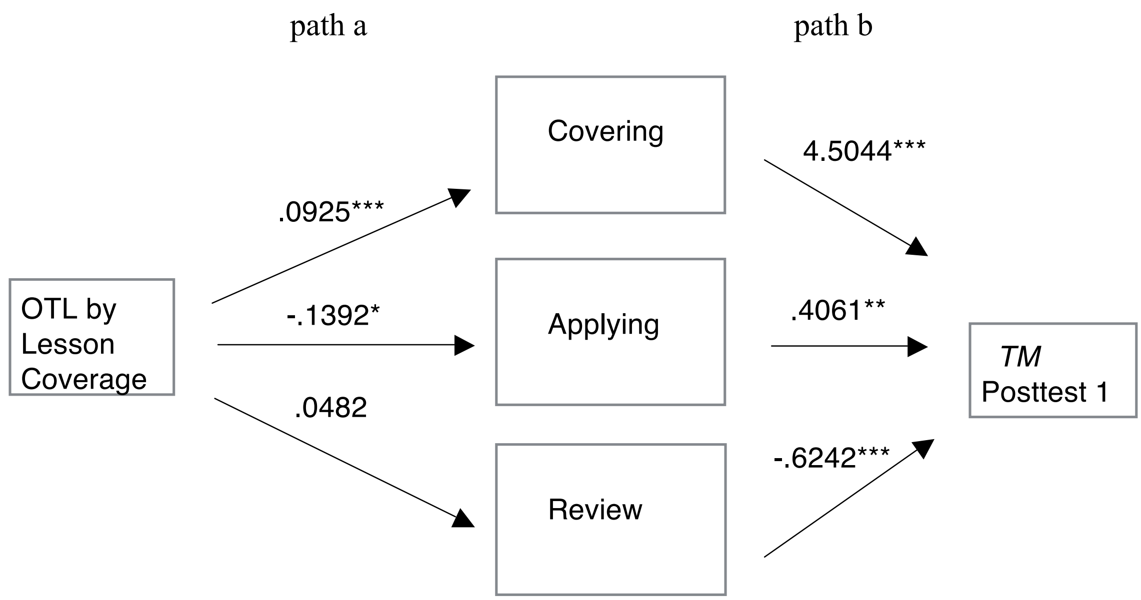

Figure 8. Coefficients and significance test for path a and path b using OTL measured by lesson coverage as the independent variable and *TM* posttest 1 as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 10

Total and Individual Indirect Effects for Homework Types as Mediators for Transition Mathematics Posttest 1

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.3300	.3357	.0057	.0640	(.2113, .4616)
Covering	.4166	.4164	-.0002	.0958	(.2596, .6406)
Applying	-.0565	-.0484	.0081	.0300	(-.1215, -.0080)
Review	-.0301	-.0322	-.0022	.0715	(-.1904, .0959)
C1	.4731	.4648	-.0083	.0961	(.3108, .6968)
C2	.4466	.4486	.0020	.1579	(.1892, .8181)
C3	-.0265	-.0162	.0103	.0857	(-.2114, .1284)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL measured by lesson coverage only through review homework was -.03 (.05 from IV to review * -.62 from review to DV) and confidence interval ranged from -.19 to .10. Because 0 was between the lower and upper limits of the bias corrected confidence interval, review homework did not have a significant impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement.

Table 10 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C1 and C2, but not C3, showed significant effect differences because the value of 0 was not in the ranges of the 95% confidence interval. In other words, covering the ideas had a significantly positive effect and applying the mathematics had a significantly negative effect. This finding occurred because covering the ideas and applying the mathematics both were significant even though they weren't similar effects whereas review did not have any mediating effect.

Conclusion. In this path analysis I used a sample of 237 students. Overall, OTL measured by lesson coverage as predictor and the three mediators used in the path analysis were valid. Approximately 42% of the variance in the *TM* posttest 1 was accounted for by the predictors through these three mediators. The total indirect effect of the OTL measured by lesson coverage on student mathematics achievement measured by *Transition Mathematics* posttest 1 achievement was significant (.33). The specific effects for covering the ideas, applying the mathematics, and review were .42, -.06, and -.03, respectively. Homework covering the ideas had significant, positive impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement and homework applying the mathematics had a significant, negative effect. However, review had no significant impact. This led to the significantly different effect between applying the mathematics and review.

Using *TM* posttest 2 achievement as dependent variable. Overall, the whole model showed that OTL measured by lesson coverage as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *TM* posttest 2, (F (5, 231) = 28.92, $p < .001$). The R^2 was .39 and adjusted R^2 was .37, indicating that 37% of variance in the *TM* posttest 2 was accounted for by OTL measured by lesson coverage through the three mediators.

The total effect (i.e., direct and indirect effects) of the OTL measured by lesson coverage on the impact of posttest 2 achievement (c path) was significant, $t = 4.00$, $p < .0001$. The direct effect of OTL measured by lesson coverage (c′ path) to *TM* posttest 2 achievement was not significant, $t = .50$, $p = .62$. The partial effect of OTL measured by lesson coverage on *TM* posttest 2 achievement after controlling for pretest score was significant, $t = 7.84$, $p < .001$. The direct effects of OTL measured by lesson coverage on homework covering the ideas and applying the mathematics were significant ($p < .01$), however review homework was not significant ($p = .78$). The direct effects of the three mediators (Covering, Applying, and Review) on posttest 2 achievement were all significant at the level of at least .01. All the coefficients and significant levels of the direct effects are presented in Figure 9.

Table 11 reports the indirect effect of the homework types on student achievement measured by *Transition Mathematics* posttest 2.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .32 (.40 for covering + (-.06) for applying +

(-.02) for review). The 95% confidence interval of the total effect ranged from .1868 to .4466. Because 0 did not occur between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators had significant impact on the posttest 2 achievement.

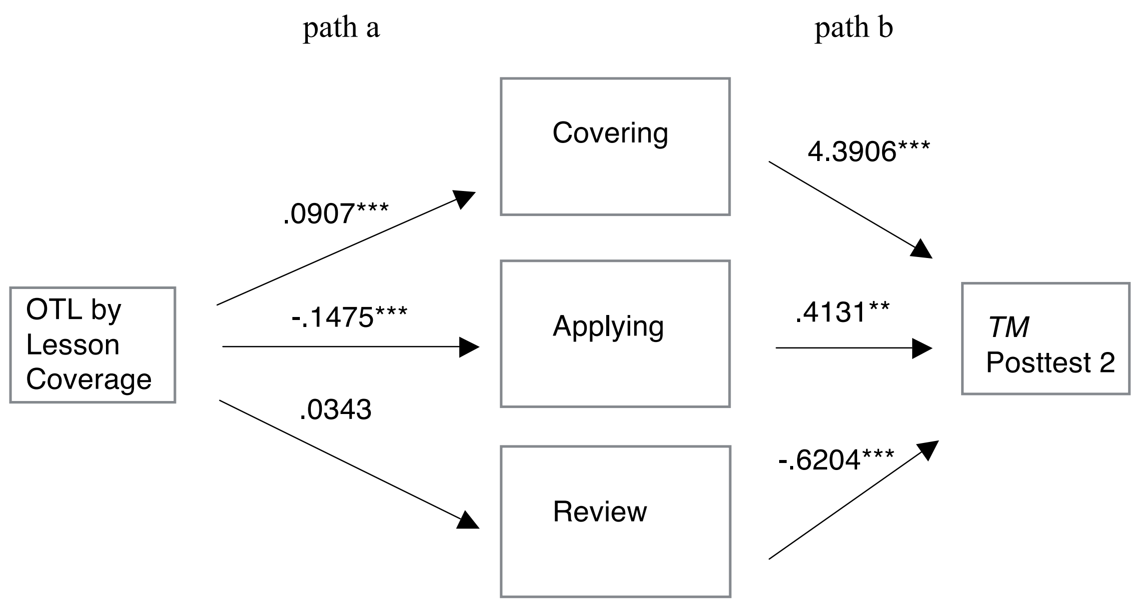

Figure 9. Coefficients and significance test for path a and path b using OTL measured by lesson coverage as the independent variable and *TM* posttest 2 as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

The true indirect effect of the OTL measured by lesson coverage only through covering the ideas was .40 (.09 from IV to covering * 4.39 from covering to DV) and confidence interval ranged from .25 to .62. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a positive significant impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement.

The true indirect effect of the OTL measured by lesson coverage only through applying the mathematics was -.06 (-.15 from IV to applying * .41 from applying to DV) and confidence interval ranged from -.13 to -.01. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics was a mediator that had a negative significant impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement.

Table 11

Total and Individual Indirect Effects for Homework Types as Mediators for Transition Mathematics Posttest 2

	Est. from Data	Est. from Bootstrap	Bias	SE	Bias Corrected Confidence Interval
Total	.3160	.3237	.0077	.0669	(.1868, .4466)
Covering	.3982	.4011	.0029	.0943	(.2451, .6198)
Applying	-.0609	-.0526	.0084	.0331	(-.1301, -.0058)
Review	-.0213	-.0249	-.0036	.0694	(-.1730, .1022)
C1	.4591	.4536	-.0055	.0965	(.2929, .6805)
C2	.4195	.4260	.0065	.1531	(.1689, .7754)
C3	-.0397	-.0277	.0120	.0849	(-.2305, .1067)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL measured by lesson coverage only through review homework was -.02 (.03 from IV to review * -.62 from review to DV) and confidence interval ranged from -.17 to .10. Because 0 was between the lower and upper limits of the bias corrected confidence interval, review homework did not have a significant impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement.

Table 11 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect difference between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C1 and C2, but not C3, showed the significant effect differences because 0 was not in the ranges of the 95% confidence interval. In other words, covering the ideas had a significantly positive effect and applying the mathematics had a significantly negative effect.

This finding occurred because covering the ideas and applying the mathematics both were significant even though they weren't similar effects whereas review did not have any mediating effect.

Conclusion. In this path analysis I used a sample of 237 students. Overall, OTL measured by lesson coverage as predictor and the three mediators used in the path analysis were valid. Approximately 37% of the variance in the *TM* posttest 2 was accounted for by the predictors through these three mediators. The total indirect effect of the OTL measured by lesson coverage on student mathematics achievement measured by *Transition Mathematics* posttest 2 achievement was significant (.32). The specific effects for covering the ideas, applying the mathematics, and review were .40, -.06, and -.02, respectively. Homework covering the ideas had significant, positive impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement and review homework had a significant, negative effect. However, review had no significant effect. This led to the significantly different effect between applying the mathematics and review.

Using *TM* posttest 3 achievement as dependent variable. Overall, the whole model showed that OTL measured by lesson coverage as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *TM* posttest 3, (F (5, 231) = 83.35, p < .001). The R^2 was .64 and adjusted R^2 was .64, indicating that 64% of variance in the *TM* posttest 3 was accounted for by OTL measured by lesson coverage through the three mediators.

The total effect (i.e., direct and indirect effects) of the OTL measured by lesson coverage on the impact of the posttest 3 achievement (c path) was significant, t = 3.61, p < .001. The direct effect of OTL measured by lesson coverage (c′ path) to *TM* posttest 3 achievement was not significant, $t = .27$, $p = .79$. The partial effect of OTL measured by lesson coverage on *TM* posttest 3 achievement after controlling for pretest score was significant, $t = 16.48$, $p < .001$. The direct effects of OTL measured by lesson coverage on homework covering the ideas and applying the mathematics were significant ($p < .01$), however review homework was not significant ($p = .62$). The direct effects of the three mediators (Covering, Applying, and Review) on the posttest 3 achievement were all significant at the level of at least .01. All the coefficients and significant levels of the direct effects are presented in Figure 10.

Table 12 reports indirect effect of the homework types on student achievement measured by *Transition Mathematics* posttest 3.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .32 (.36 for covering + (-.07) for applying + .04 for review). The 95% confidence interval of the total effect ranged from .19 to .46. Because 0 was not between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators had significant impact on the posttest 3 achievement.

The true indirect effect of the OTL measured by lesson coverage only through covering the ideas was .36 (.08 from IV to covering * 4.58 from covering to DV) and confidence interval ranged from .22 to .58. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a positive significant impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement.

The true indirect effect of the OTL measured by lesson coverage only through applying the mathematics was -.07 (-.17 from IV to applying * .42 from applying to DV) and confidence interval ranged from -.15 to -.01. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics was a mediator that had a negative significant impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement.

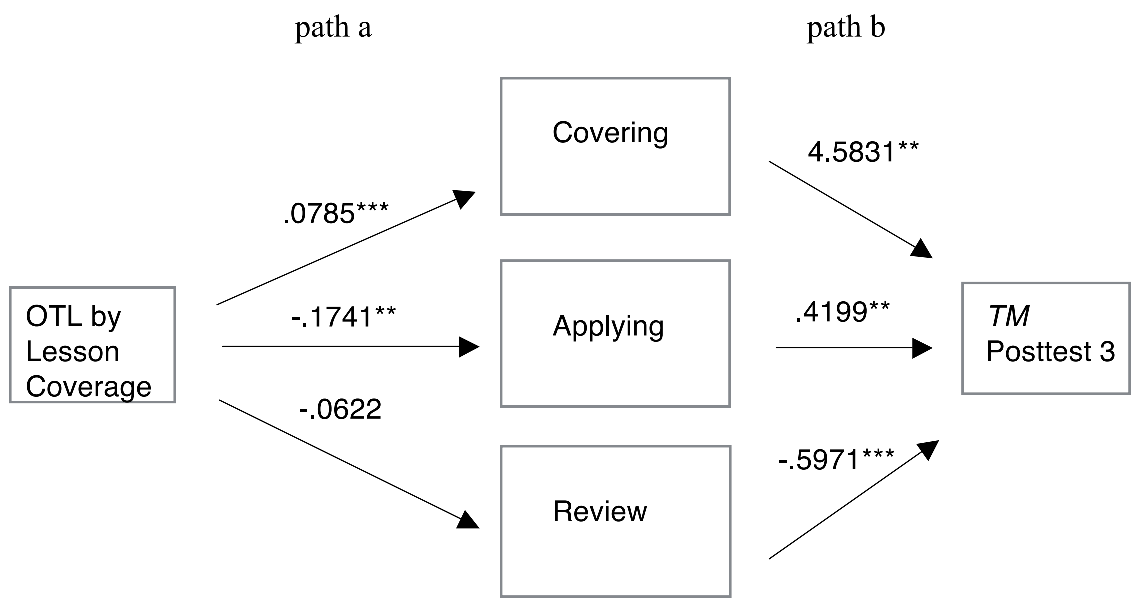

Figure 10. Coefficients and significance test for path a and path b using OTL measured by lesson coverage as the independent variable and *TM* posttest 3 as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 12

Total and Individual Indirect Effects for Homework Types as Mediators for Transition Mathematics Posttest 3

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.3240	.3303	.0063	.0691	(.1899, .4604)
Covering	.3600	.3605	.0005	.0899	(.2181, .5770)
Applying	-.0731	-.0644	.0087	.0376	(-.1495, -.0072)
Review	.0371	.0342	-.0029	.0618	(-.0850, .1591)
C1	.4331	.4248	-.0083	.0955	(.2623, .6445)
C2	.3229	.3263	.0034	.1392	(.0979, .6496)
C3	-.1102	-.0986	.0117	.0817	(-.2997, .0247)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL measured by lesson coverage only through review homework was .04 (-.06 from IV to review * -.60 from review to DV) and confidence interval ranged from -.09 to .16. Because 0 was between the lower and upper limits of the bias corrected confidence interval, review homework did not have a significant impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement.

Table 12 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C1 and C2 showed the significant effect differences because the value of 0 was not in the ranges of the 95% confidence interval, but not C3. In other words, covering the ideas had a significantly positive effect and applying the mathematics had a significantly negative effect. This finding occurred because covering the ideas and applying the mathematics both were significant even though they weren't similar effects whereas review did not have any mediating effect.

Conclusion. In this path analysis I used a sample of 237 students. Overall, OTL measured by lesson coverage as predictor and the three mediators used in the path analysis were valid. Approximately 64% of the variance in the *TM* posttest 3 was accounted for by the predictor through these three mediators. The total indirect effect of the OTL measured by lesson coverage on student mathematics achievement measured by *Transition Mathematics* posttest 3 achievement was significant (.32). The specific effects for covering the ideas, applying the mathematics, and review were .36, -.07, and .04, respectively. Homework covering the ideas had significant, positive impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement and applying the mathematics homework had a significant, negative effect. However, review was not statistically significant. This led to the significantly different effect between applying the mathematics and review.

Algebra

Using *Algebra* posttest 1 achievement as dependent variable. Overall, the whole model showed that OTL measured by lesson coverage as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *Algebra* posttest 1, (F (5, 226) = 71.90, p < .001). The R^2 was .61 and adjusted R^2 was .61, indicating that 61% of variance in the *Algebra* posttest 1 was accounted for by OTL measured by lesson coverage through the three mediators.

The total effect (i.e., direct and indirect effects) of the OTL measured by lesson coverage on the impact of the posttest 1 achievement (c path) was significant, t = 9.23, p < .001. The direct effect of OTL measured by lesson coverage (c′ path) to *Algebra* posttest 1 achievement was also significant, t = 7.62, p < .001. The partial effect of OTL measured by lesson coverage on *Algebra* posttest 1 achievement after controlling for pretest score was significant, t = 9.37, p < .001. The direct effects of OTL measured by lesson coverage on the mediators (Covering, Applying, and Review) were significant at the level of at least .001. The direct effects of covering the ideas and review on posttest 1 achievement were significant at the level of at least .001. However, the direct effect of applying the mathematics was not significant (p = .06). All the coefficients and significant levels of the direct effects are presented in Figure 11.

Table 13 reported the indirect effect of the homework types on student achievement measured by *Algebra* posttest 1.

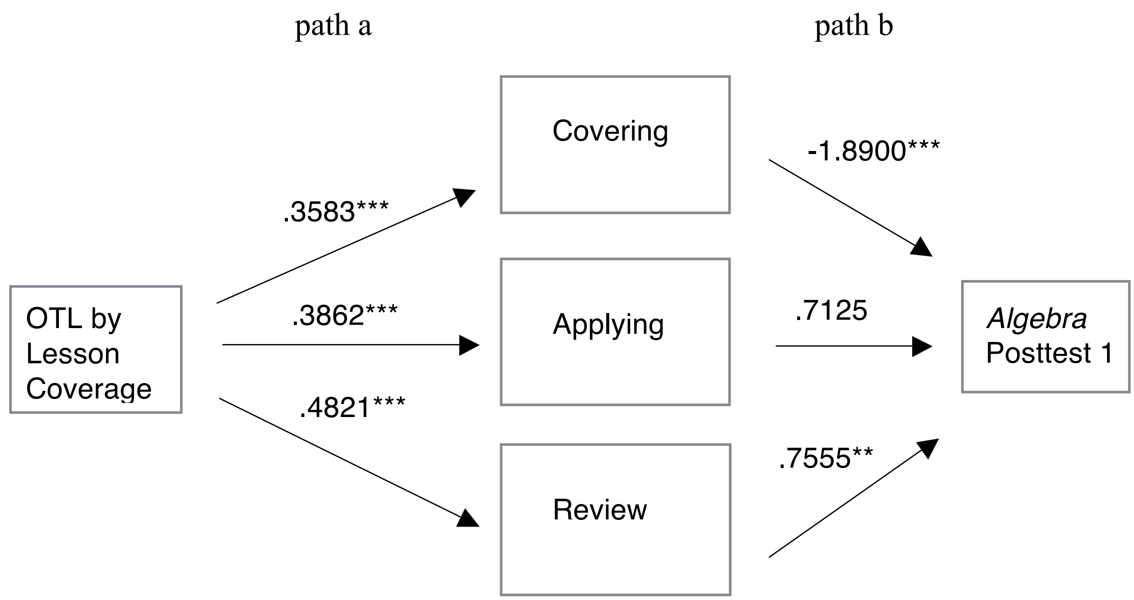

Figure 11. Coefficients and significance test for path a and path b using OTL measured by lesson coverage as the independent variable and *Algebra* posttest 1 as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 13
Total and Individual Indirect Effects for Homework Types as Mediators for Algebra Posttest 1

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	-.0378	-.0360	.0018	.0725	(-.1836, .1014)
Covering	-.6771	-.6742	.0029	.1914	(-1.1023, -.3395)
Applying	.2752	.2719	-.0032	.1742	(-.0299, .6590)
Review	.3642	.3662	.0021	.1185	(.1698, .6513)
C1	-.9523	-.9461	.0062	.3541	(-1.7512, -.3424)
C2	-1.0413	-1.0404	.0009	.2199	(-1.5390, -.6671)
C3	-.0890	-.0943	-.0053	.2531	(-.6123, .3855)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was -.04 ((-.68) for covering + .28 for applying + .36 for review). The 95% confidence interval of the total effect ranged from -.18 to .10. Because 0 was between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators had no significant impact on the posttest 1 achievement.

The true indirect effect of the OTL measured by lesson coverage only through covering the ideas was -.68 (.36 from IV to covering * -1.89 from covering to DV) and confidence interval ranged from -1.10 to -.34. Because 0 was not between the lower and the upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a negative significant impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement.

The true indirect effect of the OTL measured by lesson coverage only through applying the mathematics was .28 (.39 from IV to applying * .71 from applying to DV) and confidence interval ranged from -.03 to .66. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics had no significant impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement.

The true indirect effect of the OTL measured by lesson coverage only through review homework was .36 (.48 from IV to review * .76 from review to DV) and confidence interval ranged from .17 to .65. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, review homework was significant and had a positive impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement.

Table 13 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval (95% CIs in Table 13), C1 and C2, but not C3, showed significant effect differences because the value of 0 was not in the ranges of the 95% confidence interval. In other words, covering the ideas had a significantly negative effect and review had a significantly positive effect. This finding occurred because covering the ideas and review both were significant even though they weren't similar effects whereas applying the mathematics did not have any mediating effect.

Conclusion. In this path analysis I used a sample of 232 students. Overall, OTL measured by lesson coverage as predictor and the three mediators used in the path analysis were valid. Approximately 61% of the variance in the *Algebra* posttest 1 was accounted for by the predictor through these three mediators. The total indirect effect of the OTL measured by lesson coverage on student mathematics achievement measured by *Algebra* posttest 1 achievement was not significant (-.04). The specific effects for covering the ideas, applying the mathematics, and review were -.68, .28, and .36, respectively. Homework covering the ideas had significant, negative impact on the relationship between OTL measured by lesson coverage and posttest 1 achievement and review homework had a significant, positive effect. However, applying the mathematics was statistically insignificant as a mediator. This led to the significantly different effect between applying the mathematics and review.

Using *Algebra* posttest 2 achievement as dependent variable. Overall, the whole model showed that OTL measured by lesson coverage as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *Algebra* posttest 1, (F (5, 226) = 62.03, p < .001). The R^2 was .58 and adjusted R^2 was .57, indicating that 57% of variance in the *Algebra* posttest 2 was accounted for by OTL measured by lesson coverage through the three mediators.

The total effect (i.e., direct and indirect effects) of the OTL measured by lesson coverage on the impact of posttest 2 achievement (c path) was significant, $t = 9.18$, $p < .001$. The direct effect of OTL measured by lesson coverage (c′ path) to *Algebra* posttest 2 achievement was also significant, $t = 8.35$, $p < .001$. The partial effect of OTL measured by lesson coverage on *Algebra* posttest 2 achievement after controlling for pretest score was significant, $t = 9.90$, $p < .001$. The direct effects of OTL measured by lesson coverage on the mediators (Covering, Applying, and Review) were significant at the level of at least .001. The direct effects of covering the ideas and applying the mathematics on posttest 2 achievement were significant at the level of at least .001. However, the direct effect of review was not significant ($p = .09$). All the coefficients and significance levels of the direct effects are presented in Figure 12.

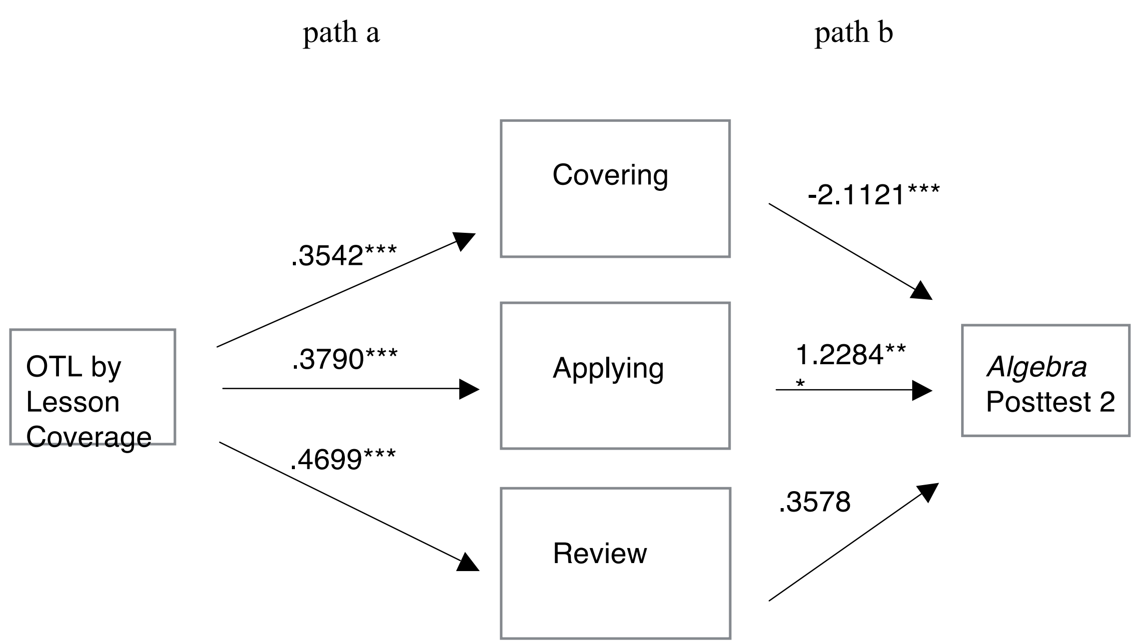

Figure 12. Coefficients and significance test for path a and path b using OTL measured by lesson coverage as the independent variable and *Algebra* posttest 2 as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 14 reports indirect effect of the homework types on student achievement measured by *Algebra* posttest 2.

Table 14

Total and Individual Indirect Effects for Homework Types as Mediators for Algebra Posttest 2

	Est. from Data	Est. from Bootstrap	Bias	SE	Bias Corrected Confidence Interval
Total	-.1145	-.1118	.0027	.0732	(-.2633, .0211)
Covering	-.7482	-.7464	.0018	.1993	(-1.2122, -.4063)
Applying	.4656	.4642	-.0013	.1830	(.1685, .9134)
Review	.1681	.1704	.0022	.0945	(.0082, .3799)
C1	-1.2138	-1.2107	.0031	.3734	(-2.1078, -.5910)
C2	-.9163	-.9168	-.0004	.2101	(-1.3997, -.5541)
C3	.2974	.2939	-.0036	.2398	(-.1189, .8435)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was -.11 ((-.75) for covering + .47 for applying + .17 for review). The 95% confidence interval of the total effect ranged from -.26 to .02. Because 0 occurred between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators did not have a significant impact on the posttest 2 achievement.

The true indirect effect of the OTL measured by lesson coverage only through covering the ideas was -.75 (.35 from IV to covering * -.2.11 from covering to DV) and confidence interval ranged from -1.21 to -.41. Because 0 was not between the lower and the upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a negative significant impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement.

The true indirect effect of the OTL measured by lesson coverage only through applying the mathematics was .47 (.38 from IV to applying * 1.23 from applying to DV) and confidence interval ranged from .17 to .91. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics had a significant, positive impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement.

The true indirect effect of the OTL measured by lesson coverage only through review homework was .17 (.47 from IV to review * .36 from review to DV) and confidence interval ranged from .01 to .38. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, review homework was significant and had a positive impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement.

Table 14 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval (95% CIs in Table 14), C1 and C2, but not C3, showed significant effect differences because the value of 0 was not in the ranges of the 95% confidence interval. In other words, covering the ideas had a significantly negative effect, applying the mathematics and review had significantly positive effects. This finding occurred because applying the mathematics and review both had significant, positive effects, whereas covering the ideas had a significant, negative effect. The effects of applying the mathematics and review were both stronger than the effect of covering the ideas.

Conclusion. In this path analysis I used a sample of 232 students. Overall, OTL measured by lesson coverage as predictor and the three mediators used in the path analysis were valid. Approximately 57% of the variance in the *Algebra* posttest 2 was accounted for by the predictor through these three mediators. The total indirect effect of the OTL measured by lesson coverage on student mathematics achievement measured by *Algebra* posttest 2 achievement was not significant (-.11). The specific effects for covering the ideas, applying the mathematics, and review were -.75, .47, and .17, respectively. Homework covering the ideas had significant, negative impact on the relationship between OTL measured by lesson coverage and posttest 2 achievement. However, applying the mathematics and review were both significant and positive as mediators. This led to the significantly different effect between covering the ideas and review and between applying the mathematics and review.

Using *Algebra* posttest 3 achievement as dependent variable. Overall, the whole model showed that OTL measured by lesson coverage as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *Algebra* posttest 3, (F (5, 226) = 83.40, p < .001). The R^2 was .65 and adjusted R^2 was .64, indicating that 64% of variance in the *Algebra* posttest 3 was accounted for by OTL measured by lesson coverage through the three mediators.

The total effect (i.e., direct and indirect effects) of the OTL measured by lesson coverage on the impact of the posttest 3 achievement (c path) was significant, t = 9.26, p < .001. The direct effect of OTL measured by lesson coverage (c′ path) to *Algebra* posttest 3 achievement was also significant, t = 8.68, p < .001. The partial effect of OTL measured by lesson coverage on *Algebra* posttest 3 achievement after controlling for pretest score was significant, t = 11.59, p < .001. The direct effects of OTL measured by lesson coverage on the mediators (Covering, Applying, and Review) were significant at the level of at least .001. The direct effects of covering the ideas and applying the mathematics on posttest 3 achievement were significant at the level of at least .001. However, the direct effect of review was not significant (p = .16). All the coefficients and significant levels of the direct effects are presented in Figure 13.

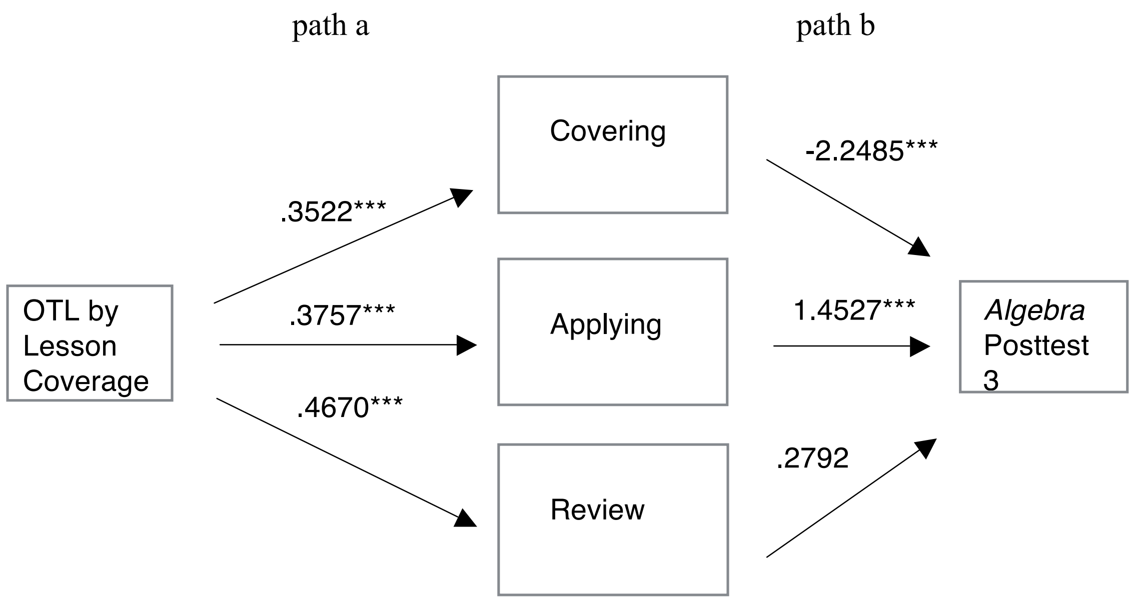

Figure 13. Coefficients and significance test for path a and path b using OTL measured by lesson coverage as the independent variable and *Algebra* posttest 3 as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 15 reports indirect effect of the homework types on student achievement measured by *Algebra* posttest 3.

Table 15

Total and Individual Indirect Effects for Homework Types as Mediators for Algebra Posttest 3

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	-.1157	-.1155	.0002	.0708	(-.2572, .0179)
Covering	-.7919	-.7938	-.0020	.1945	(-1.2163, -.4445)
Applying	.5458	.5474	.0016	.1798	(.2478, .9658)
Review	.1304	.1309	.0006	.0874	(-.0212, .3230)
C1	-1.3377	-1.3413	-.0036	.3661	(-2.1824, -.7149)
C2	-.9222	-.9248	-.0025	.2023	(-1.3527, -.5625)
C3	.4155	.4165	.0011	.2311	(.0069, .9200)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was -.12 ((-.79) for covering + .55 for applying + .13 for review). The 95% confidence interval of the total effect ranged from -.26 to .02. Because

0 occurred between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators did not have a significant impact on the posttest 3 achievement.

The true indirect effect of the OTL measured by lesson coverage only through covering the ideas was -.79 (.35 from IV to covering * -2.25 from covering to DV) and confidence interval ranged from -1.22 to -.44. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, the homework type of covering the ideas was a mediator that had negative significant impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement.

The true indirect effect of the OTL measured by lesson coverage only through applying the mathematics was .55 (.38 from IV to applying * 1.45 from applying to DV) and confidence interval ranged from .25 to .97. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics had a statistically significant, positive impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement.

The true indirect effect of the OTL measured by lesson coverage only through review homework was .13 (.47 from IV to review * .28 from review to DV) and confidence interval ranged from -.02 to .32. Because 0 was between the lower and upper limits of the bias corrected confidence interval, review homework had no significant impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement.

Table 15 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C1, C2 and C3 all showed the significant effect differences because the value of 0 was not in the ranges of the 95% confidence interval. In other words, covering the ideas had a significant, negative effect on the relationship between OTL measured by lesson coverage and posttest 3 achievement. Applying the mathematics and review both had significant, positive impact.

Conclusion. In this path analysis I used a sample of 232 students. Overall, OTL measured by lesson coverage as predictor and the three mediators used in the path analysis were valid. Approximately 64% of the variance in the *Algebra* posttest 3 was accounted for by the predictor through these three mediators. The total indirect effect of the OTL measured by lesson coverage on student mathematics achievement measured by *Algebra* posttest 3 achievement was not significant (-.12). The specific effects for covering the ideas, applying the mathematics, and review were -.79, .55, and .13, respectively. Homework covering the ideas had significant, negative impact on the relationship between OTL measured by lesson coverage and posttest 3 achievement and applying the mathematics and review homework had significant, positive effects. This led to significantly different effect between covering the ideas and applying the mathematics and between covering the ideas and review. C3 showed that the effect of review is stronger than the effect of applying the mathematics.

Summary of the Results

I can summarize the true and estimated effects using lesson coverage to measure OTL in Tables 16 and 17. In the tables PTM means *Pre-Transition Mathematics*, TM stands for *Transition Mathematics*, A stands for *Algebra*, OTL means opportunity to learn, LC means lesson coverage, PT stands for posttest. So for example, PTMOTLLC measure OTL measured by lesson coverage in *Pre-Transition Mathematics*, and PTMPT1 means *Pre-Transition Mathematics* posttest 1.

Extent of Homework Influence on Posttest OTL and Achievement (Research Question 3)

The third research question focuses on the relationship between homework and teachers' reported posttest OTL: To what extent do different types of homework influence the impact of posttest opportunity to learn (i.e., teachers' perceived opportunity to learn the content on each posttest) on student mathematics achievement measured by each corresponding posttest in *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*?

Regression models are again constructed using each posttest percent correct as the dependent variable, with teachers' reported OTL on each posttest as the independent variable while controlling for the standardized pretest in each mathematics course. The three mediators are the percent of each of the three homework types (*covering the ideas, applying the mathematics,* and *review*) assigned for students to complete. The same analysis process used to answer research question 2 is also used to answer research question 3.

Table 16

True Indirect Effect for OTL measured by Lesson Coverage

	Covering the ideas	Applying the mathematics	Review	Total
PTMOTLLC→PTMPT1	.0147	.1868*	-.1036*	.0979*
PTMOTLLC→PTMPT2	.0136	.0869*	-.0341	.0663*
PTMOTLLC→PTMPT3	.0218	.1346*	-.0190	.1374*
TMOTLLC→TMPT1	.4166*	-.0565*	-.0301	.3300*
TMOTLLC→TMPT2	.3982*	-.0609*	-.0213	.3160*
TMOTLLC→TMPT3	.3600*	-.0731*	.0371	.3240*
AOTLLC→APT1	-.6771*	.2752	.3642*	-.0378
AOTLLC→APT2	-.7482*	.4656*	.1681*	-.1145
AOTLLC→APT3	-.7919*	.5458*	.1304	-.1157

Note: *indicates the bias corrected confidence interval does not contain zero, hence the effect is statistically significant.

Table 17

Estimated Indirect Effect for OTL measured by Lesson Coverage

	Covering the ideas	Applying the mathematics	Review	Total
PTMOTLLC→PTMPT1	.0146	.1865*	-.1045	.0966*
PTMOTLLC→PTMPT2	.0136	.0872*	-.0350	.0659*
PTMOTLLC→PTMPT3	.0214	.1352*	-.0200	.1366*
TMOTLLC→TMPT1	.4164*	-.0484*	-.0322	.3357*
TMOTLLC→TMPT2	.4011*	-.0526*	-.0249	.3237*
TMOTLLC→TMPT3	.3605*	-.0644*	.0342	.3303*
AOTLLC→APT1	-.6742*	.2719	.3662*	-.0360
AOTLLC→APT2	-.7464*	.4642*	.1704*	-.1118
AOTLLC→APT3	-.7938*	.5474*	.1309	-.1155

Note: *indicates the bias corrected confidence interval does not contain zero, hence the effect statistically significant.

Pre-Transition Mathematics

Using *PTM* posttest 1 achievement as dependent variable. Overall, the whole model shows that OTL on posttest 1 as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *PTM* posttest 1, (F (5, 281) = 49.30, $p < .001$.). The R^2 was .47 and adjusted R^2 was .46, indicating that 46% of variance in the *PTM* posttest 1 was accounted for by OTL on posttest 1 achievement through the three mediators.

The total effect (i.e., direct and indirect effects) of the teachers' reported OTL on *PTM* posttest 1 on the impact of the posttest 1 achievement (c path) was significant, $t = 9.74$, $p < .001$. The direct effect of teachers' reported *PTM* posttest 1 OTL (c′ path) to *PTM* posttest 1 achievement was significant as well, $t = 6.53$, $p < .001$. The partial effect of teachers' reported *PTM* posttest 1 OTL on *PTM* posttest 1 after controlling for pretest score was significant too, $t = 6.81$, $p < .001$. All the direct effects of OTL on posttest 1 achievement on the three mediators (Covering, Applying, and Review) and of the three mediators on the posttest 1 achievement were significant at the level of at least .01. All the coefficients and significant levels of the direct effects are presented in Figure 14.

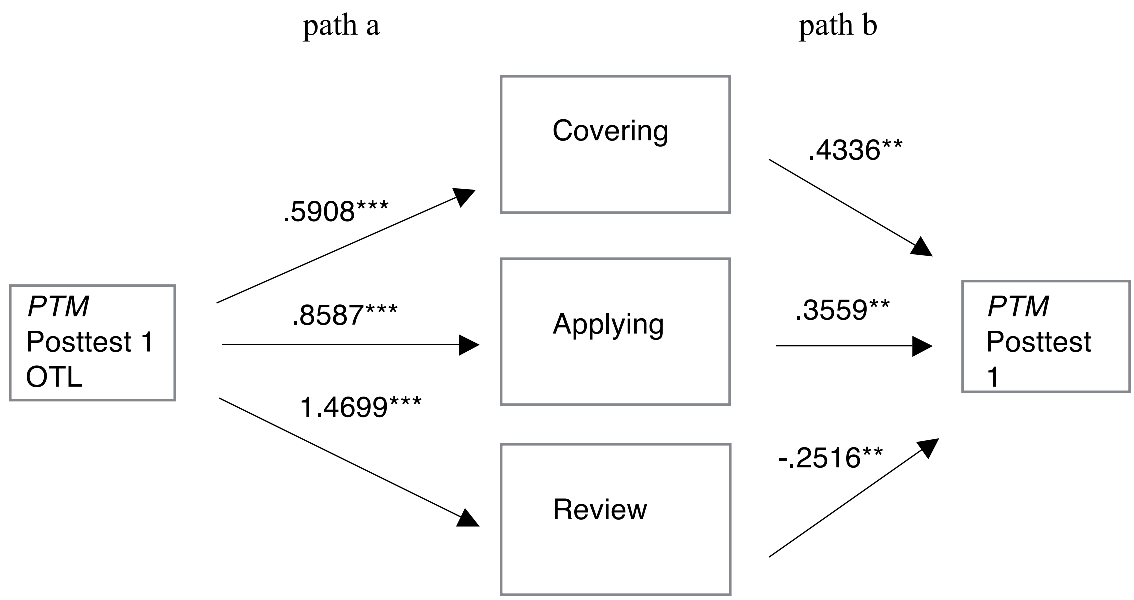

Figure 14. Coefficients and significance for path a and path b using teachers' reported OTL on *PTM* posttest 1 as the independent variable and *PTM* posttest 1 achievement as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 18 reports the indirect effect of the homework types on student achievement measured by *Pre-Transition Mathematics* posttest 1.

Table 18

Indirect Effects of Independent Variable on Dependent Variable through Three Homework Types as Mediators for Pre-Transition Mathematics Posttest 1

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.1919	.1905	-.0014	.0708	(.0169, .3689)
Covering	.2562	.2565	.0004	.1945	(.0964, .4048)
Applying	.3056	.3031	-.0025	.1798	(.0992, .5123)
Review	-.3699	-.3691	.0008	.0874	(-.5575, -.1952)
C1	-.0494	-.0465	.0029	.3661	(-.3753, .2726)
C2	-.6260	.6256	-.0004	.2023	(.4251, .8351)
C3	.6754	.6721	-.0033	.1779	(.3262, 1.0225)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .19 (.26 for covering + .31 for applying + (-.37) for review). The 95% confidence interval of the total effect ranged from .02 to .37. Because 0 was not between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators had significant impact on posttest 1 achievement.

The true indirect effect of the OTL on posttest 1 only through covering the ideas was .26 (.59 from IV to covering *. 43 from covering to DV) and confidence interval ranged from .10 to .40. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a positive significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement.

The true indirect effect of the OTL on posttest 1 only through applying the mathematics was .31 (.86 from IV to applying * .36 from applying to DV) and confidence interval ranged from .10 to .51. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics was a mediator that had a positive significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement.

The true indirect effect of the OTL on posttest 1 only through review homework was -.37 (1.47 from IV to review * -.25 from review to DV) and confidence interval ranged from -.56 to -.20. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, review homework was a mediator that had a negative significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement.

Table 18 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C2 and C3, but not C1, showed the significant effect differences because 0 was not in the ranges of the 95% confidence interval. In other words, the effects of covering the ideas and applying the mathematics were similar. This finding occurred because covering the ideas and applying the mathematics had similar positive indirect effects whereas review had a negative indirect effect.

Conclusion. In this path analysis, I used a sample of 287 students. Overall, OTL on posttest 1 as the predictor and the three mediators used in the path analysis are valid. Approximately 46% of the variance in the *PTM* posttest 1 was accounted for by the predictor through these three mediators. The total indirect effect of teachers' reported OTL on *Pre-Transition Mathematics* posttest 1 on achievement measured by the same test was positive and statistically significant (.19). The specific effects for covering the ideas, applying the mathematics, and review were .26, .31, and -.37, respectively. All these three mediators have significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement. However, covering the ideas and applying the mathematics have similar, positive effects, while review has a negative effect. This led to the significantly different effect between covering the ideas and review and between applying the mathematics and review.

Using *PTM* posttest 2 achievement as dependent variable. Overall, the whole model shows that OTL on posttest 2 as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *PTM* posttest 2 achievement, (F (5, 281) =

49.30, $p < .001$.). The R^2 was .40 and adjusted R^2 was .39, indicating that 39% of variance in the *PTM* posttest 2 was accounted for by OTL on posttest 2 achievement through the three mediators.

The total effect (i.e., direct and indirect effects) of the teachers' reported OTL on *PTM* posttest 2 on the impact of the posttest 2 achievement (c path) was significant, $t = 12.35$, $p < 0.001$. The direct effect of teachers' reported *PTM* posttest 2 OTL (c′ path) to *PTM* posttest 2 achievement was significant was well, $t = 7.85$, $p < .001$. The partial effect of teachers' reported *PTM* posttest 2 OTL on *PTM* posttest 2 after controlling for pretest score was significant too, $t = 4.25$, $p < .001$. All the direct effects of OTL on posttest 2 achievement on the three mediators (Covering, Applying, and Review) were significant at the level of at least .001. Applying the mathematics and review homework were significant on the relationship between posttest 2 OTL and posttest 2 achievement at the level of at least .001. However, covering the ideas was not significant ($p = .20$). All the coefficients and significant levels of the direct effects are presented in Figure 15.

Table 19 reports the indirect effect of the homework types on student achievement measured by *Pre-Transition Mathematics* posttest 2.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .22 (.12 for covering + (-.20) for applying + (-.10) for review). The 95% confidence interval of the total effect ranged from .08 to .37. Because 0 was not between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the OTL measured by lesson coverage through the three mediators had significant impact on the posttest 2 achievement.

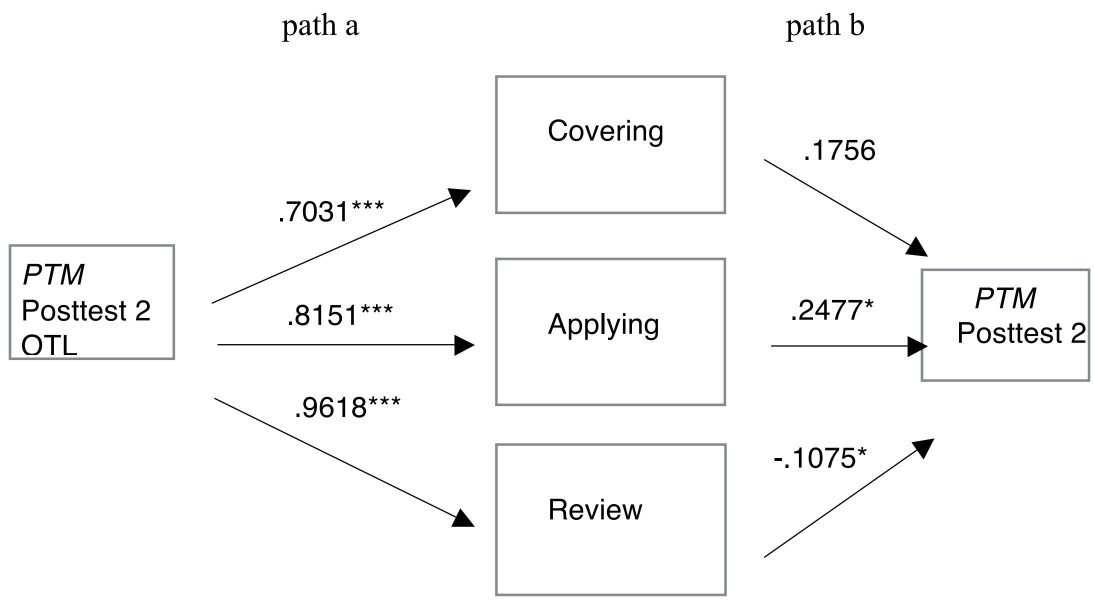

Figure 15. Coefficients and significance for path a and path b using teachers' reported OTL on *PTM* posttest 2 as the independent variable and *PTM* posttest 2 achievement as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 19

Indirect Effects of Independent Variable on Dependent Variable through Three Homework Types as Mediators for Pre-Transition Mathematics Posttest 2

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.2220	.2223	.0003	.0720	(.0830, .3653)
Covering	.1235	.1247	.0012	.0819	(-.0441, .2806)
Applying	.2019	.2013	-.0006	.0864	(.0378, .3804)
Review	-.1034	-.1036	-.0003	.0480	(-.2052, -.0162)
C1	-.0784	-.0766	.0018	.1486	(-.3859, .1996)
C2	.2268	.2283	.0015	.0859	(.0558, .3926)
C3	.3053	.3049	-.0004	.1217	(.0788, .5552)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL on posttest 2 only through covering the ideas was .12 (.70 from IV to covering *. 18 from covering to DV) and confidence interval ranged from -.04 to .28. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas had no significant effect on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement.

The true indirect effect of the OTL on posttest 2 only through applying the mathematics was .20 (.82 from IV to applying * .25 from applying to DV) and confidence interval ranged from .04 to .38. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics was a mediator that had a positive significant impact on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement.

The true indirect effect of the OTL on posttest 2 only through review homework was -.10 (.96 from IV to review * -.11 from review to DV) and confidence interval ranged from -.21 to -.02. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, the homework type of review was a mediator that had a negative significant impact on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement.

Table 19 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C2 and C3, but not C1, showed significant effect differences because 0 was not in the ranges of the 95% confidence interval. In other words, the effects of applying the mathematics and review were both significant, with applying the mathematics positive and review negative. However, covering the ideas did not have a significant effect.

Conclusion. In this path analysis, I used a sample of 287 students. Overall, OTL on posttest 2 as the predictor and the three mediators used in the path analysis are valid.

Approximately 39% of the variance in the *PTM* posttest 2 was accounted for by the predictor through these three mediators. The total indirect effect of teachers' reported OTL on *Pre-Transition Mathematics* posttest 2 on achievement measured by the same test was positive and statistically significant (.22). The specific effects for covering the ideas, applying the mathematics, and review were .12, .20, and -.10, respectively. Applying the mathematics and review had significant impacts on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement, with applying the mathematics having a positive effect and review having a negative effect. Covering the ideas had no significant effect. This led to the significantly different effect between covering the ideas and applying the mathematics.

Using *PTM* posttest 3 achievement as dependent variable. Overall, the whole model shows that OTL on posttest 3 as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *PTM* posttest 1, (F (5, 281) = 49.30, $p < .001$.). The R^2 was .52 and adjusted R^2 was .51, indicating that 51% of variance in the *PTM* posttest 3 was accounted for by OTL on posttest 3 through the three mediators.

The total effect (i.e., direct and indirect effects) of the teachers' reported OTL on *PTM* posttest 3 on the impact of the posttest 3 achievement (c path) was significant, $t = 9.64$, $p < .001$. The direct effect of teachers' reported *PTM* posttest 3 OTL (c′ path) to *PTM* posttest 3 achievement was significant as well, $t = 6.82$, $p < .001$. The partial effect of teachers' reported *PTM* posttest 3 OTL on *PTM* posttest 3 after controlling for pretest score was significant too, $t = 8.49$, $p < .001$. All the direct effects of OTL on posttest 3 achievement on the three mediators (Covering, Applying, and Review) were significant at the level of at least .001. The direct effect of homework covering the ideas on the posttest 3 achievement was significant at the level of at least .0001, however, homework applying the mathematics and review were not significant (*p* = .42 and *p* = .76). All the coefficients and significant levels of the direct effects are presented in Figure 16.

Table 20 reports the indirect effect of the homework types on student achievement measured by *Pre-Transition Mathematics* posttest 3.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .33 (.48 for covering + (-.14) for applying + (-.02) for review). The 95% confidence interval of the total effect ranged from .12 to .54. Because 0 was not between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the teachers' reported *PTM* posttest 3 OTL through the three mediators had significant impact on posttest 3 achievement.

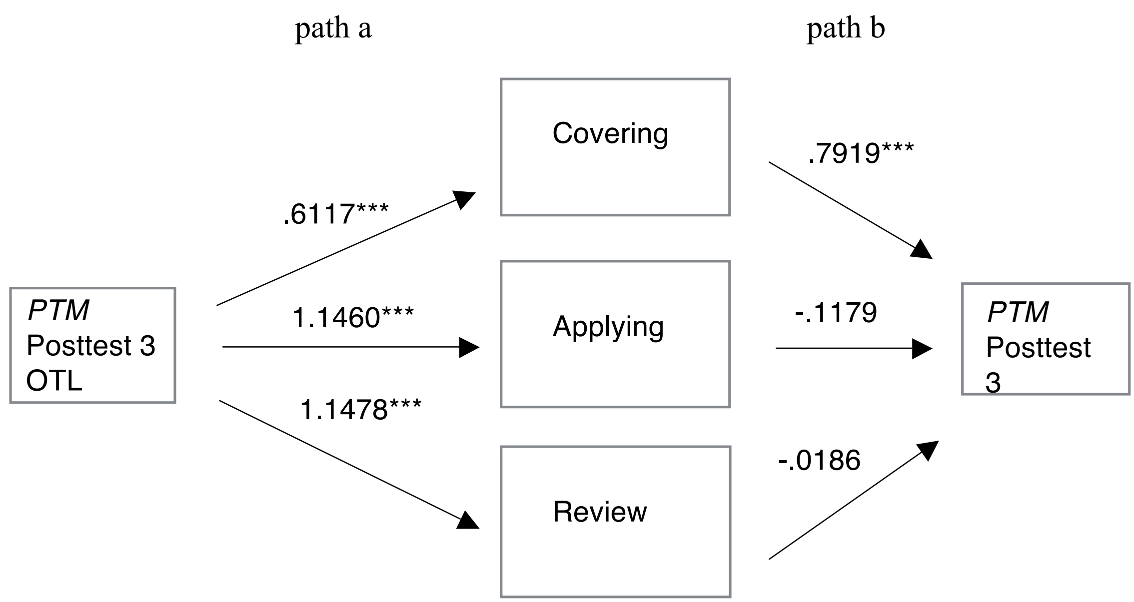

Figure 16. Coefficients and significance for path a and path b using teachers' reported OTL on *PTM* posttest 3 as the independent variable and *PTM* posttest 3 achievement as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 20

Indirect Effects of Independent Variable on Dependent Variable through Three Homework Types as Mediators for Pre-Transition Mathematics Posttest 3

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.3279	.3260	-.0019	.1065	(.1197, .5400)
Covering	.4844	.4875	.0032	.0831	(.3229, .6459)
Applying	-.1352	-.1409	-.0058	.1584	(-.4516, .1689)
Review	-.0213	-.0205	.0008	.0661	(-.1566, .1047)
C1	.6195	.6285	.0090	.2141	(.1971, 1.0411)
C2	.5057	.5081	.0024	.0957	(.3190, .6921)
C3	-.1139	-.1204	-.0065	.2069	(-.5198, .2977)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL on posttest 3 only through covering the ideas was .48 (.61 from IV to covering *. 79 from covering to DV) and confidence interval ranged from .32 to .65. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a positive significant impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement.

The true indirect effect of the OTL on posttest 3 only through applying the mathematics was -.14 (1.15 from IV to applying * -.12 from applying to DV) and confidence interval ranged from -.45 to .17. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics was not a mediator that had a significant impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement.

The true indirect effect of the OTL on posttest 3 only through review homework was -.02 (1.15 from IV to review * -.02 from review to DV) and confidence interval ranged from -.16 to .10. Because 0 was between the lower and upper limits of the bias corrected confidence interval, review homework had no significant impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement.

Table 20 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval (95% CIs in Table 20), C1 and C2 showed the significant effect differences because the value of 0 was not in the ranges of the 95% confidence interval, but not C3. This finding occurred because covering the ideas had a significant, positive effect and applying the mathematics had a significant, negative effect, whereas review had no significant effect.

Conclusion. In this path analysis, I used a sample of 287 students. Overall, OTL on posttest 3 as the predictor and the three mediators used in the path analysis are valid. Approximately 51% of the variance in the *PTM* posttest 3 was accounted for by the predictor through these three mediators. The total indirect effect of teachers' reported OTL on *Pre-Transition Mathematics* posttest 3 on achievement measured by the same test was positive and statistically significant (.33). The specific effects for covering the ideas, applying the mathematics, and review were .48, -.14, and -.02, respectively. The homework covering the ideas had a significant, positive impact on the relationship between the teachers' reported posttest 3 OTL and posttest 3 achievement, and the effect of applying the mathematics was significant but negative. Review homework had no significant effect. This leads to the significantly different effect between applying the mathematics and review.

Transition Mathematics

Using *TM* posttest 1 achievement as dependent variable. Overall, the whole model shows that OTL on posttest 1 as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *TM* posttest 1, (F (5, 231) = 34.96, $p < .001$.). The R^2 was .43 and adjusted R^2 was .42, indicating that 42% of variance in the *TM* posttest 1 was accounted for by OTL on posttest 1 through the three mediators.

The total effect (i.e., direct and indirect effects) of the teachers' reported OTL on *TM* posttest 1 on the impact of the posttest 1 achievement (c path) was not significant, $t = .99$, $p = .32$. The direct effect of teachers' reported *TM* posttest 1 OTL (c′ path) to *TM* posttest 1 achievement was not significant either, $t = -1.20$, $p = .23$. The partial effect of teachers' reported *TM* posttest 1 OTL on *TM* posttest 1 after controlling for pretest score was significant, $t = 6.73$, $p < .001$. All the direct effects of OTL on posttest 1 achievement on the three mediators (Covering, Applying, and Review) and of the three mediators on the posttest 1 achievement were significant at the level of at least .01. All the coefficients and significant levels of the direct effects are presented in Figure 17.

Table 21 reports the indirect effect of the homework types on student achievement measured by *Transition Mathematics* posttest 1.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .45 (.56 for covering + .59 for applying + (-.71) for review). The 95% confidence interval of the total effect ranged from -.07 to .99. Because 0 was between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the teachers' reported *TM* posttest 1 OTL through the three mediators had no significant impact on the posttest 1 achievement.

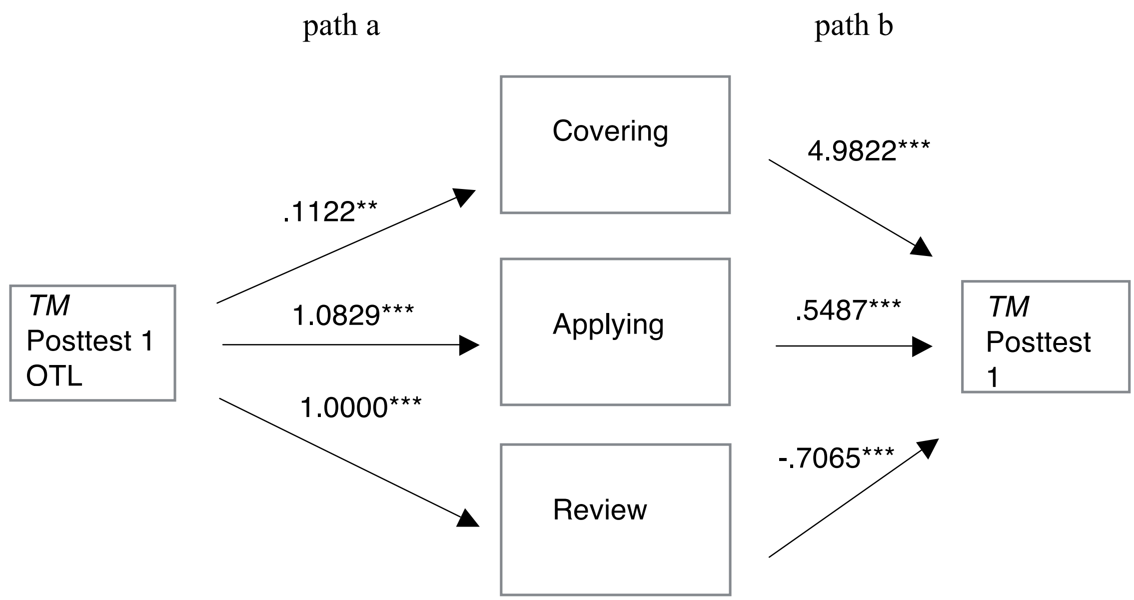

Figure 17. Coefficients and significance for path a and path b using teachers' reported OTL on *TM* posttest 1 as the independent variable and *TM* posttest 1 achievement as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 21

Indirect Effects of Independent Variable on Dependent Variable through Three Homework Types as Mediators for Transition Mathematics Posttest 1

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.4469	.4356	-.0113	.2726	(-.0736, .9890)
Covering	.5592	.5546	-.0046	.1581	(.2724, .8973)
Applying	.5942	.5805	-.0138	.3203	(-.0367, 1.2243)
Review	-.7065	-.6995	.0070	.1840	(-1.1360, -.3945)
C1	-.0350	-.0259	.0092	.2973	(-.6080, .5616)
C2	1.2657	1.2541	-.0116	.3287	(.6805, 1.9963)
C3	1.3007	1.2799	-.0208	.4621	(.4067, 2.2402)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL on posttest 1 only through covering the ideas was .56 (.11 from IV to covering * 4.98 from covering to DV) and confidence interval ranged from .27 to .90. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a positive significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement.

The true indirect effect of the OTL on posttest 1 only through applying the mathematics was .59 (1.08 from IV to applying * .55 from applying to DV) and confidence interval ranged from -.04 to 1.22. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics did not have a significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement.

The true indirect effect of the OTL on posttest 1 only through review homework was -.71 (1.00 from IV to review * -.71 from review to DV) and confidence interval ranged from -1.14 to -.39. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, review homework was a mediator that had a negative significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement.

Table 21 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval (95% CIs in Table 21), C2 and C3 showed the significant effect differences because the value of 0 was not in the ranges of the 95% confidence interval, but not C1. In other words, the effect of covering the ideas was not significant on the relationship between teachers' reported posttest 1 OTL and posttest 1 achievement. The effect of homework applying the mathematics was significant and positive and the effect of review homework was significant and negative.

Conclusion. In this path analysis, I used a sample of 237 students. Overall, OTL on posttest 1 as the predictor and the three mediators used in the path analysis are valid. Approximately 42% of the variance in the *TM* posttest 1 was accounted for by the predictor through these three mediators. The total indirect effect of teachers' reported OTL on *Transition Mathematics* posttest 1 on achievement measured by the same test was not significant. The specific effects for covering the ideas, applying the mathematics, and review were .56, .59, and -.71, respectively. Covering the ideas and review had significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement. However, the homework that applies the mathematics did not have any significant effect. This led to the significantly different effect between covering the ideas and applying the mathematics.

Using *TM* posttest 2 achievement as dependent variable. Overall, the whole model shows that OTL on posttest 2 as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *TM* posttest 2, (F (5, 231) = 35.03, p < .001). The R^2 was .43 and adjusted R^2 was .42, indicating that 42% of variance in the *TM* posttest 2 was accounted for by OTL on posttest 2 through the three mediators.

The total effect (i.e., direct and indirect effects) of the teachers' reported OTL on *TM* posttest 2 on the impact of the posttest 2 achievement (c path) was significant, t = 6.06, p < .001. The direct effect of teachers' reported *TM* posttest 2 OTL (c′ path) to *TM* posttest 2 achievement was significant was well, t = 4.37, p < .001. The partial effect of teachers' reported *TM* posttest 2 OTL on *TM* posttest 2 after controlling for pretest score was significant too, t = 7.87, p < .001. Posttest 2 OTL had a significant impact on homework applying the mathematics but no significant impact on homework covering the ideas and review. Homework covering the ideas and review had significant effect on posttest 2 achievement but homework applying the mathematics did not have a significant effect on posttest 2 achievement. All the coefficients and significant levels of the direct effects are presented in Figure 18.

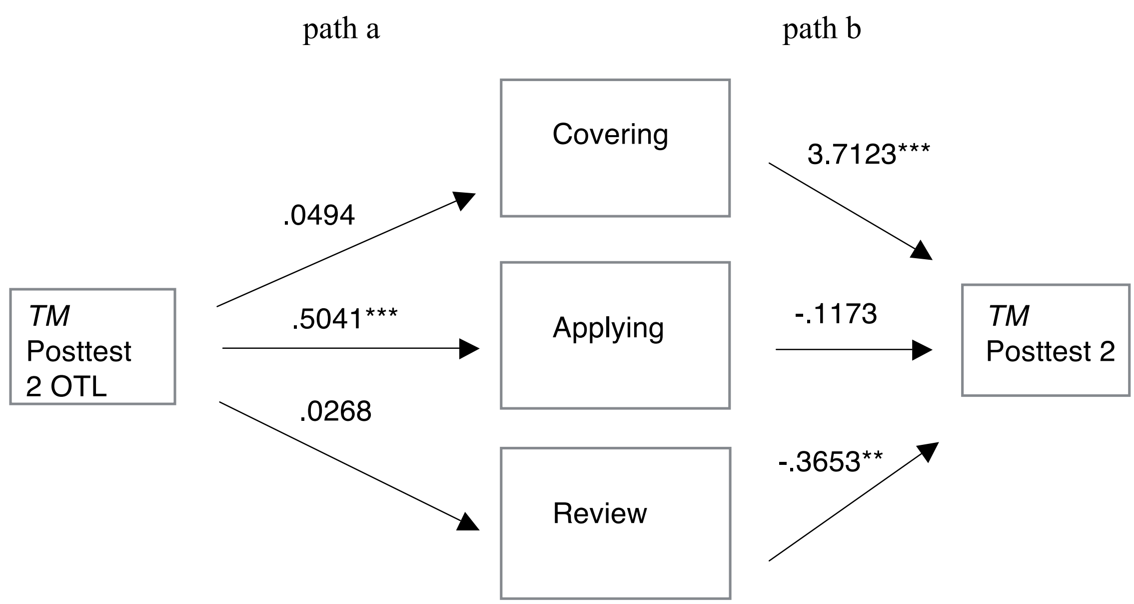

Figure 18. Coefficients and significance for path a and path b using teachers' reported OTL on *TM* posttest 2 as the independent variable and *TM* posttest 2 achievement as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 22 reports the indirect effect of the homework types on student achievement measured by *Transition Mathematics* posttest 2.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was .11 (.18 for covering + (-.06) for applying + (-.01) for review). The 95% confidence interval of the total effect ranged from -.11 to .33. Because 0 was between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the teachers' reported *TM* posttest 2 OTL through the three mediators had no significant impact on the posttest 2 achievement.

Table 22

Indirect Effects of Independent Variable on Dependent Variable through Three Homework Types as Mediators for Transition Mathematics Posttest 2

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	.1145	.1187	.0042	.1095	(-.1054, .3277)
Covering	.1834	.1688	-.0146	.0759	(.0466, .3155)
Applying	-.0591	-.0553	.0038	.0868	(-.2467, .1007)
Review	-.0098	.0053	.0150	.0775	(-.1201, .1624)
C1	.2425	.2241	-.0184	.1090	(.0551, .4456)
C2	.1932	.1635	-.0297	.1474	(-.0864, .4306)
C3	-.0493	-.0606	-.0113	.1109	(-.2120, .2358)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL on posttest 2 only through covering the ideas was .18 (.05 from IV to covering *3.71 from covering to DV) and confidence interval ranged from .05 to .32. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a positive significant impact on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement.

The true indirect effect of the OTL on posttest 2 only through applying the mathematics was -.06 (.50 from IV to applying * -.12 from applying to DV) and confidence interval ranged from -.25 to .10. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics had no significant impact on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement.

The true indirect effect of the OTL on posttest 2 only through review homework was -.01 (.03 from IV to review * -.37 from review to DV) and confidence interval ranged from -.12 to .16. Because 0 was between the lower and upper limits of the bias corrected confidence interval, review homework had no significant impact on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement.

Table 22 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C1 showed the significant effect differences because 0 was not in the range of the 95% confidence interval, but not C2 and C3. In other words, there were no effects of homework applying the mathematics and review. This finding occurred because homework covering the ideas had a significant positive impact on the relationship of posttest 2 OTL and posttest 2 achievement whereas homework applying the mathematics and review had no significant indirect effect.

Conclusion. In this path analysis, I used a sample of 237 students. Overall, OTL on posttest 2 as the predictor and the three mediators used in the path analysis are valid. Approximately 42% of the variance in the *TM* posttest 2 was accounted for by the predictor through these three mediators. The total indirect effect of teachers' reported OTL on *Transition Mathematics* posttest 2 on achievement measured by the same test was not statistically significant (.11). The specific effects for covering the ideas, applying the mathematics, and review were .18, -.06, and -.01, respectively. Covering the ideas had a positive, significant impact on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement. However, applying the mathematics and review did not have any significant impact. This leads to the significantly different effect between covering the ideas and review and between applying the mathematics and review.

Using *TM* posttest 3 achievement as dependent variable. Overall, the whole model shows that OTL on posttest 3 as a predictor via three mediators (i.e., Covering, Applying, and

Review) in path analysis had significant impact on *TM* posttest 3, (F (5, 231) = 84.74, p < .001.). The R^2 was .65 and adjusted R^2 was .64, indicating that 64% of variance in the *TM* posttest 3 was accounted for by OTL on posttest 3 through the three mediators.

The total effect (i.e., direct and indirect effects) of the teachers' reported OTL on *TM* posttest 3 on the impact of the posttest 3 achievement (c path) was not significant, t = 1.33, p = .19. The direct effect of teachers' reported *TM* posttest 3 OTL (c′ path) to *TM* posttest 3 achievement was not significant either, t = 1.60, p = .11. The partial effect of teachers' reported *TM* posttest 3 OTL on *TM* posttest 3 after controlling for pretest score was significant, t = 15.77, p < .001. The direct effects of OTL on posttest 3 achievement on the homework covering the ideas and review were significant at the level of at least .001, however applying the mathematics was not significant. Homework covering the ideas and review also had significant impacts on posttest 3 achievement, however homework applying the mathematics did not have any significant impact. All the coefficients and significant levels of the direct effects are presented in Figure 19.

Table 23 reports the indirect effect of the homework types on student achievement measured by *Transition Mathematics* posttest 3.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was -.05 ((-.48) for covering + (-.02) for applying + .45 for review). The 95% confidence interval of the total effect ranged from -.20 to .12. Because 0 was between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the teachers' reported *TM* posttest 3 OTL through the three mediators had no significant impacts on the posttest 3 achievement.

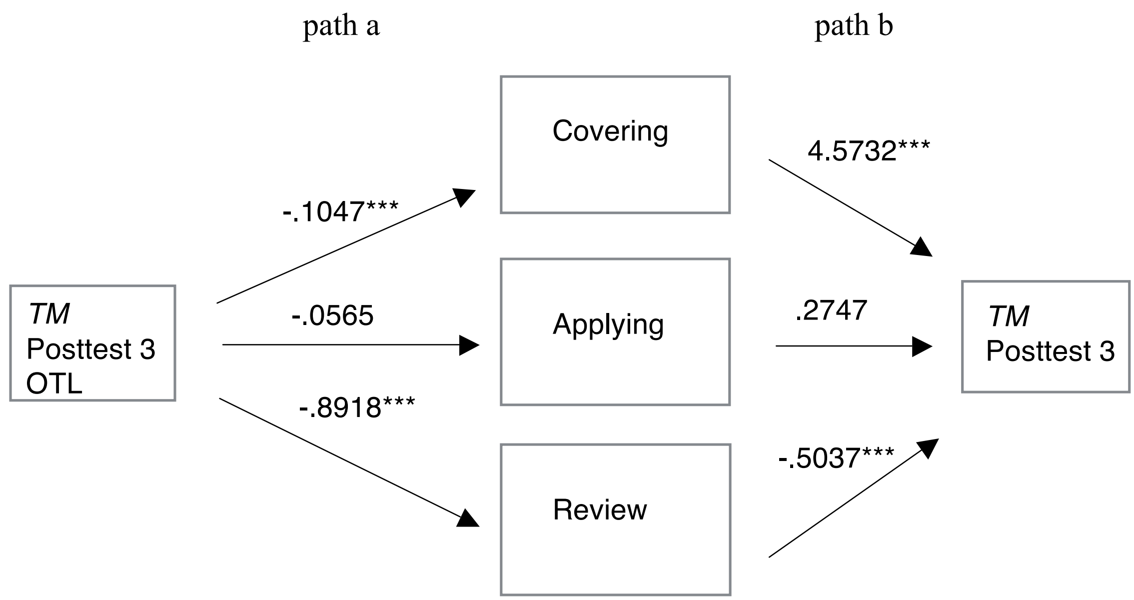

Figure 19. Coefficients and significance for path a and path b using teachers' reported OTL on *TM* posttest 3 as the independent variable and *TM* posttest 3 achievement as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 23

Indirect Effects of Independent Variable on Dependent Variable through Three Homework Types as Mediators for Transition Mathematics Posttest 3

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	-.0452	-.0414	.0038	.0827	(-.2000, .1231)
Covering	-.4789	-.4739	.0050	.0794	(-.6548, -.3369)
Applying	-.0155	-.0107	.0048	.0278	(-.1074, .0186)
Review	.4492	.4432	-.0060	.1084	(.2587, .6888)
C1	-.4634	-.4632	.0002	.0719	(-.6240, -.3378)
C2	-.9281	-.9171	.0110	.1679	(-1.3060, -.6360)
C3	-.4647	-.4539	.0109	.1275	(-.7729, .2548)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL on posttest 3 only through covering the ideas was -.02 (-.11 from IV to covering * .4.57 from covering to DV) and confidence interval ranged from

-.65 to -.34. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas had a significant, negative impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement.

The true indirect effect of the OTL on posttest 3 only through applying the mathematics was -.02 (-.06 from IV to applying * .27 from applying to DV) and confidence interval ranged from -.11 to .02. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics had no significant impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement.

The true indirect effect of the OTL on posttest 3 only through review homework was .45 (-.89 from IV to review * -.50 from review to DV) and confidence interval ranged from .26 to .69. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, review homework was a mediator that had a positive, significant impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement.

Table 23 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C1, C2 both showed the significant effect differences because the value of 0 was not in the ranges of the 95% confidence interval, but not C3. This finding occurred because covering the ideas had a significant negative impact and review had a significant positive impact on the relationship of teachers' reported posttest 3 OTL and posttest 3 achievement, but applying the mathematics had no significant indirect effect.

Conclusion. In this path analysis, I used a sample of 237 students. Overall, OTL on posttest 3 as the predictor and the three mediators used in the path analysis are valid. Approximately 64% of the variance in the *TM* posttest 3 was accounted for by the predictor through these three mediators. The total indirect effect of teachers' reported OTL on *Transition Mathematics* posttest 3 on achievement measured by the same test was not significant (-.05). The specific effects for covering the ideas, applying the mathematics, and review were -.48, -.02, and .45, respectively. Homework covering the ideas had a significant, negative impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement, and review homework had a significant, positive impact. However, applying the mathematics had no significant indirect effect. This led to the significantly different effects between covering the ideas and applying the mathematics, covering the ideas and review, and between applying the mathematics and review.

Algebra

Using *Algebra* posttest 1 achievement as dependent variable. Overall, the whole model shows that OTL on posttest 1 as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *Algebra* posttest 1, (F (5, 226) = 75.07, p < .001.). The R^2 was .62 and adjusted R^2 was .62, indicating that 62% of variance in the *Algebra* posttest 1 was accounted for by OTL on posttest 1 through the three mediators.
The total effect (i.e., direct and indirect effects) of the teachers' reported OTL on *Algebra* posttest 1 on the impact of the posttest 1 achievement (c path) was significant, t = 11.33, p < .001. The direct effect of teachers' reported *Algebra* posttest 1 OTL (c′ path) to *Algebra* posttest 1 achievement was significant as well, t = 8.11, p < .001. The partial effect of teachers' reported *Algebra* posttest 1 OTL on *Algebra* posttest 1 after controlling for pretest score was

significant too, $t = 9.42$, $p < .001$. All the direct effects of OTL on posttest 1 achievement on the three mediators (Covering, Applying, and Review) and of the three mediators on the posttest 1 achievement were significant at the level of at least .05. All the coefficients and significant levels of the direct effects are presented in Figure 20.

Table 24 reports the indirect effects of the homework types on student achievement measured by *Algebra* posttest 1.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was -.25 ((-1.06) for covering + (-.78) for applying + 1.59 for review). The 95% confidence interval of the total effect ranged from -.51 to .01. Because 0 was between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the teachers' reported *Algebra* posttest 1 OTL through the three mediators had no significant impact on the posttest 1 achievement.

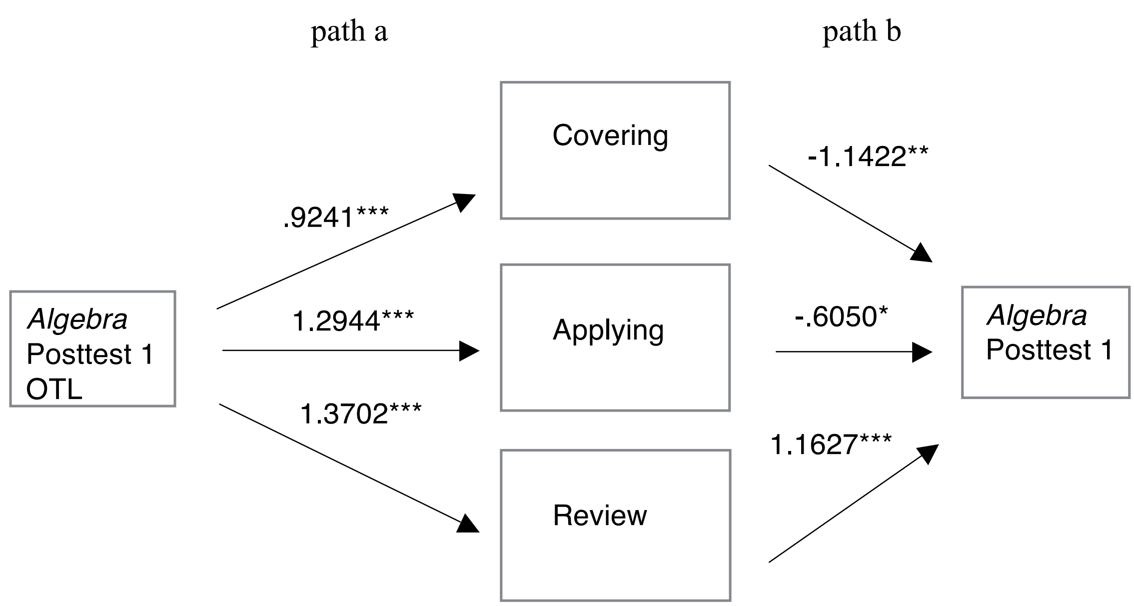

Figure 20. Coefficients and significance for path a and path b using teachers' reported OTL on *Algebra* posttest 1 as the independent variable and *Algebra* posttest 1 achievement as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 24

Indirect Effects of Independent Variable on Dependent Variable through Three Homework Types as Mediators for Algebra Mathematics Posttest 1

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	-.2456	-.2444	.0012	.1324	(-.5118, .0055)
Covering	-1.0555	-1.0463	.0093	.3851	(-1.8096, -.2975)
Applying	-.7831	-.7799	.0032	.4228	(-1.5931, 1.5818)
Review	1.5931	1.5818	-.0113	.2563	(1.1333, 2.1439)
C1	-.2724	-.2664	.0061	.7626	(-1.7145, 1.2959)
C2	-2.6486	-2.6280	.0205	.4558	(-3.5752, -1.7849)
C3	-2.3762	-2.3617	.0145	.6096	(-3.6551, -1.2558)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL on posttest 1 only through covering the ideas was -1.06 (.92 from IV to covering *-1.14 from covering to DV) and confidence interval ranged from -1.81 to -.30. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a significant negative impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement.

The true indirect effect of the OTL on posttest 1 only through applying the mathematics was -.78 (1.29 from IV to applying * -.61 from applying to DV) and confidence interval ranged from -1.67 to .00. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics had no significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement.

The true indirect effect of the OTL on posttest 1 only through review homework was 1.59 (1.37 from IV to review * 1.16 from review to DV) and confidence interval ranged from 1.13 to 2.14. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, review homework was a mediator that had a positive significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement.

Table 24 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval (95% CIs in Table 24), C2 and C3, but not C1, showed the significant effect differences because 0 was not in the ranges of the 95% confidence interval. This finding occurred because homework covering the ideas had a significant, negative indirect effect on the relationship between teachers' reported posttest 1 OTL and posttest 1 achievement, and review had a positive significant effect. But applying the mathematics did not have any significant indirect effect.

Conclusion. In this path analysis, I used a sample of 232 students. Overall, OTL on posttest 1 as the predictor and the three mediators used in the path analysis are valid. Approximately 62% of the variance in the *Algebra* posttest 1 was accounted for by the predictor through these three mediators. The total indirect effect of teachers' reported OTL on *Algebra* posttest 1 on achievement measured by the same test was statistically insignificant (-.25). The specific effects for covering the ideas, applying the mathematics, and review were -1.06, -.78, and 1.59, respectively. Homework covering the ideas had a negative, significant impact on the relationship between teachers' reported OTL on posttest 1 and posttest 1 achievement, and review had a positive, significant impact. However, applying the mathematics did not have any significant impact. This led to the significantly different effect between covering the ideas and review and between applying the mathematics and review.

Using *Algebra* posttest 2 achievement as dependent variable. Overall, the whole model shows that OTL on posttest 2 as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *Algebra* posttest 2, (F (df1, df2) = 45.79, p < .001.). The R^2 was .50 and adjusted R^2 was .49, indicating that 49% of variance in the *Algebra* posttest 2 was accounted for by OTL on posttest 2 through the three mediators.

The total effect (i.e., direct and indirect effects) of the teachers' reported OTL on *Algebra* posttest 2 on the impact of the posttest 2 achievement (c path) was significant, t = 5.39, p < 0.001. The direct effect of teachers' reported *Algebra* posttest 2 OTL (c′ path) to *Algebra* posttest 2 achievement was significant as well, t = 4.99, p < 0.001. The partial effect of teachers' reported *Algebra* posttest 2 OTL on *Algebra* posttest 2 after controlling for pretest score was significant too, t = 9.29, p < .001. All the direct effects of OTL on posttest 2 achievement on the three mediators (Covering, Applying, and Review) and of the three mediators on the posttest 2 achievement were significant at the level of at least .05. All the coefficients and significant levels of the direct effects are presented in Figure 21.

Table 25 reports the indirect effects of the homework types on student achievement measured by *Algebra* posttest 2.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was -.40 ((-1.49) for covering + (-1.27) for applying + 2.37 for review). The 95% confidence interval of the total effect ranged from -.78 to -.00. Because 0 was not between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the teachers' reported *Algebra* posttest 2 OTL through the three mediators had a negative, significant impact on the posttest 2 achievement.

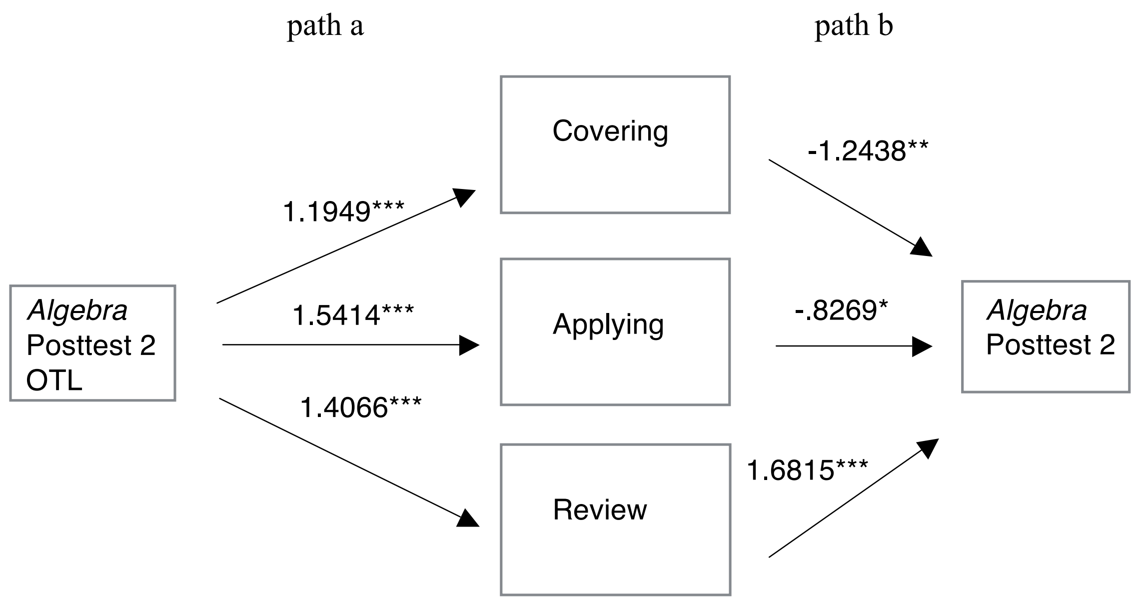

Figure 21. Coefficients and significance for path a and path b using teachers' reported OTL on *Algebra* posttest 2 as the independent variable and *Algebra* posttest 2 achievement as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 25

Indirect Effects of Independent Variable on Dependent Variable through Three Homework Types as Mediators for Algebra Posttest 2

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	-.3955	-.4018	-.0062	.1962	(-.7803, -.0046)
Covering	-1.4862	-1.4673	.0189	.5922	(-2.8239, -.4370)
Applying	-1.2745	-1.2890	-.0145	.5563	(-2.5145, -.3043)
Review	2.3653	2.3546	-.0107	.4981	(1.4910, 3.4394)
C1	-.2117	-.1783	.0334	.9661	(-2.1797, 1.6741)
C2	-3.8515	-3.8219	.0296	.9279	(-5.8868, -2.2202)
C3	-3.6398	-3.6436	-.0038	.9446	(-5.7251, -2.0274)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL on posttest 2 only through covering the ideas was -1.49 (1.19 from IV to covering *-1.24 from covering to DV) and confidence interval ranged from -2.82 to -.44. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a mediator that had a negative, significant impact on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement.

The true indirect effect of the OTL on posttest 2 only through applying the mathematics was -1.27 (1.54 from IV to applying * -.83 from applying to DV) and confidence interval ranged from -2.52 to -.30. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics had a negative, significant impact on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement.

The true indirect effect of the OTL on posttest 2 only through review homework was 2.37 (1.41 from IV to review * 1.68 from review to DV) and confidence interval ranged from 1.49 to 3.44. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, review homework was a mediator that had a positive significant impact on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement.

Table 25 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C2 and C3, but not C1, showed significant effect differences because 0 was not in the ranges of the 95% confidence interval. This finding occurred because the effect of homework covering the ideas and applying the mathematics were negative and significant on the impact of teachers' reported posttest 2 OTL on posttest 2 achievement, however, review had a positive, significant impact.

Conclusion. In this path analysis, I used a sample of 232 students. Overall, OTL on posttest 2 as the predictor and the three mediators used in the path analysis are valid.

Approximately 49% of the variance in the *Algebra* posttest 2 was accounted for by the predictor through these three mediators. The total indirect effect of teachers' reported OTL on *Algebra* posttest 2 on achievement measured by the same test was negative and statistically significant (-.40). The specific effects for covering the ideas, applying the mathematics, and review were -1.49, -1.27, and 2.37, respectively. Homework covering the ideas and applying the mathematics had negative, significant impacts on the relationship between teachers' reported OTL on posttest 2 and posttest 2 achievement, and review had a positive, significant impact. This led to the significantly different effects between covering the ideas and review and between applying the mathematics and review.

Using *Algebra* posttest 3 achievement as dependent variable. Overall, the whole model shows that OTL on posttest 3 as a predictor via three mediators (i.e., Covering, Applying, and Review) in path analysis had significant impact on *Algebra* posttest 3, (F (5, 226) = 89.82, p < .001.). The R^2 was .67 and adjusted R^2 was .66, indicating that 66% of variance in the *Algebra* posttest 3 was accounted for by OTL on posttest 3 through the three mediators.

The total effect (i.e., direct and indirect effects) of the teachers' reported OTL on *Algebra* posttest 3 on the impact of the posttest 3 achievement (c path) was significant, t = 11.96, p < .001. The direct effect of teachers' reported *Algebra* posttest 3 OTL (c′ path) to *Algebra* posttest 3 achievement was significant as well, t = 9.51, p < .001. The partial effect of teachers' reported *Algebra* posttest 3 OTL on *Algebra* posttest 3 achievement after controlling for pretest score was significant too, t = 11.56, p < .001. All the direct effects of OTL on posttest 3 achievement on the three mediators (Covering, Applying, and Review) were significant at the level of at least .001. Homework covering the ideas and review had significant impact on the *Algebra* posttest 3 achievement at the level of at least .001, however, homework applying the mathematics did not have any significant effect. All the coefficients and significant levels of the direct effects are presented in Figure 22.

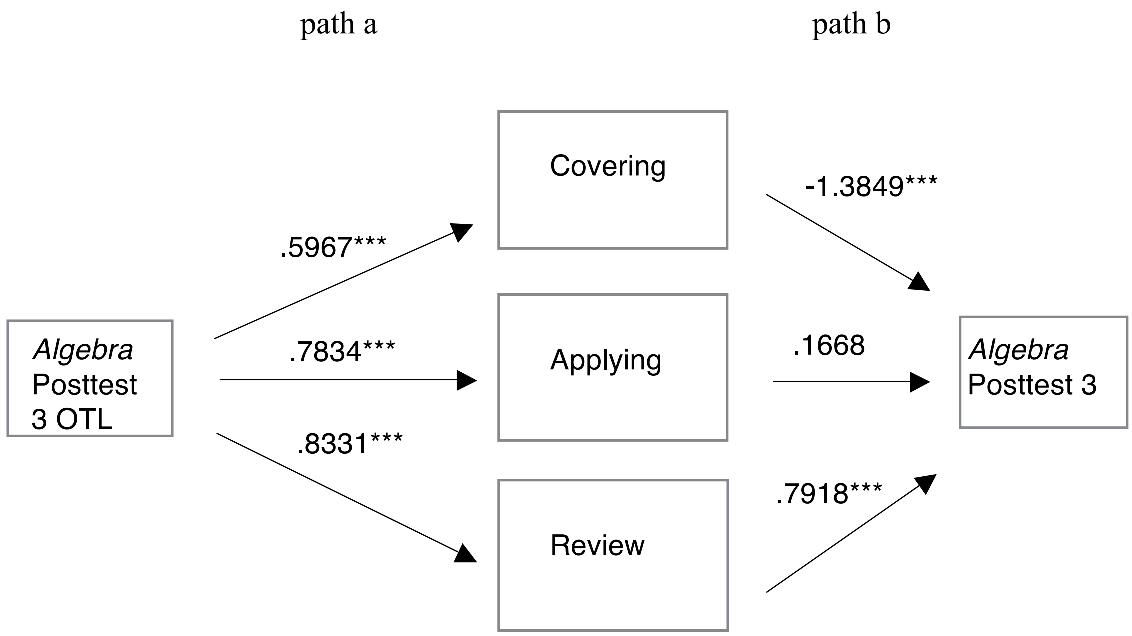

Figure 22. Coefficients and significance for path a and path b using teachers' reported OTL on *Algebra* posttest 3 as the independent variable and *Algebra* posttest 3 achievement as the dependent variable.
Note: * indicated $p < .01$, ** indicated $p < .05$, *** indicated $p < .001$.

Table 27 reports the indirect effects of the homework types on student achievement measured by *Algebra* posttest 3.

Total indirect effect refers to combining indirect effects when the effects of all three mediators are considered. Total indirect effect was -.04 ((-.83) for covering + .13 for applying + .66 for review). The 95% confidence interval of the total effect ranged from -.16 to .08. Because 0 was between the lower limit and upper limit of the bias corrected confidence interval, the total indirect effect of the teachers' reported *Algebra* posttest 3 OTL through the three mediators had no significant impact on the posttest 3 achievement.

Table 27

Indirect Effects of Independent Variable on Dependent Variable through Three Homework Types as Mediators for Algebra Posttest 3

	Est. from Data	**Est. from Bootstrap**	**Bias**	**SE**	**Bias Corrected Confidence Interval**
Total	-.0361	-.0357	.0004	.0617	(-.1573, .0846)
Covering	-.8264	-.8226	.0038	.2559	(-1.3472, .6220)
Applying	.1306	.1267	-.0040	.2553	(-.3698, .6220)
Review	.6596	.6602	.0007	.1501	(.4001, .9998)
C1	-.9570	-.9493	.0077	.4864	(-1.9281, -.0314)
C2	-1.4860	-1.4829	.0031	.3060	(-2.1317, -.9266)
C3	-.5289	-.5336	-.0046	.3544	(-1.2600, .1267)

Note: C1 = Covering the ideas – Applying the mathematics; C2 = Covering the ideas – Review; C3 = Applying the mathematics – Review.

The true indirect effect of the OTL on posttest 3 only through covering the ideas was -.83 (.60 from IV to covering *-1.38 from covering to DV) and confidence interval ranged from -1.35 to -.62. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework covering the ideas was a not mediator that had significant impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement.

The true indirect effect of the OTL on posttest 3 only through applying the mathematics was .13 (.78 from IV to applying * .17 from applying to DV) and confidence interval ranged from -.37 to .62. Because 0 was between the lower and upper limits of the bias corrected confidence interval, homework applying the mathematics had no significant impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement.

The true indirect effect of the OTL on posttest 1 only through review homework was .66 (.83 from IV to review * .79 from review to DV) and confidence interval ranged from .40 to 1.00. Because 0 was not between the lower and upper limits of the bias corrected confidence interval, review homework was a mediator that had a positive significant impact on the relationship between teachers' reported OTL on posttest 3 and posttest 3 achievement.

Table 26 also shows the comparisons of the three indirect effects for the mediators denoted by C1, C2, and C3. C1, C2, C3 represent the effect differences between covering the ideas and applying the mathematics, between covering the ideas and review, and between applying the mathematics and review, respectively. Based on the estimates of the 95% confidence interval, C1 and C2, but not C3, showed the significant effect differences because the value of 0 was not in the ranges of the 95% confidence interval. This finding occurred because d review homework had a positive significant effect on the relationship between teachers' reported posttest 3 OTL and posttest 3 achievement. But applying the mathematics and review homework did not have any significant indirect effect.

Conclusion. In this path analysis, I used a sample of 232 students. Overall, OTL on posttest 3 as the predictor and the three mediators used in the path analysis are valid. Approximately 66% of the variance in the *Algebra* posttest 3 was accounted for by the predictor through these three mediators. The total indirect effect of teachers' reported OTL on *Algebra Mathematics* posttest 3 on achievement measured by the same test was negative and statistically insignificant (-.04). The specific effects for covering the ideas, applying the mathematics, and review were -.83, .13, and .66, respectively. Review homework had a positive, significant impact. However, applying the mathematics and review did not have any significant impact. This led to the significantly different effect between covering the ideas and review and between applying the mathematics and review.

General Conclusion

The results for the true and estimated effects using teachers' reported OTL on posttests to measure OTL are reported in Table 27 and Table 28.

Table 27

True Indirect Effect for Posttest OTL

	Covering the ideas	Applying the mathematics	Review	Total
PTMOTLLC→PTMPT1	.2562*	.3056*	-.3699*	.1919*
PTMOTLLC→PTMPT2	.1235	.2019*	-.1034*	.2220*
PTMOTLLC→PTMPT3	.4844*	-.1352	-.0213	.3279*
TMOTLLC→TMPT1	.5592*	.5942	-.7065*	.4469
TMOTLLC→TMPT2	.1834*	-.0591	-.0098	.1145
TMOTLLC→TMPT3	-.4789*	-.0155	.4492*	-.0452
AOTLLC→APT1	-1.0555*	-.7831	1.5931*	-.2456
AOTLLC→APT2	-1.4862*	-1.2745*	2.3653*	-.3955*
AOTLLC→APT3	-.8264*	.1306	.6596*	-.0361

Note: *indicates the bias corrected confidence interval does not contain zero, hence the effect is statistically significant.

Table 28

Estimated Indirect Effect for Posttest OTL

	Covering the ideas	Applying the mathematics	Review	Total
PTMOTLLC→PTMPT1	.2565*	.3031*	-.3691*	.1905*
PTMOTLLC→PTMPT2	.1247	.2013*	-.1036*	.2223*
PTMOTLLC→PTMPT3	.4875*	-.1409	.0205	.3260*
TMOTLLC→TMPT1	.5546*	.5805	-.6995*	.4356
TMOTLLC→TMPT2	.1688*	-.0553	.0053	.1187
TMOTLLC→TMPT3	-.4739*	-.0107	.4432*	-.0414
AOTLLC→APT1	-1.0463*	-.7799	1.5818*	-.2444
AOTLLC→APT2	-1.4673*	-1.2890*	2.3546*	-.4018*
AOTLLC→APT3	-.8226*	.1267	.6602*	-.0357

Note: *indicates the bias corrected confidence interval does not contain zero, hence the effect is statistically significant.

Conclusion from Mediation Effects of Types of Homework (Research Question 4)

The final research question focuses on relationships leading to the mediation effects: What can I conclude from the difference of mediation effects of types of homework on the correlation of opportunity to learn measured by lesson coverage and mathematics achievement and on the correlation of teachers' reported opportunity to learn on posttests and mathematics achievement?

The results of the true and estimated indirect effects of the three types of homework on the correlation between OTL measured by lesson coverage and student mathematics achievement measured by 3 posttests, respectively, are summarized in Table 29, Table 30, and Table 31. Significant indirect effect indicates mediating effect of the type of homework.

Table 29

Covering the Ideas Homework Type Indirect Effect Results

Posttests	**Est. IE from Data using OTL LC**	**Est. IE from Bootstrapping using OTL LC**	**Est. IE from Data using Posttest OTL**	**Est. IE from Bootstrapping using Posttest OTL**
PTM **Posttest 1**	.0147	.0146	.2562*	.2565*
PTM **Posttest 2**	.0136	.0136	.1235	.1247
PTM **Posttest 3**	.0218	.0214	.4844*	.4875*
TM **Posttest 1**	.4166*	.4164*	.5592*	.5546*
TM **Posttest 2**	.3982*	.4011*	.1834*	.1688*
TM **Posttest 3**	.3600*	.3605*	-.4789*	-.4739*
Algebra **Posttest 1**	-.6771*	-.6742*	-1.0555*	-1.0463*
Algebra **Posttest 2**	-.7482*	-.7464*	-1.4862*	-1.4673*
Algebra **Posttest 3**	-.7919*	-.7938*	-.8264*	-.8226*

Note: *indicates the bias corrected confidence interval does not contain zero, hence the effect is statistically significant.

The estimated indirect effects (IE) were calculated to validate the true indirect effect within the bias corrected confidence interval. Therefore, it is not surprising that there is not much difference between each true IE and estimated IE in each model. For homework covering the ideas, all indirect effects are significant except when investigating its indirect effects on the influence of teachers' reported OTL on *PTM* posttest 2 on student mathematics achievement measured by the same test. All results for the indirect effects using *Algebra* posttests were significantly negative for both OTL measured by lesson coverage and by posttest OTL provided by teachers (See Table 30).

Table 30

Applying the Mathematics Homework Type Indirect Effect Results

Posttests	Est. IE from Data using OTL LC	Est. IE from Bootstrapping using OTL LC	Est. IE from Data using Posttest OTL	Est. IE from Bootstrapping using Posttest OTL
PTM **Posttest 1**	.1868*	.1865*	.3056*	.3031*
PTM **Posttest 2**	.0869*	.0872*	.2019*	.2013*
PTM **Posttest 3**	.1346*	.1352*	-.1352	-.1409
TM **Posttest 1**	-.0565*	-.0484*	.5942	.5805
TM **Posttest 2**	-.0609*	-.0526*	-.0591	-.0553
TM **Posttest 3**	-.0731*	-.0644*	-.0155	-.0107
Algebra **Posttest 1**	.2752	.2719	-.7831	-.7799
Algebra **Posttest 2**	.4656*	.4642*	-1.2745*	-1.2890*
Algebra **Posttest 3**	.5458*	.5474*	.1306	.1267

Note: *indicates the bias corrected confidence interval does not contain zero, hence the effect is statistically significant.

For homework applying the mathematics, the difference between using OTL measured by lesson coverage and teachers' reported posttest OTL are obvious. Using OTL measured by lesson coverage, 4 of the indirect results are significantly positive, 3 are significantly negative but the magnitude is small, and 2 have no mediating effects. Using teachers' reported posttest OTL, only 2 have significantly positive indirect effects, 6 have no mediating effects, and one is significantly negative. Such noticeable difference can be explained by the difference between what was covered in teachers' lesson coverage and teachers' perceived posttest opportunity to learn. Because of the nature of this type of homework, students are required to extend their knowledge of the mathematics concepts to situations other than what was covered in the lessons (See Table 31).

Table 31

Review Homework Type Indirect Effect Results

Posttests	**Est. IE from Data using OTL LC**	**Est. IE from Bootstrapping using OTL LC**	**Est. IE from Data using Posttest OTL**	**Est. IE from Bootstrapping using Posttest OTL**
PTM **Posttest 1**	-.1036*	-.1045*	-.3699*	-.3691*
PTM **Posttest 2**	-.0341	-.0350	-.1034*	-.1036*
PTM **Posttest 3**	-.0190	-.0200	-.0213	-.0205
TM **Posttest 1**	-.0301	-.0322	-.7065*	-.6995*
TM **Posttest 2**	-.0213	-.0249	-.0098	-.0053
TM **Posttest 3**	.0371	.0342	.4492*	.4432*
Algebra **Posttest 1**	.3642*	.3662*	1.5931*	1.5818*
Algebra **Posttest 2**	.1681*	.1704*	2.3653*	2.3546*
Algebra **Posttest 3**	.1304	.1309	.6596*	.6602*

Note: *indicates the bias corrected confidence interval does not contain zero, hence the effect is statistically significant.

The review homework type overall does not have any mediating effects except for 2 *Algebra* posttests using OTL measured by lesson coverage as the independent variable, the indirect effects in these two models are significantly positive. When using teachers' reported posttest OTL as the independent variable, 3 of the indirect effects are significantly negative, 4 of the indirect effects are significantly positive, and 2 have no mediating effects.

CHAPTER 5: DISCUSSION

In this chapter, I discuss the results of the study according to the research questions investigated: 1) How does opportunity to learn measured by lesson coverage and opportunity to learn the content of posttest items influence mathematics achievement within different mathematics courses? 2) To what extent do different types of homework influence the impact of opportunity to learn mathematics measured by lesson coverage on student mathematics achievement measured by 3 posttests in each of *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*? 3) To what extent do different types of homework influence the impact of opportunity to learn mathematics measured by posttest OTL (i.e., teacher perceived opportunity to learn the content on each posttest) on student mathematics achievement measured by each corresponding posttest in *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*? 4) What can we conclude from the difference of mediation effects of types of homework on the correlation of opportunity to learn measured by lesson coverage and mathematics achievement and on the correlation of opportunity to learn measured by posttest OTL and mathematics achievement? The discussions in this chapter include the limitations to the study, findings, implications of the findings, and future research directions.

Findings

Findings from Opportunity to Learn Measured by Lesson Coverage, Questions Assigned, and Opportunity to Learn Content on Posttest Items

Pre-Transition Mathematics. Thirteen teachers participated in the *Pre-Transition Mathematics* study. The OTL measured by lesson coverage ranged from 41% to 90%. OTL percentages measured by opportunity to learn the content on the posttest items had less variability among teachers, with reported coverage of the content on the two multiple-choice posttests ranging from 75% to 100% for TerraNova CAT 17, 75% to 100% for the UC Posttest, and from 81% to 100% on the problem-solving posttest.

Pre-Transition Mathematics teachers assigned between 60% and 100% (median = 95%) of the covering the ideas homework problems and 57% to 100% (median = 84%) of the applying the mathematics problems, but only 32% to 97% (median = 55%) of the review problems. So, there was noticeable variability in the nature of the types of homework problems assigned across the teachers in the *PTM* study with the percent of review homework assigned considerably lower than the percent of covering the ideas or applying the mathematics. Teachers seemed to place the most emphasis on covering the ideas homework as a supplement to classroom instruction, and not so much on review homework.

Transition Mathematics. For *Transition Mathematics*, 7 teachers participated in the study. The OTL measured by lesson coverage ranged between 56% and 92% (median = 80%). Similar to the findings from *Pre-Transition Mathematics*, OTL percentages measured by opportunity to learn the content on the posttests had considerable variability among teachers with reported coverage of the content on the two multiple choice posttests ranging from 70% to 92% for IAAT and 55% to 100% for the Algebra/Geometry Readiness Test but only 41% to 76% for the problem-solving test

For homework assigned by *Transition Mathematics* teachers, consistent with the findings from *Pre-Transition Mathematics*, percent of review homework was typically the lowest for teachers. Although 1 teacher assigned 91% of the review problems, another teacher assigned only 27% of these problems. However, the percent of covering the ideas and applying the mathematics questions assigned were generally higher, ranging from 91% to 99% for covering the ideas and 61-99% for applying the mathematics.

Algebra. In the *Algebra* study, there were 6 teachers. Their reported percentages of OTL measured by lesson coverage also varied. Although one teacher reported teaching 100% of the lessons, another teacher reported teaching only 47% of the lessons. Teacher reported posttest OTL also varied. However, with the exception of two teachers, teachers generally reported teaching or reviewing the content needed for posttest 1 for at least 90% of the items; the other two teachers reported teaching from 59% to 72% of these posttest items. Teachers' reported posttest 2 OTL ranged from 74% to 100% and from 7% to 100% for the problem-solving test.

Percent of homework assigned by *Algebra* teachers showed again that teachers assigned the least amount of review homework; although one teacher assigned 83% of review problems, another assigned only 2% of such problems. The percent of covering the ideas questions assigned ranged from 48% to 100% and for applying the mathematics from 25% to 99%, considerably higher than the related review problems.

Summary. There was considerable variability in OTL measured by lesson coverage across courses and teachers. The differences can perhaps be explained by teachers' educational background, work experience, and expected needs of their students. Because most of these teachers were at the middle school level or the first year of high school, tests for accountability purposes are often part of the environment. Thus, teachers may have adjusted their lesson plans to address topics that were on state or standardized tests and did not include some chapters that were part of the UCSMP curriculum but not part of their state's objectives. It is unclear why the percent of review homework assigned was so much lower than the percent of covering the ideas or applying the mathematics homework assigned. It suggests that teachers may not have understood the importance of review within the UCSMP philosophy.

Findings from Impact of OTL Measured by Lesson Coverage on Achievement

The three regression models using OTL measured by lesson coverage as the independent variable and achievement on three *PTM* posttests as dependent variables and standardized pretest scores as the covariates showed statistical significance ($p < .001$). Likewise, when using achievement on three *TM* posttests as dependent variables, OTL as measured by lesson coverage as the independent variable, and standardized pretest scores as the covariates, all three regression models showed statistical significance ($p < .001$). In addition, when using achievement on three *Algebra* posttests as dependent variables, OTL measured by lesson coverage as the independent variable, and standardized pretest scores as covariates, all three regression models also showed significant impact on *Algebra* posttest achievement ($p < .001$). In summary, the findings from the 9 regression models showed opportunity to learn measured by lesson coverage had significant impact on students' mathematics achievement across courses. These findings are consistent with research findings in the literature that OTL has a significant impact on student mathematics achievement (Floden, 2002; Stein at al., 1996; Stevens, 1993).

Findings from Impact of Teachers' Reported Posttest OTL on Achievement

When using teachers' reported opportunity to learn the content on 3 posttests as the independent variables and students' mathematics achievement as the dependent variables with standardized pretest scores as covariates, all regression models showed statistical significance for *Pre-Transition Mathematics* ($p < .001$). For *Transition Mathematics*, teachers' reported OTL on 3 posttests as the independent variables with standardized pretest scores as covariates and students' mathematics achievement as dependent variables also showed significant impact on posttest achievement in all three regression models ($p < .001$). The impact of teachers' reported posttest OTL as the independent variable with standardized pretest scores as covariates was also significant on *Algebra* posttest achievement in all three regression models ($p < .001$). Therefore, teachers' reported posttest OTL significantly predicted student mathematics achievement for all three courses. These findings agreed with Husén's (1967) finding that opportunity to learn the content assessed ultimately influences achievement.

Findings from Investigating the Extent to Which Types of Homework Impact OTL Measured by Lesson Coverage on Achievement

When examining the extent to which types of homework impact OTL measured by lesson coverage on achievement, homework *covering the ideas* had no significant effect on the relationship of OTL measured by lesson coverage and all 3 *PTM* posttests, positive mediating effects on the relationship of OTL measured by lesson coverage and all 3 *TM* posttests, and had significant, negative mediating effects on OTL measured by lesson coverage on all 3 *Algebra* posttests.

Homework *applying the mathematics* showed significant, positive mediating effects on OTL measured by lesson coverage on achievement for all three *PTM* posttests and for *Algebra* posttests 2 and 3; however, such homework showed significant and negative mediating effect on the impact of OTL measured by lesson coverage on achievement for all 3 *TM* posttests, and showed no significant effect on the impact of OTL by lesson coverage on *Algebra* posttest 1 achievement.

Review homework, in contrast, showed no significant effects on achievement for 6 of the posttests, and only showed significant, positive mediating effect on achievement for *Algebra* posttests 1 and 2, and negative and significant effect on achievement for *PTM* posttest 1.

The finding for review homework was consistent with the findings from data collection prior to the analyses where I found review homework was the least assigned homework by the teachers. This type of homework that was barely assigned had almost no significant mediating effects when controlling for the other two types of homework. Although homework covering the ideas was the most assigned homework type, it had no effect on the impact of OTL measured by lesson coverage on students' *PTM* posttest achievement, positive significant effect on *TM* posttest achievement, and negative significant effect on *Algebra* posttest achievement. Applying the mathematics, although not the most assigned, had the most significant, positive impact on achievement (for 5 out of 9 posttests). The negative mediating effects of review homework for *Algebra* could be explained by the fact that *Algebra* teachers had the least lesson coverage compared to teachers using UCSMP *PTM* and *TM* curricula. The differences in mediating effects may be due to the extent to which the items on the posttests are reflective of the types of questions in the covering and applying exercises, but verifying the similarities and differences was beyond the scope of this study. Covering the ideas questions focus on basic ideas in the lesson while applying the ideas extend such ideas; the Director of Evaluation for UCSMP suspects that the test items are more like applying questions than covering questions, but that suspicion has not been independently verified.

Findings from Investigating the Extent to Which Types of Homework Impact Teachers' Reported Posttest OTL on Achievement

When examining the extent to which types of homework impact teachers' reported posttest OTL on students' posttest achievement, the findings for all homework types showed inconsistencies across the three mathematics courses. Homework *covering the ideas* showed 4 significant, positive mediating effects in 4 of the regression models, 4 significant, negative mediating effects in 4 of the regression models, and showed no significance in 1 model. Homework *applying the mathematics* showed no significance in 5 of the models, showed significant, positive mediating effects in 3 models, and showed significant, negative mediating effect in 1 model. *Review* homework showed significant, positive mediating effects in 4 of the models, showed significant, negative mediating effects in 3 models, and showed no significant effect in 1 model.

The inconsistency in the mediating effects investigated using teachers' reported posttest OTL might be explained by a few things. First, teachers' reported posttest OTL as an independent variable was teachers' perceived coverage of posttest items. Yet in the UCSMP *TM* evaluation report's discussion, mention was made that teachers might have adjusted the curricula and supplemented with other materials addressing topics related closely to those on the state or standardized tests their students were required to take (Thompson, Senk, & Yu, 2012). Second, there were no available data on the completion of different types of homework by students. So there was no way of knowing if students benefited from the homework assignments. Third, there was no examination of how relative the posttest items were to the homework problems of the three types in the UCSMP curricula.

Conclusion

Overall, the findings showed that OTL measured by lesson coverage and by teachers' reported posttest OTL have significant impact. However, each type of homework as a mediator might have significant, positive or negative mediating effects or no mediating effects at all. The findings from having OTL measured by lesson coverage as the independent variable were more consistent within each mathematics course.

The differences of the mediating effects of types of homework on the impact of OTL measured by lesson coverage on student mathematics achievement and on the impact of teachers' reported posttest OTL on students' mathematics achievement may also be explained through the nature of the types of homework. Covering the ideas appeared to be the most assigned type of homework in each mathematics course by teachers. However, students were required to extend their knowledge beyond basic ideas covered on homework problems that apply the mathematics. Teachers in the field study might not think homework applying the mathematics and review were relevant to standardized testing. Teachers may also not have understood the perceived importance of the review problems in providing students with opportunities to master the content in accord with the philosophy of the UCSMP materials, hence resulting in the lowest percent of assignment of review homework in each course.

The negative effects in the results represent the extent to which the types of the homework reduce the impact of OTL on student mathematics achievement. This might be because there were different levels of student participants in the study in each mathematics course. Although all UCSMP courses were often used at multiple grades, the core audience for each course was students who were on grade level for the course's target grade. Advanced students often completed a course at an earlier grade than the target grade; likewise, students who were behind grade level often completed the course at a later grade than the target grade. For example, for *PTM* the target was 6^{th} graders; so, 7^{th} graders taking *PTM* were often weaker than the 6^{th} graders. Teachers might tend to assign more homework for the weaker students. Similarly, for *TM,* there were advanced 6^{th} graders taking this course and their mathematics skills were much stronger than the 7^{th} graders. So teachers tend to assign less homework because they may perceive their advanced students do not need the extra supplement. These situations might have influenced teachers' decisions on the amount of different types of homework assigned to these students and resulted in the negative effects.

Limitations

The variables measuring OTL by lesson coverage and by opportunity to learn the content of posttest items were both based on teachers' reported data from chapter evaluation forms. There is no guarantee that teachers accurately filled out the actual coverage of the lessons and of the posttest items. As mentioned in the UCSMP evaluation report for *Transition Mathematics*, for example, teachers tend to make adjustments to their lesson plans not just according to the UCSMP curriculum but also because of test preparation pressure; as a result, they may choose to supplement their lessons with other curriculum that they are more familiar with or more aligned with test standards (Thompson, Senk, & Yu, 2012). For instance, teachers sometimes used supplementary materials for class instruction or for homework, but such assignments would not have been reflected in the percent used in the regression models.

Teacher demographics were not included as one of the independent variables, but teachers' characteristics might affect their decision-making in assigning types of homework as well as providing OTL according to the UCSMP curricula. It could also be that their decisions were affected by their own backgrounds, their perceptions of their students' abilities, as well as overall school expectations on the amount of homework students do, as mentioned in the conclusions from the findings. It is also not clear how prior experience with a UCSMP curriculum, particularly with *Transition Mathematics* or *Algebra*, might have influenced decisions on lesson coverage or homework assigned.

The variables used to measure the amount of types of homework assigned by teachers were developed from homework assignments reported by teachers on chapter evaluation forms.

It was, however, unknown if the amount of homework assigned was actually completed by students or graded by teachers. The original dataset contains additional teacher data on homework, such as interview responses and questionnaire data on homework expectations, and additional student data on homework assigned measured by students' estimates of the hours spent in a week on homework. However, these data were not available as part of this dissertation study.

Another issue mentioned in the UCSMP evaluation report was that the pretests and posttests given to students were not included as part of students' grades. So it is unclear if students gave their best effort in completing these tests or prepared for the tests to serve the purpose of the study. Consequently, students' mathematics achievement in the courses may be underestimated by their results on the posttests used in the evaluation study.

The mathematics courses included in the study were *Pre-Transition Mathematics*, *Transition Mathematics*, and *Algebra*. These courses were only three courses out of seven courses developed and field-tested by UCSMP from 2005-2008. The nature of these mathematics courses meant they were to be studied by students of different grades, sometimes with advanced students taking the course at an earlier grade level than intended, and with below grade level students taking the course at a later grade than intended. Advanced students normally have higher achievement and below grade level students have lower achievement than students who were taking the course at grade level. However, in this study, grade level for each course was not considered as a variable, and it was not feasible to analyze data for each course by grade level. Thus, differences in results across courses became inevitable. Consequently, the results were not consistent across courses, and therefore, care should be taken in making generalizations. It may be that differences in the mathematics courses and the nature of students taking those courses play a part in the differences in effects of types of homework.

Finally, OTL investigated in this study was measured by lesson coverage and teachers' reports of whether they taught or reviewed the content of the items on the posttest. However, there should be more dimensions to OTL, especially from students' perspectives. Unfortunately, such data were not available on homework types, such as which types of homework students found the most useful or easiest to complete.

Implications

Through the findings of the study, I hope to provide teachers insight on factors to consider when assigning homework in order to maximize students' mathematics achievement with opportunities to learn mathematics.

Few studies in the literature have investigated types of homework problems in relation with OTL. Available studies have focused only on the impact of the amount of homework problems assigned or time spent on homework on student mathematics achievement. The present study shows that OTL has significant impact on student achievement. Most models conducted in this study have shown that homework types have significant mediating effect on the relationship between opportunity to learn and student mathematics achievement. These effects can be either positive or negative. Thus, it is essential for teachers to understand the different effects of different types of homework with respect to the mathematics courses in order to enhance student mathematics performance. The differences among different effects of types of homework show that sometimes assigning certain types of homework may hinder student learning.

The findings in this study might provide teachers and educators a new angle for making homework assignment decisions and also add to the limited existing literature on homework types in mathematics education. Homework types that were examined in this study are the most common types of homework problems teachers assign in mathematics classrooms. Covering the ideas homework was the most assigned by teachers in this study; however, such homework did not show the most significant mediating effect. Applying the mathematics homework was less assigned by teachers across courses in this study, and yet showed more positive mediating effect than covering the ideas homework. This could mean that homework problems that go beyond what students have learned in class might benefit them more in developing conceptual understanding of the content of the curricula than homework that is too basic. The inconsistencies of the findings prevented me from drawing definite conclusions. But the results raise questions for teachers, educators, and policy makers beyond making decisions on what types of homework questions to assign to students; they might consider whether to assign certain type of homework at times if such homework type has no mediating effect or might even hinder student achievement when it's irrelevant to what might be tested.

The findings of the study have the potential to inform teachers and educators on how to assign different types of homework in each mathematics course. If the mediating effect of a particular type of homework is positive on the impact of OTL on achievement, the teacher should assign more of this type of homework. Variables, such as how students completed the assigned homework (i.e., independently or in groups), accuracy, and relevance to the posttests and lessons covered, should also be taken into consideration.

Future Research

The dataset used for this study was a subset of the must larger UCSMP dataset. Therefore, there are data in the UCSMP dataset that I did not include in the study because of availability. However, I could have included variables by acquiring data such as students' reported time spent on homework each week to explain some of the negative mediating effects shown in the findings. Also, teacher perspectives towards homework in the transcription of interviews with teachers or teacher questionnaires may explain how teachers play a role in providing OTL and reasons behind their decisions. So, future research might investigate these additional aspects of homework and consider their potential to help explain the results of this dissertation study.

From the findings of the pilot study that was conducted on only 7th graders using *Transition Mathematics*, the results were more consistent for the mediating effects of different types of homework. In the present study, *TM* also included advanced 6th graders who took the same class as the 7th graders and their achievement and OTL provided by teachers. In addition, *PTM* and *Algebra* were included in this study to examine the indirect effects of the types of homework across courses. There were also potential grade differences in participants using these two curricula, because *PTM* included 6th graders and weaker 7th graders, and *Algebra* included middle and high school students. This may suggest that potential grade differences might have affected the consistency of the results of the analysis. Because the results might be more consistent within each mathematics course based on from the findings in the pilot study, for future investigation of types of homework, it would be beneficial to rerun the data after separating different grade levels in each course.

As mentioned in the literature review, studies on homework have been mostly on the amount of homework or duration of time students spent on homework assignment in relation with student mathematics achievement (Cooper, 1989; Cooper et al., 2006). The present study showed different effects of different types of homework across courses. Hence, it is necessary that educators and teachers investigate homework types from more aspects.

I recommend future studies on the same topic to minimize differences among participants by having the same group of participants beyond only controlling for their prior knowledge. More dimensions should be included to define OTL, such as including observed or recorded data in addition to teachers' self-reported data. Students' completion of different types of homework as well as their accuracy on different types of homework may also be documented as part of the data collection process.

My findings confirmed OTL as a good predictor of mathematics achievement and exposed issues related to measurement of variables using self-reported data. Although the results of mediating effects of the different types of homework were inconsistent, there is little doubt that homework types mediate the impact of OTL on achievement as a whole. Teachers tended to assign more covering the ideas and applying the mathematics homework and less review homework in this study. The results became inconsistent when specific types of homework were being examined while controlling for the other types. Through careful measurement of the exact variables that one needs to investigate the types of homework and their effects on other instructional factors and mathematics achievement, future research will have more detailed understanding of the effects of homework types than was possible in this study.

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APPENDIX A: *PRE-TRANSITION MATHEMATICS* INSTUMENTS

UCSMP

The University of Chicago School Mathematics Project

Test Number __________

ENTERING MATHEMATICS TEST

Do not open this booklet until you are told to do so.

This test contains 29 questions. You have 40 minutes to take the test.

1. All questions are multiple-choice. Some questions have four choices and some have five. There is only one correct answer to each question.

2. Using the portion of the answer sheet marked **TEST 2**, fill in the circle • corresponding to your answer beginning with question 32. Be sure to use a number 2 pencil.

3. If you want to change an answer, completely erase the first answer on your answer sheet.

4. If you do not know the answer, you may guess.

5. Use the scrap paper provided to do any writing or drawing. **DO NOT MAKE ANY STRAY MARKS IN THE TEST BOOKLET OR ON THE ANSWER SHEET.**

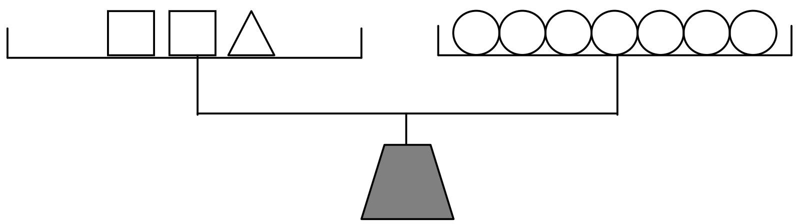
6. You may **not** use a calculator.

DO NOT TURN THE PAGE until your teacher says that you may begin.

32. Suppose that 3 × (□ + 5) = 30. The number in the box should be ______.

F. 2
G. 5
H. 10
J. 95

33. The objects on the scale below make it balance exactly.



According to this scale, if △ balances ○○○ , then □ balances which of the following?

A. ○
B. ○○
C. ○○○
D. ○○○○

34. What number can be placed in the box to make the statement below true?

15 + □ = 22 + 3

F. 7
G. 10
H. 34
J. 40

35. If there are 300 calories in 100 g of a certain food, how many calories are there in a 30 g portion of this food?

A. 90

B. 100
C. 900
D. 1000
E. 9000

36. Which of the following equals 25%?

F. 0.025
G. 0.25
H. 2.5
J. 25
K. All of (F) – (J) equal 25%.

37. $3 + 15 \div 3 - 4 \times 2 =$

A. -9
B. -2
C. 0
D. 4
E. 5

38. $\frac{2}{3} + \frac{3}{4} =$

F. $\frac{1}{2}$

G. $\frac{5}{7}$

H. $1\frac{5}{12}$

J. 2

K. $2\frac{1}{4}$

39. How many yards equals 39 feet?

A. $4\frac{1}{3}$

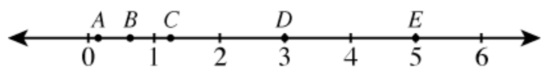
B. 13

C. 117

D. 468

E. 1404

40. Which letter represents $\frac{3}{5}$ on the number line?

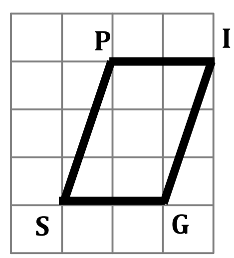


F. point A
G. point B
H. point C
J. point D
K. point E

41. -3 + 7 + -8 =

A. -18
B. -12
C. -4
D. 2
E. 4

42. Each square on the grid at the right represents 1 square unit. Find the area of figure PIGS.



F. 3 square units
G. 6 square units
H. 7 square units
J. 10 square units
K. 12 square units

43. Jim has $\frac{3}{4}$ of a yard of string which he wishes to divide into pieces, each $\frac{1}{8}$ of a yard long. How many pieces will he have?

A. 3
B. 4

C. 6
D. 8

44. Which of these is the smallest number?

F. 0.625
G. 0.25
H. 0.375
J. 0.5
K. 0.125

45. A rectangle has length of 3.6 cm and width of 5 cm. Which numerical expression gives the perimeter of the rectangle?

A. $3.6 + 5$
B. $2(3.6 + 5)$
C. 3.6×5
D. $2(3.6 \times 5)$
E. $3.6 \times 5 \times 3.6 \times 5$

46. Of the following, which is the closest approximation to a 15 percent tip on a restaurant check of $24.99?

F. $2.50
G. $3.00
H. $3.75
J. $4.50
K. $5.00

47. The total weight of a pile of 500 salt crystals is 6.5 g. What is the average weight of a salt crystal?

A. 0.0078 g
B. 0.013 g
C. 0.0325 g
D. 0.078 g

48. If $1\frac{1}{3}$ cups of flour are needed for a batch of cookies, how many cups of flour will be needed for 3 batches?

F. $4\frac{1}{3}$

G. 4

H. 3

J. $2\frac{2}{3}$

49. How many cubes 1 cm by 1 cm by 1 cm can be packed in a box measuring 2 cm by 5 cm by 6 cm?

A. 13
B. 16
C. 60
D. 70
E. 120

50. A coat that normally sells for $150 is on sale for 30% off the price. How much does Jennifer pay for the coat on sale? (Ignore sales tax.)

F. $15
G. $30
H. $45
J. $105
K. $195

51. Which of the following equals 387 centimeters?

A. 0.387 meters
B. 3.87 meters
C. 3870 meters
D. 38700 meters

52. Which of these numbers is between 0.07 and 0.08?

F. 0.00075
G. 0.0075

H. 0.075
J. 0.75

53. If $n + n + n = 60$, what is the value of n?

A. 6
B. 10
C. 15
D. 20
E. 30

54. The perimeter of a square is 36 inches. What is the length of one side of the square?

F. 4 inches
G. 6 inches
H. 9 inches
J. 18 inches

55. If you know that 10% of a number is 15, which of the following is 60% of the number?

A. 15×6
B. $15 \div 6$
C. $15 + 6$
D. $15 - 6$
E. There is not enough information to answer the question.

56. Jenny ran 2.3 miles on Monday, 0.75 miles on Tuesday, and 3 miles on Wednesday. Find the total number of miles she ran on these three days.

F. 3.08
G. 6.05
H. 10.05
J. 10.1
K. 12.8

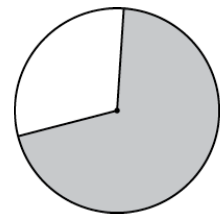
57. Sally bought 12 yards of ribbon at 80 cents per yard. She cut the ribbon into 4 equal parts and made a bow from each part. What is the cost of the ribbon for making one bow?

A. \$2.40
B. \$3.20

C. $3.94
D. $9.60

58. $2.5 \div 0.05 =$

F. 0.2
G. 0.02
H. 5
J. 50
K. 500



59. What fraction of the circle is shaded?

A. Between 0 and $\frac{1}{4}$

B. Between $\frac{1}{4}$ and $\frac{1}{2}$

C. Between $\frac{1}{2}$ and $\frac{3}{4}$

D. Between $\frac{3}{4}$ and 1

60. Which of the following means the same as $\frac{2}{3}$?

F. $2 \div 3$
G. $3 \div 2$
H. $2 - 3$
J. 2.3

UCSMP

The University of Chicago School Mathematics Project

Test Number __________

MATHEMATICS TEST ONE

<u>Do not open this booklet until you are told to do so.</u>

This test contains 36 questions. You have 40 minutes to take the test.

1. All questions are multiple-choice. Some questions have four choices and some have five. There is only one correct answer to each question.

2. Using the portion of the answer sheet marked **TEST 2**, fill in the circle • corresponding to your answers to questions 1-36. Be sure to use a number 2 pencil.

3. If you want to change an answer, completely erase the first answer on your answer sheet.

4. If you do not know the answer, you may guess.

5. Use the scrap paper provided to do any writing or drawing. **DO NOT MAKE ANY STRAY MARKS IN THE TEST BOOKLET OR ON THE ANSWER SHEET.**

6. You may **NOT** use a calculator.

DO NOT TURN THE PAGE until your teacher says that you may begin.

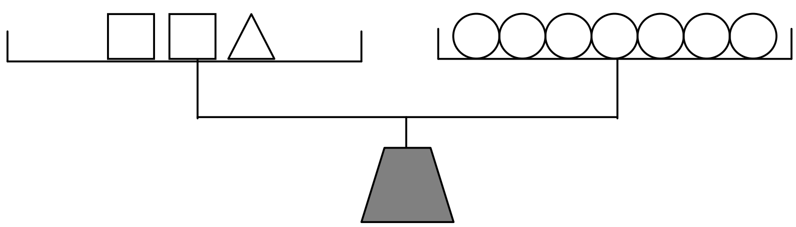
1. $3 + 15 \div 3 - 4 \times 2 =$

A. -9
B. -2
C. 0
D. 4
E. 5

2. Suppose that $3 \times (\square + 5) = 30$. The number in the box should be ______.

F. 2
G. 5
H. 10
J. 95

3. The objects on the scale below make it balance exactly.



According to this scale, if △ balances ○○○, then □ balances which of the following?

A. ○
B. ○○
C. ○○○
D. ○○○○

4. What number can be placed in the box to make the statement below true?

$$15 + \square = 22 + 3$$

F. 7
G. 10
H. 34
J. 40

5. -3 + 7 + -8 =

A. -18
B. -12
C. -4
D. 2
E. 4

6. Which sentence is true?

F. $\frac{3}{5} > 0.8$

G. $\frac{2}{5} > 0.4$

H. $\frac{2}{3} < 0.66$

J. $\frac{5}{9} > 0.5$

7. There were x boxes. Each box had s shoes in it. How many shoes are there in all?

A. $x + s$

B. $x - s$

C. $s - x$

D. xs

E. $\frac{x}{s}$

8. Which of these fractions is smallest?

F. $\frac{1}{6}$

G. $\frac{2}{3}$

H. $\frac{1}{3}$

J. $\frac{1}{2}$

9. What is the value of $\frac{4}{5} - \frac{1}{3} - \frac{1}{15}$?

A. $\frac{1}{5}$

B. $\frac{2}{5}$

C. $\frac{7}{15}$

D. $\frac{3}{4}$

E. $\frac{4}{5}$

10. Bill has b marbles. Rosa has r marbles. How many marbles do Bill and Rosa have together?

F. $b + r$

G. $b - r$

H. $r - b$

J. br

K. $\frac{b}{r}$

11. There are x students from a class on school teams. There are 40 students in the class. How many students are <u>not</u> on school teams?

A. $x + 40$

B. $x - 40$

C. $40 - x$

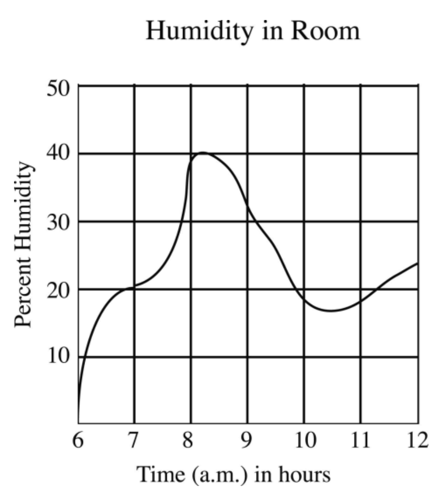
D. $40x$

E. $\frac{40}{x}$

12. Which of the following equals 25%?

F. 0.025
G. 0.25
H. 2.5
J. 25
K. All of (F) – (J) equal 25%.

13. The graph below shows the humidity in a room as recorded on a certain morning.



On the morning shown in the graph, how many times between 6 a.m. and 12 noon was the humidity exactly 20 percent?

A. One
B. Two
C. Three
D. Four

14. $\frac{2}{3} + \frac{3}{4} =$

F. $\frac{1}{2}$

G. $\frac{5}{7}$

H. $1\frac{5}{12}$

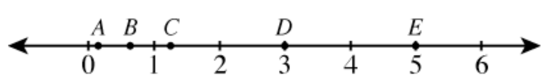
J. 2

K. $2\frac{1}{4}$

15. If there are 300 calories in 100 g of a certain food, how many calories are there in a 30 g portion of this food?

A. 90
B. 100
C. 900
D. 1000
E. 9000

16. Which point represents $\frac{3}{5}$ on the number line?



F. point A
G. point B
H. point C
J. point D
K. point E

17. The total weight of a pile of 500 salt crystals is 6.5 g. What is the average weight of a salt crystal?

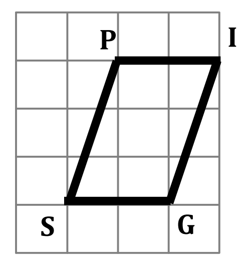
A. 0.0078 g

B. 0.013 g

C. 0.0325 g

D. 0.078 g

18. Each square on the grid at the right represents 1 square unit. Find the area of figure *PIGS*.



F. 3 square units
G. 6 square units
H. 7 square units
J. 10 square units
K. 12 square units

19. How many yards equals 39 feet?

A. $4\frac{1}{3}$

B. 13

C. 117

D. 468

E. 1404

20. Which of these is the smallest number?

F. 0.625
G. 0.25
H. 0.375
J. 0.5
K. 0.125

21. Jim has $\frac{3}{4}$ of a yard of string which he wishes to divide into pieces, each $\frac{1}{8}$ of a yard long. How many pieces will he have?

A. 3
B. 4
C. 6
D. 8

22. Of the following, which is the closest approximation to a 15 percent tip on a restaurant check of $24.99?

F. $2.50
G. $3.00
H. $3.75
J. $4.50
K. $5.00

23. A rectangle has length of 3.6 cm and width of 5 cm. Which numerical expression gives the perimeter of the rectangle?

A. $3.6 + 5$
B. $2(3.6 + 5)$
C. 3.6×5
D. $2(3.6 \times 5)$
E. $3.6 \times 5 \times 3.6 \times 5$

24. If $1\frac{1}{3}$ cups of flour are needed for a batch of cookies, how many cups of flour will be needed for 3 batches?

F. $4\frac{1}{3}$

G. 4

H. 3

J. $2\frac{2}{3}$

25. How many cubes 1 cm by 1 cm by 1 cm can be packed in a box measuring 2 cm by 5 cm by 6 cm?

A. 13
B. 16
C. 60
D. 70
E. 120

26. Which of these numbers is between 0.07 and 0.08?

F. 0.00075
G. 0.0075
H. 0.075
J. 0.75

27. Which of the following equals 387 centimeters?

A. 0.387 meters
B. 3.87 meters
C. 3870 meters
D. 38700 meters

28. A coat that normally sells for $150 is on sale for 30% off the price. How much does Jennifer pay for the coat on sale? (Ignore sales tax.)

F. $15
G. $30
H. $45
J. $105
K. $195

29. If $n + n + n = 60$, what is the value of n?

A. 6
B. 10
C. 15
D. 20
E. 30

30. The perimeter of a square is 36 inches. What is the length of one side of the square?

F. 4 inches
G. 6 inches
H. 9 inches
J. 18 inches

31. If you know that 10% of a number is 15, which of the following is 60% of the number?

A. 15×6
B. $15 \div 6$
C. $15 + 6$
D. $15 - 6$
E. There is not enough information to answer the question.

32. Jenny ran 2.3 miles on Monday, 0.75 miles on Tuesday, and 3 miles on Wednesday. Find the total number of miles she ran on these three days.

F. 3.08
G. 6.05
H. 10.05
J. 10.1
K. 12.8

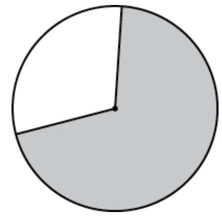
33. Sally bought 12 yards of ribbon at 80 cents per yard. She cut the ribbon into 4 equal parts and made a bow from each part. What is the cost of the ribbon for making one bow?

A. $2.40
B. $3.20
C. $3.94
D. $9.60

34. $2.5 \div 0.05 =$

F. 0.2
G. 0.02
H. 5
J. 50
K. 500

35. What fraction of the circle is shaded?



A. Between 0 and $\frac{1}{4}$

B. Between $\frac{1}{4}$ and $\frac{1}{2}$

C. Between $\frac{1}{2}$ and $\frac{3}{4}$

D. Between $\frac{3}{4}$ and 1

36. Which of the following means the same as $\frac{2}{3}$?

F. $2 \div 3$
G. $3 \div 2$
H. $2 - 3$
J. 2.3

UCSMP

The University of Chicago School Mathematics Project

Test Number ________

Problem Solving and Understanding Test

Name (Print) ______________________________________

School ______________________________________

Teacher ______________________________________

Period ______________________________________

Do you have a calculator available for use on this test? _____ Yes _____ No

If yes, what model calculator is it? ______________________________

Which is true of your calculator?

_____ It does not graph equations.

_____ It can graph equations.

Do not open this booklet until you are told to do so.

1. This test contains 16 questions.
2. You **MAY** use a calculator on this test.
3. There may be many ways to answer a question. We are interested in how you solve a problem. So, **be sure to show all your work** on the pages in the test booklet. If you use a calculator to solve a problem, be sure to explain what features or keys you used.
4. Try to do your best on each problem.
5. You have 40 minutes to answer the questions.

1. Write 0.48 as a fraction reduced to its lowest terms.

Answer: __________

2. Write a decimal between 3 and 3.1.

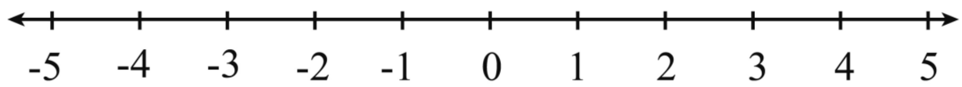
Answer: __________

3. Samuel is 4 feet 3 inches tall. How many inches tall is he?

Answer: __________

4. Graph the four points on the number line and label them with the given letter.

A = -2 B = 1.3 C = $-3\frac{1}{10}$ D = $\frac{4}{5}$



5. Carla's class is planning a picnic for the end of the school year. There will be 28 people at the picnic. She wants each person to have two bottles of water. How many packages should she buy if she buys water in packages that have 10 bottles in a package?

Answer: __________

6. One of the acute angles in a right triangle has a measure of 28 degrees. What is the measure, in degrees, of the other acute angle?

Answer: __________

7. The table at the right gives the weight of fish caught during a tournament.

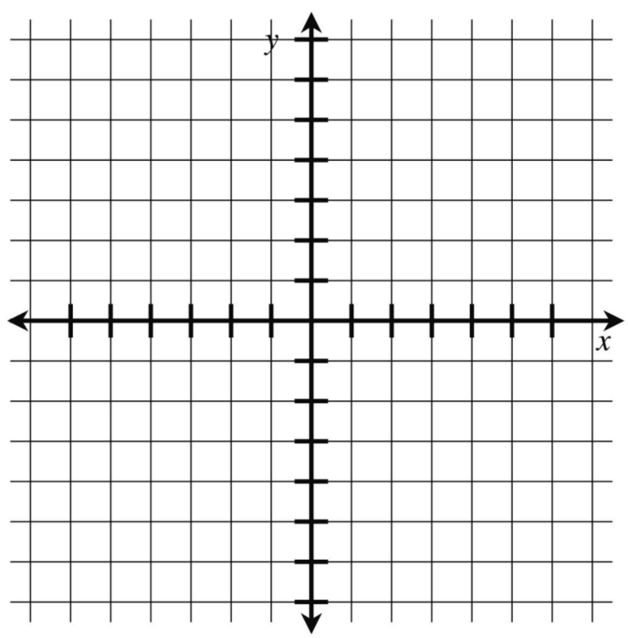
14
22
15
28
31
16
23

a. Make a stem-and-leaf plot of the data.

b. Find the range of the weights. __________

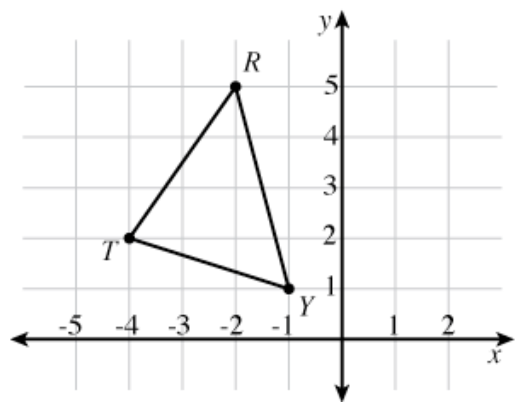
c. Find the median weight. __________

8. On the grid below, sketch the graph of $y = x + 2$.



9. In a quadrilateral, each of two angles has a measure of 115°. If the measure of a third angle is 70°, what is the measure of the remaining angle?

10. Refer to the diagram with triangle *TRY*. Give the coordinates of each point.

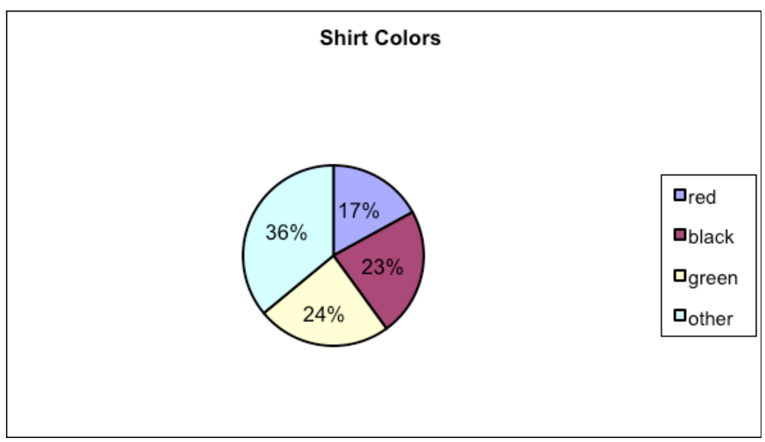


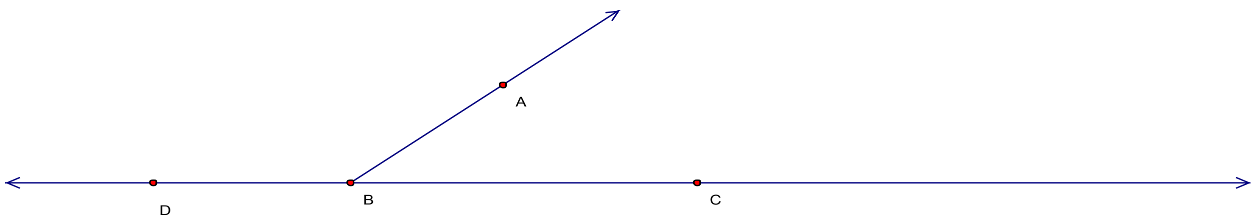
T = ______

R = ______

Y = ______

11. Refer to the graph of shirt colors worn by students in Ms. Cray's class last Monday. She has 150 students during the day. About how many of her students wore black or green shirts?





12. Refer to the figure above. $\angle DBA$ and $\angle CBA$ form a linear pair. If the measure of $\angle CBA$ is $40°$, what is the measure of $\angle DBA$?

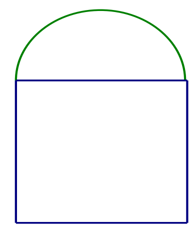
13. Ken bought a used car for $5,375. He had to pay an additional 15 percent of the purchase price to cover both sales tax and extra fees. What is the <u>total</u> amount Ken paid?

Show your work.

Answer: ____________________

14. Solve the equation $\frac{2}{3}x = \frac{4}{5}$.

15. The figure at the right consists of a square with a semicircle attached on the top. Each side of the square has a length of 20 cm. Find the area of the figure.



16. The Johnson's car gets 15 miles to the gallon, on average. The Johnson's are planning a trip of 1200 miles. If gas costs $2.75 per gallon, determine the cost of the gasoline for their trip.

APPENDIX B: *TRANSITION MATHEMATICS* INSTRUMENTS

UCSMP

The University of Chicago School Mathematics Project

Test Number ________

Middle School Mathematics Test

<u>Do not open this booklet until you are told to do so.</u>

This test contains 28 questions. You have 40 minutes to take the test.

1. All questions are multiple-choice. Some questions have four choices and some have five. There is only one correct answer to each question.

2. Using the portion of the answer sheet marked **TEST 2**, fill in the circle • corresponding to your answer. The questions on this test start at number 33.

3. If you want to change an answer, completely erase the first answer on your answer sheet.

4. If you do not know the answer, you may guess.

5. Use the scrap paper provided to do any writing or drawing. **DO NOT MAKE ANY STRAY MARKS IN THE TEST BOOKLET OR ON THE ANSWER SHEET.**

6. You may **not** use a calculator.

DO NOT TURN THE PAGE until your teacher says that you may begin.

33. If $n + n + n = 60$, what is the value of n?

A. 6
B. 10
C. 15
D. 20
E. 30

34. Bill has b marbles. Rosa has r marbles. How many marbles do Bill and Rosa have together?

F. $b + r$

G. $b - r$

H. $r - b$

J. br

K. $\frac{b}{r}$

35. There were x boxes. Each box had s shoes in it. How many shoes are there in all?

A. $x + s$

B. $x - s$

C. $s - x$

D. xs

E. $\frac{x}{s}$

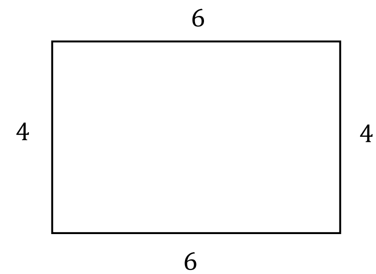
36. The perimeter of a square is 36 inches. What is the length of one side of the square?

F. 4 inches
G. 6 inches
H. 9 inches
J. 18 inches

37. What is the least whole number x for which $2x > 11$?

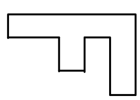
A. 5
B. 6
C. 9
D. 22
E. 23

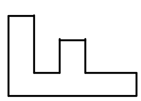
38. Which numerical expression gives the area of the rectangle at the right?

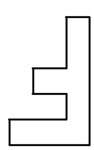


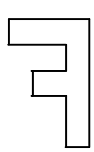
F. 4×6
G. $4 + 6$
H. $2(4 \times 6)$
J. $2(4 + 6)$
K. $4 + 6 + 4 + 6$

39. The figure to the right is shaded on the top side and white on the under side. If the figure were flipped over, its white side could look like which of the following figures?

A. 

B. 

C. 

D. 

40. Tetsu rides his bicycle x miles the first day, y miles the second day, and z miles the third day. Which of the following expressions represents the average number of miles per day that Tetsu travels?

F. $x + y + z$
G. xyz
H. $3(x + y + z)$
J. $3(xyz)$
K. $\dfrac{x + y + z}{3}$

41. Which expression describes the pattern in the first four rows of the table?

2	12
5	30
13	78
40	240
n	?

A. $n + 18$
B. $n + 10$
C. $6n$
D. $20n$
E. 360

42. A rectangle has length of 3.6 cm and width of 5 cm. Which numerical expression gives the perimeter of the rectangle?

F. $3.6 + 5$
G. $2(3.6 + 5)$
H. 3.6×5
J. $2(3.6 \times 5)$
K. $3.6 \times 5 \times 3.6 \times 5$

43. Suppose that a measurement of a rectangular box is given as 48 cubic inches. What could the measurement represent?

A. the distance around the top of the box
B. the length of an edge of the box
C. the surface area of the box
D. the volume of the box

44. Suppose that $3 \times (\square + 5) = 30$. The number in the box should be ______.

F. 2
G. 5
H. 10
J. 95

45. There are x students from a class on school teams. There are y students in the class. How many students are not on school teams?

A. $x + y$

B. $x - y$

C. $y - x$

D. xy

E. $\frac{x}{y}$

46. If m and n are not zero, which of the following is not necessarily true?

F. $m + n = n + m$

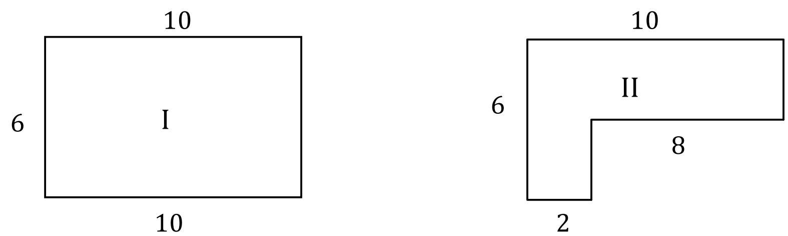
G. $m - n = n - m$

H. $mn = nm$

J. $\frac{m}{n} = \frac{2m}{2n}$

K. $2(m + n) = 2m + 2n$

47. Consider the two figures below. All of the angles are right angles. How do the perimeters of the two figures compare?



A. The perimeter of Figure I is larger than the perimeter of Figure II.
B. The perimeter of Figure II is larger than the perimeter of Figure I.
C. Both figures have the same perimeter.
D. There is not enough information given to find the perimeters of Figures I and II.

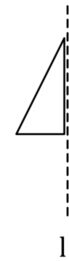
48. A plumber charges customers \$48 for each hour worked plus an additional \$9 for travel. If h represents the number of hours worked, which of the following expressions could be used to calculate the plumber's total charge in dollars?

F. $48 + 9 + h$
G. $48 \times 9 \times h$
H. $48 + (9 \times h)$
J. $(48 \times 9) + h$
K. $(48 \times h) + 9$

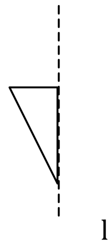
49. The dot • stands for multiplication. Suppose you can replace x by any number you wish. Which is <u>not</u> correct?

A. $x \bullet 1 = x$
B. $x + 0 = x$
C. $x \bullet 0 = 0$
D. $x + 1 = x$
E. $x - x = 0$

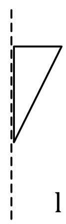
50. Consider the triangle and line shown at the right. Which of the following shows the result of flipping the triangle over the line l?



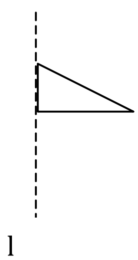
F.



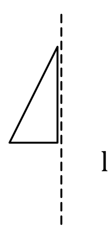
G.



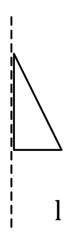
H.



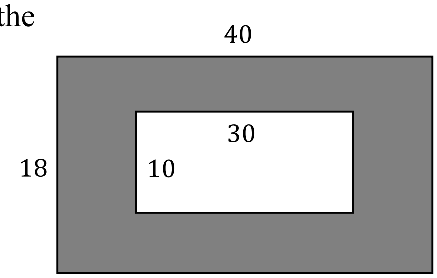
J.



K.

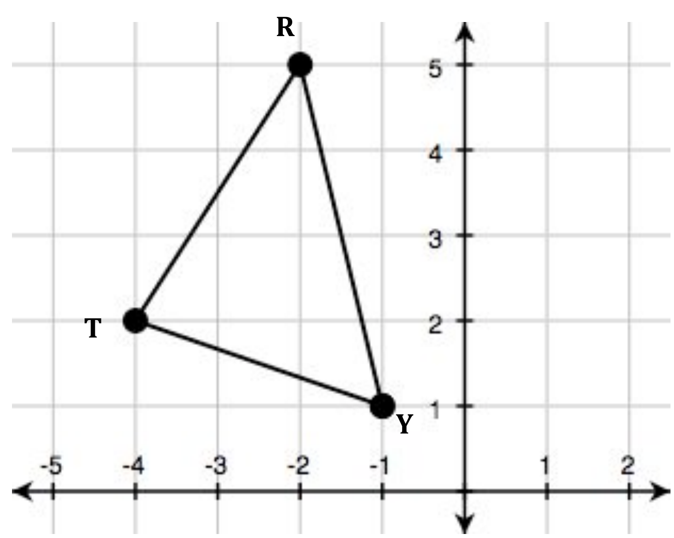


51. A rectangular pool has dimensions 10 meters by 30 meters. It is surrounded by a walkway as shown by the shading in the diagram at right. Which of the following gives the area of the walkway in square meters?



A. 40 × 18
B. 30 × 10
C. (40 × 18) – (30 × 10)
D. (40 × 18) + (30 × 10)
E. (40 – 30) × (18 – 10)

52. Triangle TRY is translated 3 units to the right and 4 units up. What will be the coordinates of the image of point Y?

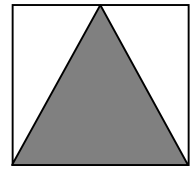


F. (3, 4)
G. (2, 5)
H. (4, 5)
J. (-4, -3)
K. (4, 3)

53. Solve: n – 3 = 2*n* + 19.

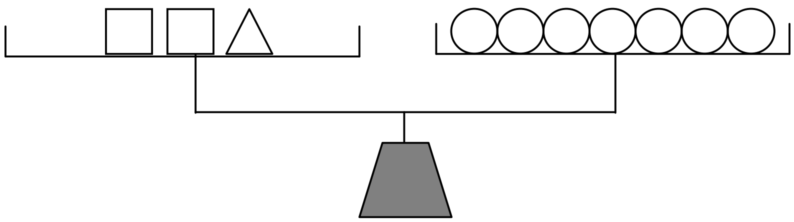
A. -57
B. -22
C. -16
D. 16
E. 22

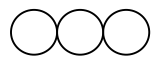
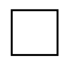
54. If the area of the shaded triangle shown at the right is 4 square inches, what is the area of the entire square?

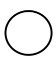
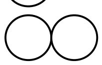
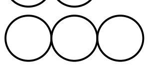
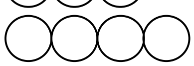


F. 4 square inches
G. 8 square inches
H. 12 square inches
J. 16 square inches
K. Not enough information given

55. The objects on the scale below make it balance exactly.



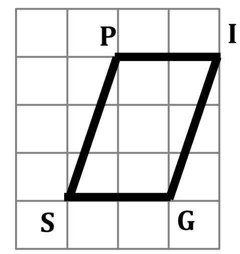
According to this scale, if  balances  , then  balances which of the following?

A. 
B. 
C. 
D. 

56. A small plastic cube has a volume of 64 cubic inches. It is going to be covered with soft fabric to make a baby toy. How much fabric will be needed to cover the cube if the fabric does not overlap?

F. 4 square inches
G. 16 square inches
H. 24 square inches
J. 96 square inches
K. 384 square inches

57. Each square on the grid at the right represents 1 square unit. Find the area of figure PIGS.



A. 3 square units
B. 6 square units
C. 7 square units
D. 10 square units
E. 12 square units

58. How many cubes 1 cm by 1 cm by 1 cm can be packed in a box measuring 2 cm by 5 cm by 6 cm?

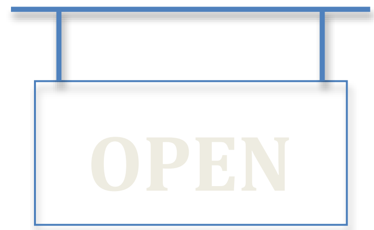
F. 13
G. 16
H. 60
J. 70
K. 120

59. Which expression fits all instances of the pattern at the right?

1	7
2	11
3	15
4	19
n	?

A. $n + 4$
B. $n + 6$
C. $3n + 4$
D. $4n$
E. $4n + 3$

60. The sign at the right is hanging in a store window. One of the hooks breaks. Which of the following shows the sign after a 90° rotation clockwise?

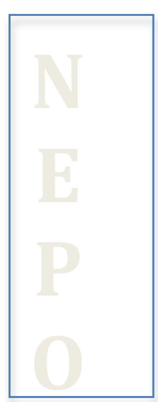


F.

G.

H.

J.



K.

UCSMP

The University of Chicago School Mathematics Project

Test Number ________

Algebra/Geometry Readiness Test: Part One

<u>Do not open this booklet until you are told to do so.</u>

This test contains 40 questions. You have 40 minutes to take the test.

1. All questions are multiple-choice. Some questions have four choices and some have five. There is only one correct answer to each question.

2. Using the portion of the answer sheet marked **TEST 2**, fill in the circle • corresponding to your answer.

3. If you want to change an answer, completely erase the first answer on your answer sheet.

4. If you do not know the answer, you may guess.

5. Use the scrap paper provided to do any writing or drawing. **DO NOT MAKE ANY STRAY MARKS IN THE TEST BOOKLET OR ON THE ANSWER SHEET.**

6. You may **not** use a calculator.

DO NOT TURN THE PAGE until your teacher says that you may begin.

1. What is the least whole number x for which $2x > 11$?

A. 5
B. 6
C. 9
D. 22
E. 23

2. Which of these fractions is smallest?

F. $\frac{1}{6}$
G. $\frac{2}{3}$
H. $\frac{1}{3}$
J. $\frac{1}{2}$

3. There were x boxes. Each box had s shoes in it. How many shoes are there in all?

A. $x + s$

B. $x - s$

C. $s - x$

D. xs

E. $\frac{x}{s}$

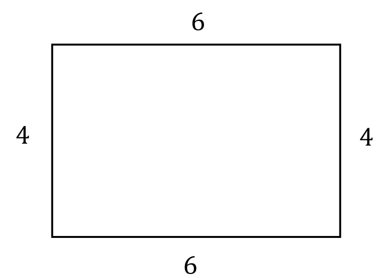
4. The perimeter of a square is 36 inches. What is the length of one side of the square?

F. 4 inches
G. 6 inches
H. 9 inches
J. 18 inches

5. Sound travels at approximately 330 meters per second. The sound of an explosion took 28 seconds to reach a person. Which of these is the closest estimate of how far away the person was from the explosion?

A. 12 000 m
B. 9000 m
C. 8000 m
D. 6000 m

6. Which numerical expression gives the area of the rectangle at the right?



F. 4×6
G. $4 + 6$
H. $2(4 \times 6)$
J. $2(4 + 6)$
K. $4 + 6 + 4 + 6$

7. If the price of a can of beans is raised from 50 cents to 60 cents, what is the percent increase in the price?

A. 83.3%
B. 20%
C. 18.2%
D. 16.7%
E. 10%

8. Tetsu rides his bicycle x miles the first day, y miles the second day, and z miles the third day. Which of the following expressions represents the average number of miles per day that Tetsu travels?

F. $x + y + z$
G. xyz
H. $3(x + y + z)$
J. $3(xyz)$
K. $\dfrac{x + y + z}{3}$

9. Which expression describes the pattern in the first four rows of the table?

2	12
5	30
13	78
40	240
n	?

A. $n + 18$
B. $n + 10$
C. $6n$
D. $20n$
E. 360

10. A rectangle has length of 3.6 cm and width of 5 cm. Which numerical expression gives the perimeter of the rectangle?

F. $3.6 + 5$
G. $2(3.6 + 5)$
H. 3.6×5
J. $2(3.6 \times 5)$
K. $3.6 \times 5 \times 3.6 \times 5$

11. Suppose that a measurement of a rectangular box is given as 48 cubic inches. What could the measurement represent?

A. the distance around the top of the box
B. the length of an edge of the box
C. the surface area of the box
D. the volume of the box

12. Suppose that $3 \times (\square + 5) = 30$. The number in the box should be _______.

F. 2
G. 5
H. 10
J. 95

13. There are x students from a class on school teams. There are y students in the class. How many students are <u>not</u> on school teams?

A. $x + y$

B. $x - y$

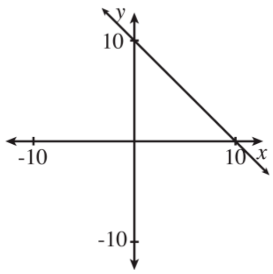
C. $y - x$

D. xy

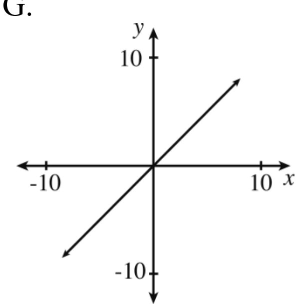
E. $\frac{x}{y}$

14. Which is the graph of the equation $x + y = 10$?

F.



G.



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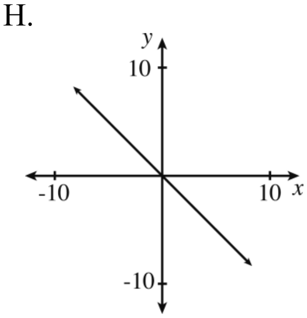
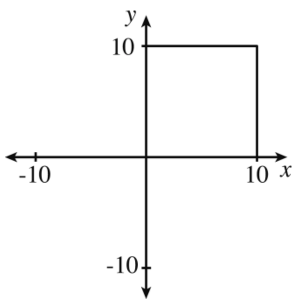
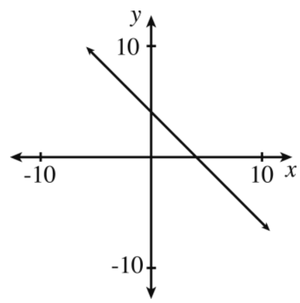


J.



K.



15. Of the following, which is NOT true for all rectangles?

A. The opposite sides are parallel.
B. The opposite sides are equal.
C. All angles are right angles.
D. The diagonals are equal.
E. The diagonals are perpendicular.

16. If m and n are not zero, which of the following is <u>not</u> necessarily true?

F. $m + n = n + m$

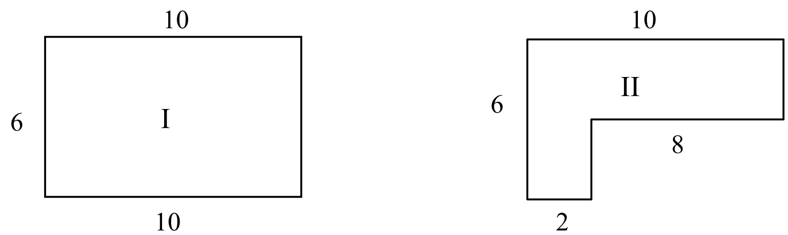
G. $m - n = n - m$

H. $mn = nm$

J. $\frac{m}{n} = \frac{2m}{2n}$

K. $2(m + n) = 2m + 2n$

17. Consider the two figures below. All of the angles are right angles. How do the perimeters of the two figures compare?



A. The perimeter of Figure I is larger than the perimeter of Figure II.
B. The perimeter of Figure II is larger than the perimeter of Figure I.
C. Both figures have the same perimeter.
D. There is not enough information given to find the perimeters of Figures I and II.

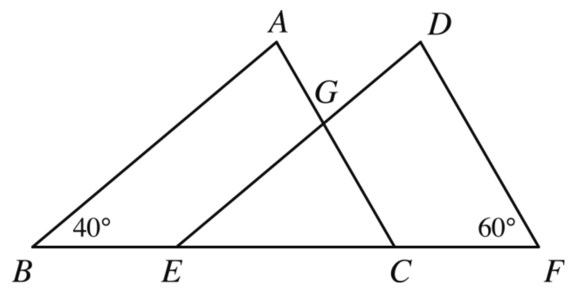
18. A plumber charges customers \$48 for each hour worked plus an additional \$9 for travel. If h represents the number of hours worked, which of the following expressions could be used to calculate the plumber's total charge in dollars?

F. $48 + 9 + h$
G. $48 \times 9 \times h$
H. $48 + (9 \times h)$
J. $(48 \times 9) + h$
K. $(48 \times h) + 9$

19. One of the acute angles in a right triangle measures 28 degrees. What is the measure, in degrees, of the other acute angle?

A. 17°
B. 28°
C. 62°
D. 90°
E. 152°

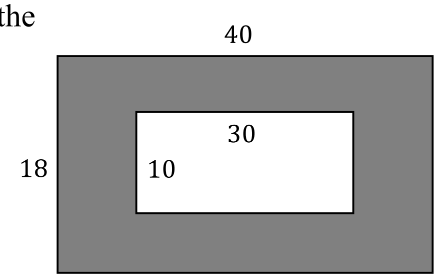
20. In this figure, triangles *ABC* and *DEF* are congruent with *BC* = *EF*.



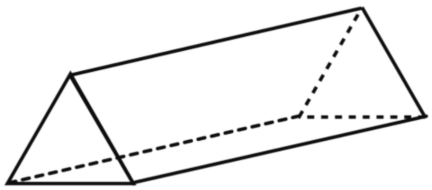
What is the measure of angle *EGC*?

F. 20°
G. 40°
H. 60°
J. 80°
K. 100°

21. A rectangular pool has dimensions 10 meters by 30 meters. It is surrounded by a walkway as shown by the shading in the diagram at right. Which of the following gives the area of the walkway in square meters?

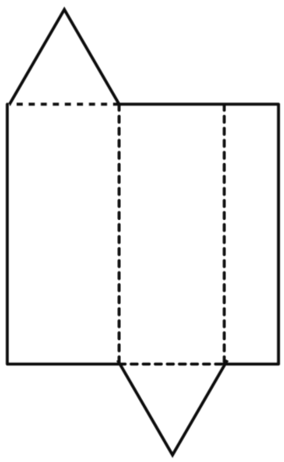


A. 40 × 18
B. 30 × 10
C. (40 × 18) – (30 × 10)
D. (40 × 18) + (30 × 10)
E. (40 – 30) × (18 – 10)

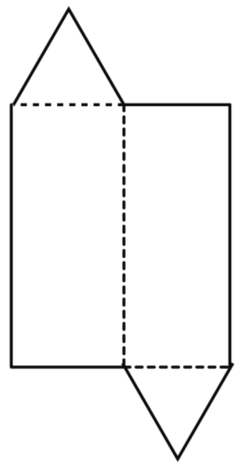


22. Which of the following can be folded to form the prism above?

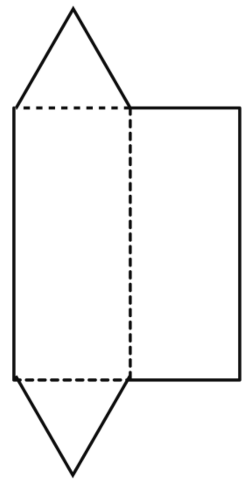
F.



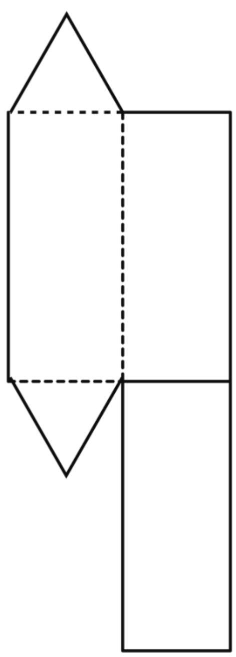
G.



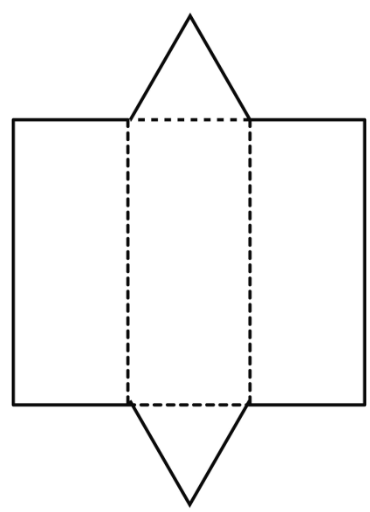
H.



J.



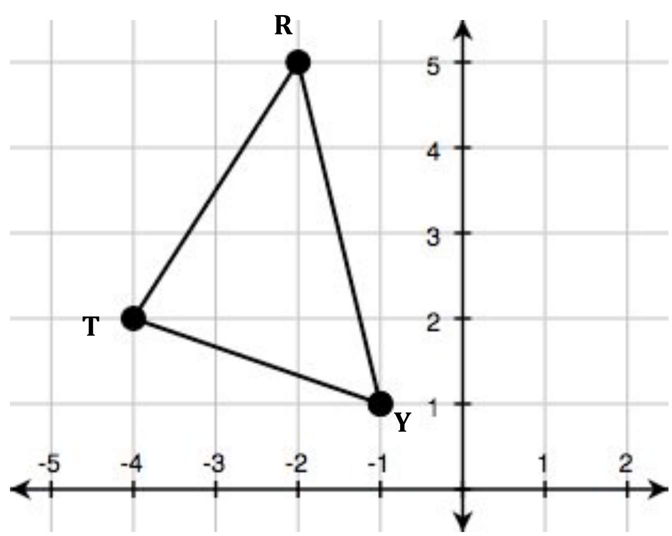
K.



23. The dot • stands for multiplication. Suppose you can replace x by any number you wish. Which is not correct?

A. $x \cdot 1 = x$
B. $x + 0 = x$
C. $x \cdot 0 = 0$
D. $x + 1 = x$
E. $x - x = 0$

24. Triangle TRY is translated 3 units to the right and 4 units up. What will be the coordinates of the image of point Y?

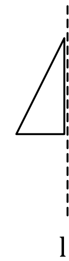


F. (3, 4)
G. (2, 5)
H. (4, 5)
J. (-4, -3)
K. (4, 3)

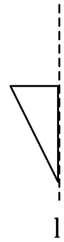
25. Solve: $n - 3 = 2n + 19$.

A. -57
B. -22
C. -16
D. 16
E. 22

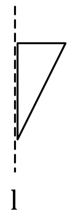
26. Consider the triangle and line shown at the right. Which of the following shows the result of flipping the triangle over the line l?



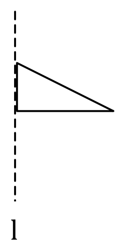
F.



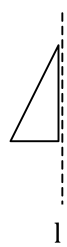
G.



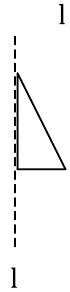
H.



J.



K.



27. What is the value of $\frac{4}{5} - \frac{1}{3} - \frac{1}{15}$?

A. $\frac{1}{5}$

B. $\frac{2}{5}$

C. $\frac{7}{15}$

D. $\frac{3}{4}$

E. $\frac{4}{5}$

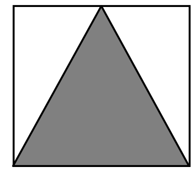
28. In a quadrilateral, each of two angles has a measure of 115°. If the measure of a third angle is 70°, what is the measure of the remaining angle?

F. 60°
G. 70°
H. 130°
J. 140°
K. None of the above.

29. Of the following, which is the closest approximation to a 15 percent tip on a restaurant check of $24.99?

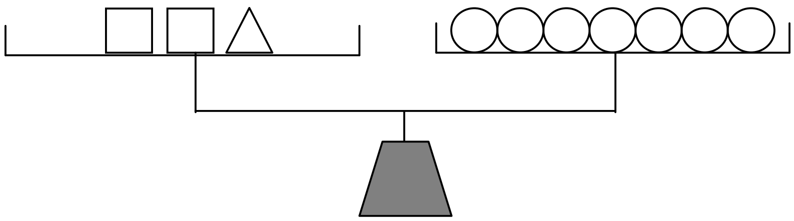
A. $2.50
B. $3.00
C. $3.75
D. $4.50
E. $5.00

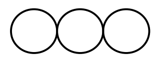
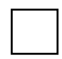
30. If the area of the shaded triangle shown at the right is 4 square inches, what is the area of the entire square?

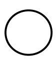


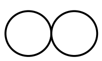
F. 4 square inches
G. 8 square inches
H. 12 square inches
J. 16 square inches
K. Not enough information given

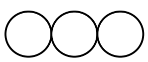
31. The objects on the scale below make it balance exactly.

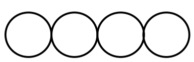


According to this scale, if  balances , then  balances which of the following?

A. 

B. 

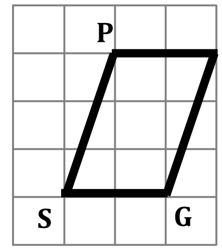
C. 

D. 

32. A small plastic cube has a volume of 64 cubic inches. It is going to be covered with soft fabric to make a baby toy. How much fabric, in square inches, will be needed to cover the cube if the fabric does not overlap?

F. 4
G. 16
H. 24
J. 96
K. 384

33. Each square on the grid at the right represents 1 square unit. Find the area of figure *PIGS* in square units.



A. 3
B. 6
C. 7
D. 10
E. 12

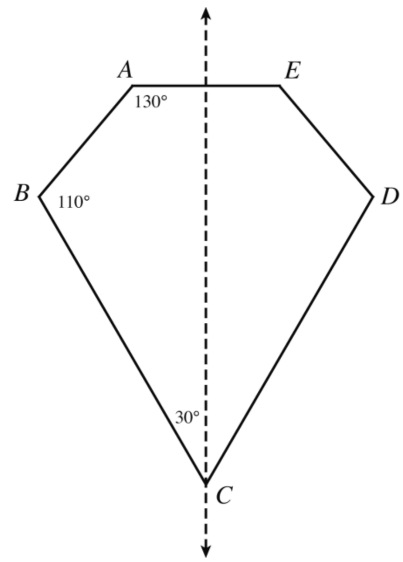
34. How many cubes 1 cm by 1 cm by 1 cm can be packed in a box measuring 2 cm by 5 cm by 6 cm?

F. 13
G. 16
H. 60
J. 70
K. 120

35. The total weight of a pile of 500 salt crystals is 6.5 g. What is the average weight of a salt crystal?

A. 0.0078 g
B. 0.013 g
C. 0.0325 g
D. 0.078 g

36. The line m is a line of symmetry for figure *ABCDE*.



The measure of angle *BCD* is

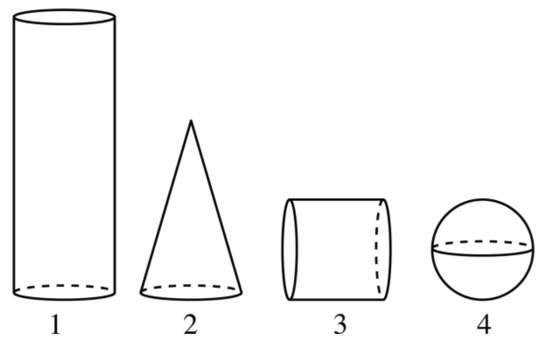
F. 30°
G. 50°
H. 60°
J. 70°
K. 110°

37. Which expression fits all instances of the pattern below?

A. $n + 4$
B. $n + 6$
C. $3n + 4$
D. $4n$
E. $4n + 3$

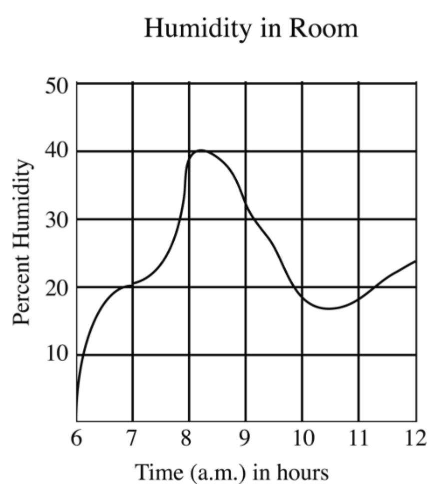
1	7
2	11
3	15
4	19
n	?

38. Which of these shapes are cylinders?



F. 1 and 2
G. 1 and 3
H. 2 and 4
J. 3 and 4

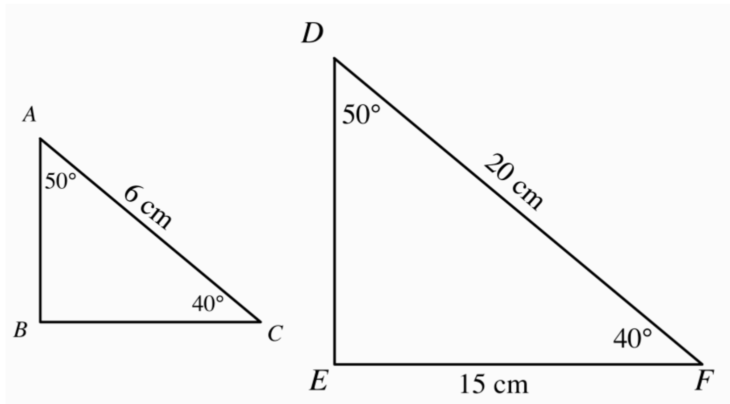
39. The graph below shows the humidity in a room as recorded on a certain morning.



On the morning shown in the graph, how many times between 6 a.m. and 12 noon was the humidity exactly 20 percent?

A. One
B. Two
C. Three
D. Four

40. The figure represents two similar triangles. The triangles are not drawn to scale.



In the actual triangle *ABC*, what is the length of side *BC*?

F. 3.5 cm
G. 4.5 cm
H. 5 cm
J. 5.5 cm
K. 8 cm

UCSMP

The University of Chicago School Mathematics Project

Test Number ________

Algebra/Geometry Readiness Test: Part Two

Name (Print) ____

School ____

Teacher____

Period ____

Do you have a calculator available for use on this test? _____ Yes _____ No

If yes, what model calculator is it? ________________________________

Which is true of your calculator?

_____ It does not graph equations.

_____ It can graph equations.

<u>Do not open this booklet until you are told to do so.</u>

1. This test contains 12 questions.

2. You may use a calculator on this test.

3. There may be many ways to answer a question. We are interested in how you solve a problem. So, be sure to show all your work on the pages in the test booklet. If you use a calculator to solve a problem, be sure to explain what features or keys you used.

4. Try to do your best on each problem.

5. You have 35 minutes to answer the questions.

1. Write 0.48 as a fraction reduced to its lowest terms.

Answer: __________

2. Write a decimal between 3 and 3.1.

Answer: __________

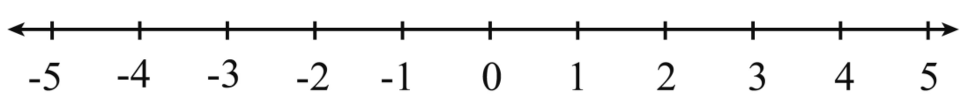
3. Laura has \$240. She spent $\frac{5}{8}$ of it. How much money did she have left?

Answer: __________

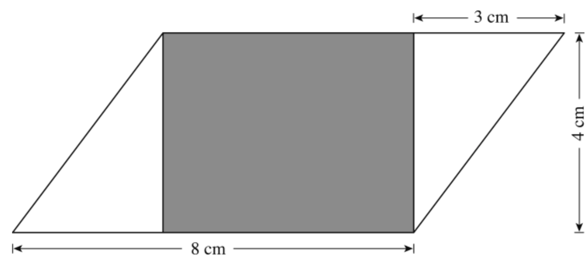
4. Find the value of x if $12x - 10 = 6x + 32$.

Answer: __________

5. Solve $x + 1 > -2$ and graph your solution on the number line below.



6. The figure shows a shaded rectangle inside a parallelogram.

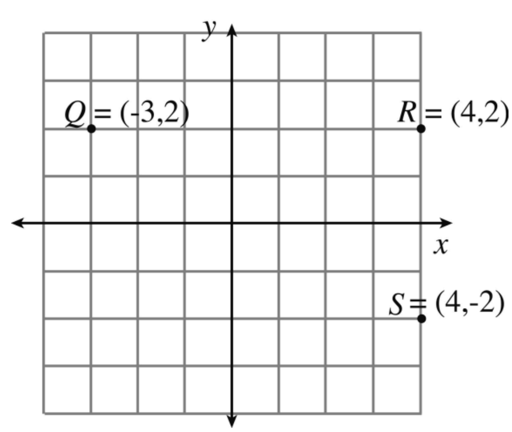


What is the area of the shaded rectangle?

Answer: ________________

7. The points Q, R, and S shown in the graph below are three vertices of rectangle $QRST$.

a. Plot and label point T so that $QRST$ is a rectangle.



b. Give the coordinates of point T. __________

8. A book publisher sent 140 copies of a certain book to a bookstore. The publisher packed the books in two types of boxes. One type of box held 8 copies of the book, and the other type held 12 copies of the book. The boxes were all full, and there were equal numbers of both types of boxes.

a. How many boxes holding 12 books were sent to the publisher?

Answer: __________

b. What fraction of the books sent to the bookstore were packed in the smaller boxes?

Answer: __________

9. Ken bought a used car for $5,375. He had to pay an additional 15 percent of the purchase price to cover both sales tax and extra fees. What is the <u>total</u> amount Ken paid?

Show your work.

Answer: ____________________

10. A club has 86 members, and there are 14 more girls than boys. How many boys and how many girls are members of the club?

Show your work.

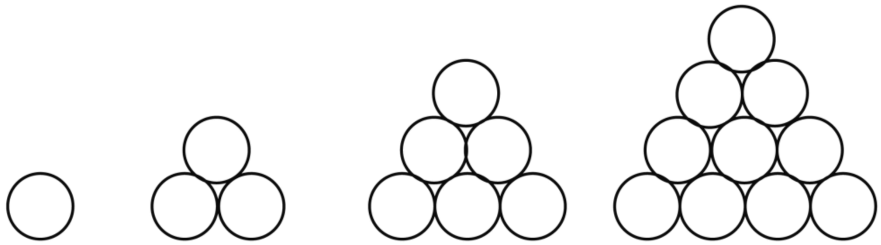
Answer: ____

11. a. For all real numbers, m, x and y, is it true that $m(x + y) = mx + y$?

_____ Yes _____ No

b. Imagine that someone does not know the answer to part **a**. Explain how you would convince that person that your answer to part **a** is correct.

12. The figures show four sets consisting of circles.



a. Complete the table below. First, fill in how many circles make up Figure 4. Then, find the number of circles that would be needed for the 5th figure if the sequence of figures is extended.

Figure	**Number of circles**
1	1
2	3
3	6
4	
5	

b. The sequence of figures is extended to the 7th figure. How many circles would be needed for Figure 7?

Answer: __________

c. The 50th figure in the sequence contains 1275 circles. Determine the number of circles in the 51st figure. Without drawing the 51st figure, explain or show how you arrived at your answer.

APPENDIX C: *ALGEBRA* INSTRUMENTS

UCSMP

The University of Chicago School Mathematics Project

Test Number ________

ENTERING ALGEBRA TEST

Do not open this booklet until you are told to do so.

This test contains 30 questions. You have 40 minutes to take the test.

1. All questions are multiple-choice. Some questions have four choices and some have five. There is only one correct answer to each question.

2. Using the portion of the answer sheet marked **TEST 2**, fill in the circle • corresponding to your answer.

3. If you want to change an answer, completely erase the first answer on your answer sheet.

4. If you do not know the answer, you may guess.

5. Use the scrap paper provided to do any writing or drawing. **DO NOT MAKE ANY STRAY MARKS IN THE TEST BOOKLET OR ON THE ANSWER SHEET.**

6. You may **not** use a calculator.

DO NOT TURN THE PAGE until your teacher says that you may begin.

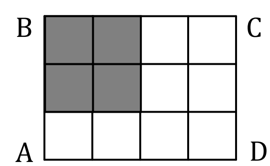
1. What are all the whole numbers that make $8 - \square > 3$ true?

A. 0, 1, 2, 3, 4, 5
B. 0, 1, 2, 3, 4
C. 0, 1, 2
D. 5

2. If $n + n + n = 60$, what is the value of n?

F. 6
G. 10
H. 15
J. 20
K. 30

3. In the figure at right, what fraction of rectangle ABCD is shaded?



A. $\frac{1}{6}$

B. $\frac{1}{5}$

C. $\frac{1}{4}$

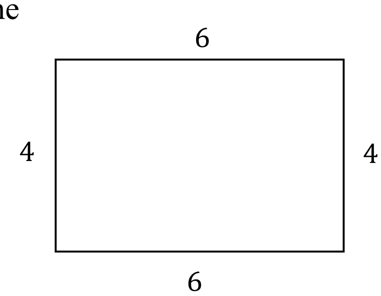
D. $\frac{1}{3}$

E. $\frac{1}{2}$

4. Which of the following ordered pairs (x, y) is a solution to the equation $2x - 3y = 6$?

F. (6, 3)
G. (3, 0)
H. (3, 2)
J. (2, 3)
K. (0, 3)

5. Which of the following numerical expressions gives the area of the rectangle at the right?



A. 4×6
B. $4 + 6$
C. $2(4 \times 6)$
D. $2(4 + 6)$
E. $4 + 6 + 4 + 6$

6. Tetsu rides his bicycle x miles the first day, y miles the second day, and z miles the third day. Which of the following expressions represents the average number of miles per day that Tetsu travels?

F. $x + y + z$
G. xyz
H. $3(x + y + z)$
J. $3(xyz)$
K. $\dfrac{x + y + z}{3}$

7. $(-5)(-7) =$

A. -35
B. -12
C. -2
D. 12
E. 35

8. If $3 + w = b$, then $w =$

F. $\dfrac{b}{3}$

G. $b \times 3$

H. $b + 3$

J. $3 - b$

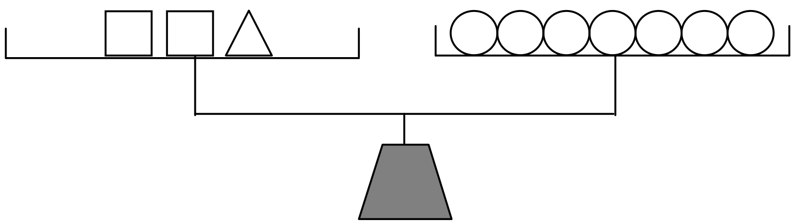
K. $b - 3$

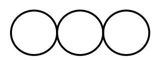
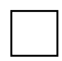
9. Which of the following equations is true for the three pairs of x and y values in the table at the right?

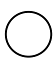
x	y
0	-3
1	-1
2	1

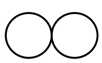
A. $3x + 2 = y$
B. $3x - 2 = y$
C. $2x + 3 = y$
D. $2x - 3 = y$
E. $x - 3 = y$

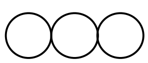
10. The objects on the scale below make it balance exactly.

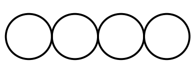


According to this scale, if  balances , then  balances which of the following?

F. 

G. 

H. 

J. 

11. $(150 \div 3) + (6 \times 2) =$

A. 10
B. 58
C. 62
D. 112

12. $\frac{2}{3} + \frac{3}{4} =$

F. $\frac{1}{2}$

G. $\frac{5}{7}$

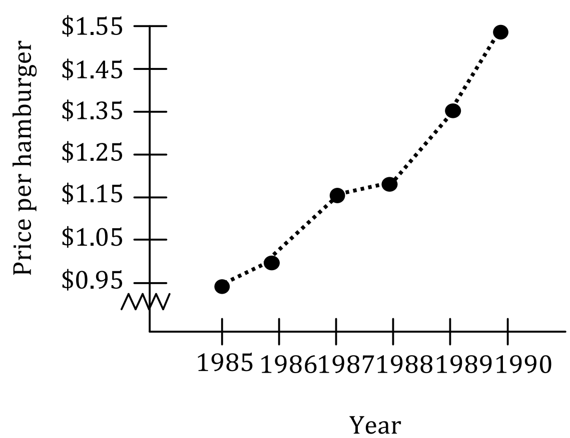
H. $1\frac{5}{12}$

J. 2

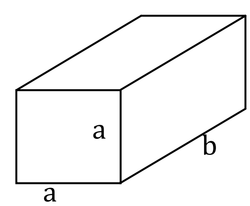
K. $2\frac{1}{4}$

13. According to the graph below, how many times did the yearly increase of the price of a hamburger exceed 10 cents?

A. None
B. One
C. Two
D. Three
E. Four



14. Consider the rectangular box at the right. Which of the following can be used to find the volume of the box?



F. $2a + b$
G. a^2b
H. $6a^2$
J. $2a^2 + 4ab$
K. $a^2 + ab$

15. Consider the table at the right with values for an expression $ax + b$. According to the table, the value of x that makes $ax + b = 7$ is ______.

x	$ax + b$
0	5
1	7
3	11
7	19
12	29

A. 1
B. 3
C. 7
D. 19
E. There is not enough information to find an answer.

16. If the list of fractions at right continues in the same pattern, which term will be equal to 0.95?

Term	Fraction
1	$\frac{1}{2}$
2	$\frac{2}{3}$
3	$\frac{3}{4}$
4	$\frac{4}{5}$
⋮	⋮

F. The 100th
G. The 95th
H. The 20th
J. The 19th
K. The 15th

17. What is the least whole number x for which $2x > 11$?

A. 5
B. 6
C. 9
D. 22
E. 23

18. A plumber charges customers $48 for each hour worked plus an additional $9 for travel. If h represents the number of hours worked, which of the following expressions could be used to calculate the plumber's total charge in dollars?

F. $48 + 9 + h$

G. $48 \times 9 \times h$

H. $48 + (9 \times h)$

J. $(48 \times 9) + h$

K. $(48 \times h) + 9$

19. The length of a rectangle is 3 more than its width. If L represents the length, what is an expression for the width?

A. $3 \div L$
B. $L \div 3$
C. $L \times 3$
D. $L + 3$
E. $L - 3$

20. $3 + 15 \div 3 - 4 \times 2 =$

F. -9
G. -2
H. 0
J. 4
K. 5

21. Which of the following is equivalent to $4(2m + 3)$?

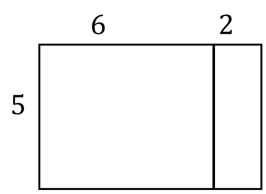
A. $8m + 3$
B. $8m + 12$
C. $16m + 12$
D. $2m + 2m + 2m + 2m + 3$
E. $8m^4 + 12$

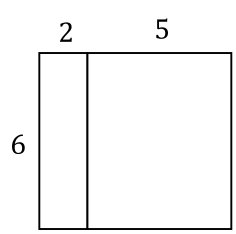
22. Jim has $\frac{3}{4}$ of a yard of string which he wishes to divide into pieces, each $\frac{1}{8}$ of a yard long. How many pieces will he have?

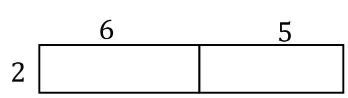
F. 3
G. 4
H. 6
J. 8

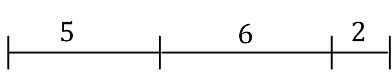
23. Which of the following figures best illustrates the statement

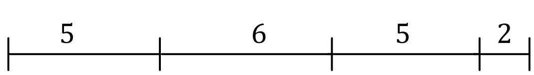
$$5 \times (6 + 2) = (5 \times 6) + (5 \times 2)$$

A. 

B. 

C. 

D. 

E. 

24. Solve: n – 3 = $2n$ + 19.

F. -57

G. -22

H. -16

J. 16

K. 22

25. $3^3 + 4(8 - 5) \div 6 =$

A. 6.5
B. 11
C. 27.5
D. 29
E. 34.16

26. Which of the following expressions is equivalent to $3p^2$?

F. $3 \times 2p$
G. $3 + p + p$
H. $3p \times 3p$
J. $3 + p \times p$
K. $3 \times p \times p$

27. Which of the following ratios is equivalent to the ratio of 6 to 4?

A. 12 to 18
B. 12 to 8
C. 8 to 6
D. 4 to 6
E. 2 to 3

28. The total distances covered by two runners during the first 28 minutes of a race are shown in the graph below. How long after the start of the race did one runner pass the other?

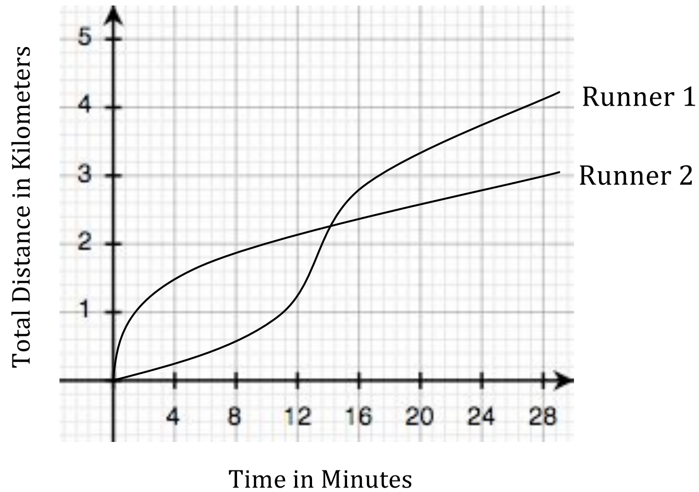
F. 3 minutes

G. 8 minutes

H. 12 minutes

J. 14 minutes

K. 28 minutes



29. If $1\frac{1}{3}$ cups of flour are needed for a batch of cookies, how many cups of flour will be needed for 3 batches?

A. $4\frac{1}{3}$

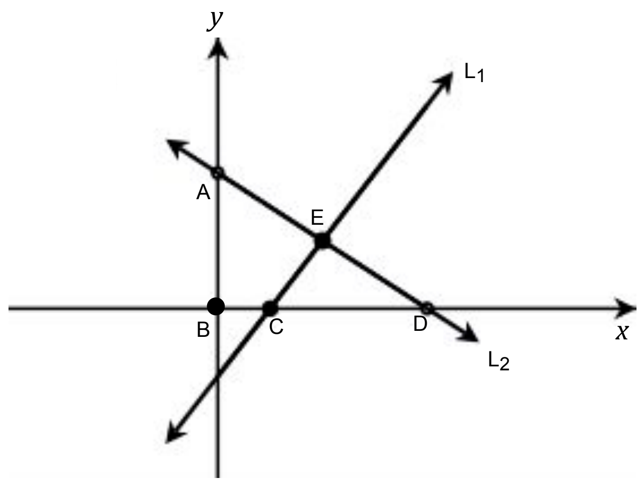
B. 4

C. 3

D. $2\frac{2}{3}$

30. Consider the graph below. Line L_1 is the graph of $y = ax + b$. Line L_2 is the graph of $y = cx + d$. Which point gives the pair of values of x and y that satisfy both equations?

F. Point A
G. Point B
H. Point C
J. Point D
K. Point E



UCSMP

The University of Chicago School Mathematics Project

Test Number ________

ALGEBRA TEST: Part One

Do not open this booklet until you are told to do so.

This test contains 38 questions. You have 40 minutes to take the test.

1. All questions are multiple-choice. Some questions have four choices and some have five. There is only one correct answer to each question.

2. Using the portion of the answer sheet marked **TEST 2**, fill in the circle • corresponding to your answer.

3. If you want to change an answer, completely erase the first answer on your answer sheet.

4. If you do not know the answer, you may guess.

5. Use the scrap paper provided to do any writing or drawing. **DO NOT MAKE ANY STRAY MARKS IN THE TEST BOOKLET OR ON THE ANSWER SHEET.**

6. You may **not** use a calculator.

DO NOT TURN THE PAGE until your teacher says that you may begin.

1. What are all the whole numbers that make $8 - \square > 3$ true?

A. 0, 1, 2, 3, 4, 5
B. 0, 1, 2, 3, 4
C. 0, 1, 2
D. 5

2. If k represents a negative number, which of these is a positive number?

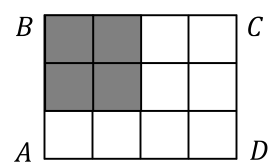
F. k^2

G. k^3

H. $2k$

J. $\frac{k}{2}$

3. In the figure at right, what fraction of rectangle $ABCD$ is shaded?



A. $\frac{1}{6}$

B. $\frac{1}{5}$

C. $\frac{1}{4}$

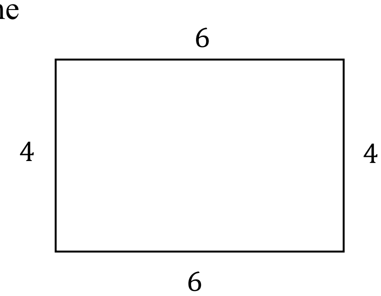
D. $\frac{1}{3}$

E. $\frac{1}{2}$

4. Which of the following ordered pairs (x, y) is a solution to the equation $2x - 3y = 6$?

F. (6, 3)
G. (3, 0)
H. (3, 2)
J. (2, 3)
K. (0, 3)

5. Which of the following numerical expressions gives the area of the rectangle at the right?



A. 4×6
B. $4 + 6$
C. $2(4 \times 6)$
D. $2(4 + 6)$
E. $4 + 6 + 4 + 6$

6. The cost C of printing greeting cards consists of a fixed charge of 100 cents and a charge of 6 cents for each card printed. Which of these equations can be used to determine the cost, in cents, of printing n cards?

F. $C = 100 + 6n$

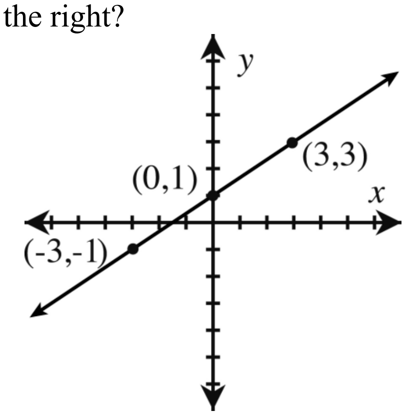
G. $C = 106 + n$

H. $C = 6 + 100n$

J. $C = 106n$

K. $C = 600n$

7. What is the slope of the line shown in the graph at the right?



A. $\frac{1}{3}$

B. $\frac{2}{3}$

C. 1

D. $\frac{3}{2}$

E. 3

8. Tetsu rides his bicycle x miles the first day, y miles the second day, and z miles the third day. Which of the following expressions represents the average number of miles per day that Tetsu travels?

F. $x + y + z$

G. xyz

H. $3(x + y + z)$

J. $3(xyz)$

K. $\dfrac{x + y + z}{3}$

9. $(-5)(-7) =$

A. -35
B. -12
C. -2
D. 12
E. 35

10. If $3 + w = b$, then $w =$

F. $\dfrac{b}{3}$

G. $b \times 3$

H. $b + 3$

J. $3 - b$

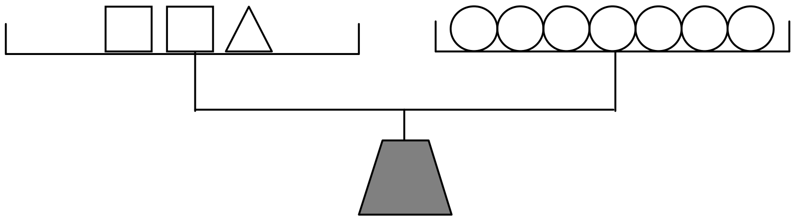
K. $b - 3$

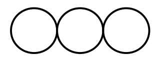
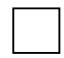
11. Which of the following equations is true for the three pairs of x and y values in the table at the right?

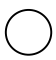
x	y
0	-3
1	-1
2	1

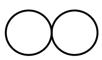
A. $3x + 2 = y$
B. $3x - 2 = y$
C. $2x + 3 = y$
D. $2x - 3 = y$
E. $x - 3 = y$

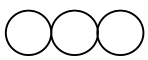
12. The objects on the scale below make it balance exactly.

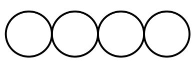


According to this scale, if  balances , then  balances which of the following?

F. 

G. 

H. 

J. 

13. If you invest \$100 for 8 years at a 7% annual yield, then how many dollars will you have at the end of this time? (Assume you make no additional deposits or withdrawals.)

A. $100(1.56)$

B. $100(8.56)$

C. $100(0.07)^8$

D. $100(1.08)^7$

E. $100(1.07)^8$

14. $\frac{2}{3} + \frac{3}{4} =$

F. $\frac{1}{2}$

G. $\frac{5}{7}$

H. $1\frac{5}{12}$

J. 2

K. $2\frac{1}{4}$

15. It has been claimed that, in this century, the world record t (in seconds) for the men's mile run in the year y can be estimated by the equation

$$t = 914.2 - 0.346y.$$

According to this claim, how is the record changing?

A. It is going down about $\frac{1}{3}$ second per year.

B. It is going down about $\frac{1}{4}$ second per year.

C. It is increasing by about $\frac{1}{3}$ second per year.

D. It is increasing by about $\frac{1}{4}$ second per year.

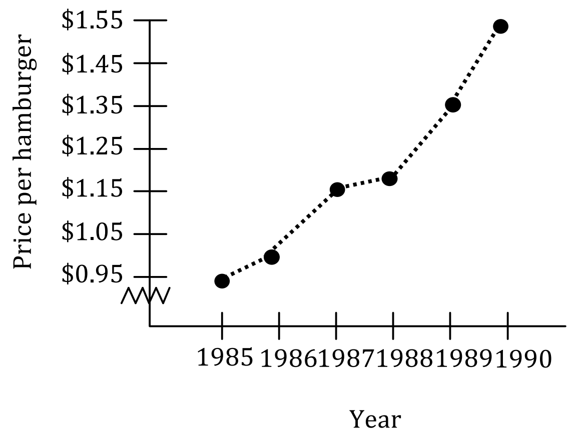
E. It is neither increasing nor decreasing.

16. If the price of a can of beans is raised from 50 cents to 60 cents, what is the percent increase in the price?

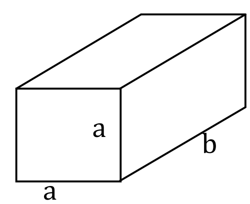
F. 83.3%
G. 20%
H. 18.2%
J. 16.7%
K. 10%

17. According to the graph below, how many times did the yearly increase of the price of a hamburger exceed 10 cents?

A. None
B. One
C. Two
D. Three
E. Four



18. Consider the rectangular box at the right. Which of the following can be used to find the volume of the box?



F. $2a + b$
G. a^2b
H. $6a^2$
J. $2a^2 + 4ab$
K. $a^2 + ab$

19. Consider the table at the right with values for an expression $ax + b$. According to the table, the value of x that makes $ax + b = 7$ is _____.

x	$ax + b$
0	5
1	7
3	11
7	19
12	29

A. 1
B. 3
C. 7
D. 19
E. There is not enough information to find an answer.

20. If the list of fractions at right continues in the same pattern, which term will be equal to 0.95?

Term	Fraction
1	$\frac{1}{2}$
2	$\frac{2}{3}$
3	$\frac{3}{4}$
4	$\frac{4}{5}$
⋮	⋮

F. The 100th
G. The 95th
H. The 20th
J. The 19th
K. The 15th

21. What is the least whole number x for which $2x > 11$?

A. 5
B. 6
C. 9
D. 22
E. 23

22. A plumber charges customers $48 for each hour worked plus an additional $9 for travel. If h represents the number of hours worked, which of the following expressions could be used to calculate the plumber's total charge in dollars?

F. $48 + 9 + h$

G. $48 \times 9 \times h$

H. $48 + (9 \times h)$

J. $(48 \times 9) + h$

K. $(48 \times h) + 9$

23. The length of a rectangle is 3 more than its width. If L represents the length, what is an expression for the width?

A. $3 \div L$
B. $L \div 3$
C. $L \times 3$
D. $L + 3$
E. $L - 3$

24. $3 + 15 \div 3 - 4 \times 2 =$

F. -9
G. -2
H. 0
J. 4
K. 5

25. Which of the following is equivalent to $4(2m + 3)$?

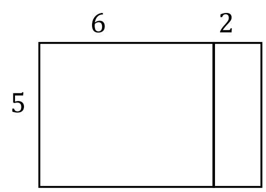
A. $8m + 3$
B. $8m + 12$
C. $16m + 12$
D. $2m + 2m + 2m + 2m + 3$
E. $8m^4 + 12$

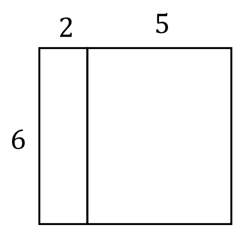
26. Jim has $\frac{3}{4}$ of a yard of string which he wishes to divide into pieces, each $\frac{1}{8}$ of a yard long. How many pieces will he have?

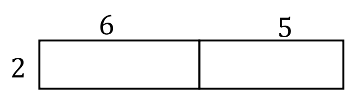
F. 3
G. 4
H. 6
J. 8

27. Which of the following figures best illustrates the statement

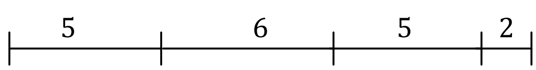
$$5 \times (6 + 2) = (5 \times 6) + (5 \times 2) \ ?$$

A. 

B. 

C. 

D. 

E. 

28. Solve: $n - 3 = 2n + 19$.

F. -57

G. -22

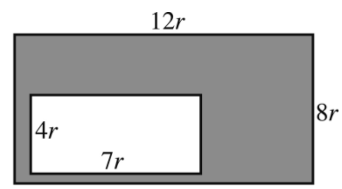
H. -16

J. 16

K. 22

29. $3^3 + 4(8 - 5) \div 6 =$

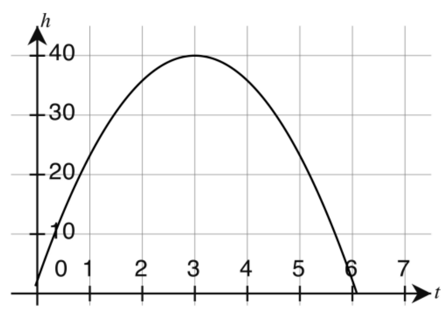
A. 6.5
B. 11
C. 27.5
D. 29
E. 34.16



30. Find the area of the shaded region between the rectangles.

F. $9r$
G. $18r$
H. $34r^2$
J. $68r^2$
K. Not enough information is given.

31. Use the graph below. It shows the height h of a ball (in feet) t seconds after it is thrown in the air. For how long was the ball over 20 feet high?



A. about 1 second
B. about 3 seconds
C. about 1 and about 5 seconds
D. from 4 to 5 seconds
E. about 6 seconds

32. Which of the following expressions is equivalent to $3p^2$?

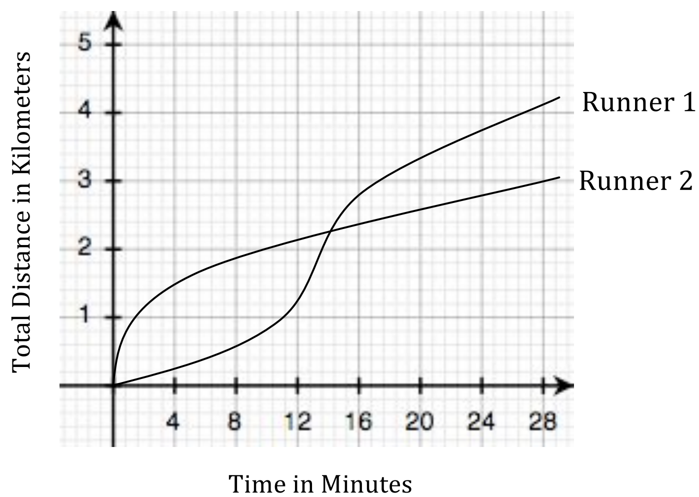
F. $3 \times 2p$
G. $3 + p + p$
H. $3p \times 3p$
J. $3 + p \times p$
K. $3 \times p \times p$

33. Which of the following ratios is equivalent to the ratio of 6 to 4?

A. 12 to 18
B. 12 to 8
C. 8 to 6
D. 4 to 6
E. 2 to 3

34. The total distances covered by two runners during the first 28 minutes of a race are shown in the graph below. How long after the start of the race did one runner pass the other?

F. 3 minutes
G. 8 minutes
H. 12 minutes
J. 14 minutes
K. 28 minutes



35. If $1\frac{1}{3}$ cups of flour are needed for a batch of cookies, how many cups of flour will be needed for 3 batches?

A. $4\frac{1}{3}$

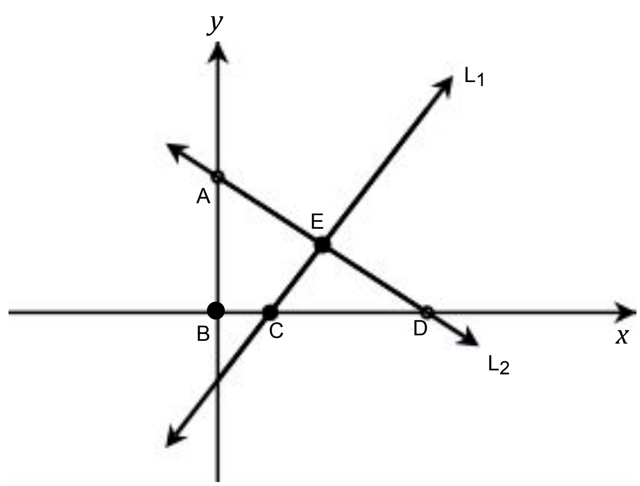
B. 4

C. 3

D. $2\frac{2}{3}$

36. Consider the graph below. Line L_1 is the graph of $y = ax + b$. Line L_2 is the graph of $y = cx + d$. Which point gives the pair of values of x and y that satisfy both equations?

F. Point A
G. Point B
H. Point C
J. Point D
K. Point E



37. What are the solutions to $5x^2 - 11x - 3 = 0$?

A. $\dfrac{11 \pm \sqrt{181}}{5}$

B. $\dfrac{-11 \pm \sqrt{181}}{10}$

C. $\dfrac{11 \pm \sqrt{181}}{10}$

D. $\dfrac{11 \pm \sqrt{61}}{10}$

E. $\dfrac{-11 \pm \sqrt{61}}{10}$

38. Of the following, which is the closest approximation to a 15 percent tip on a restaurant check of $24.99?

F. $2.50
G. $3.00
H. $3.75
J. $4.50
K. $5.00

UCSMP

The University of Chicago School Mathematics Project

Test Number ________

Algebra Test: Part Two

Name (Print) ______________________________________

School ______________________________________

Teacher ______________________________________

Period ______________________________________

Do you have a calculator available for use on this test? _____ Yes _____ No

If yes, what model calculator is it? ______________________________

Which is true of your calculator?

_____ It does not graph equations.

_____ It can graph equations.

_____ It can simplify algebraic expressions.

Do not open this booklet until you are told to do so.

1. This test contains 11 questions.
2. You may use a calculator on this test.
3. There may be many ways to answer a question. We are interested in how you solve a problem. So, be sure to show all your work on the pages in the test booklet. If you use a calculator to solve a problem, be sure to explain what features or keys you used.
4. Try to do your best on each problem.
5. You have 35 minutes to answer the questions.

1. Find the value of $4x^2 - 7x + 5$ when $x = 3$.

Answer: ______________________________

2. It takes 30 minutes for a certain bacteria population to double. If there are 5,000,000 bacteria in this population at 1:00 p.m., find the number of bacteria in the population at 2:30 p.m. on the same day.

Answer: ______________________________

3. Ken bought a used car for $5,375. He had to pay an additional 15 percent of the purchase price to cover both sales tax and extra fees. What is the total amount Ken paid?

Show your work.

Answer: ______________________________

4. A club has 86 members, and there are 14 more girls than boys. How many boys and how many girls are members of the club?

Show your work.

Answer: ____

5. Solve $\frac{2}{3}(4x-5)=\frac{3}{5}(2x+4)$. Show your work.

Answer: ______________________________

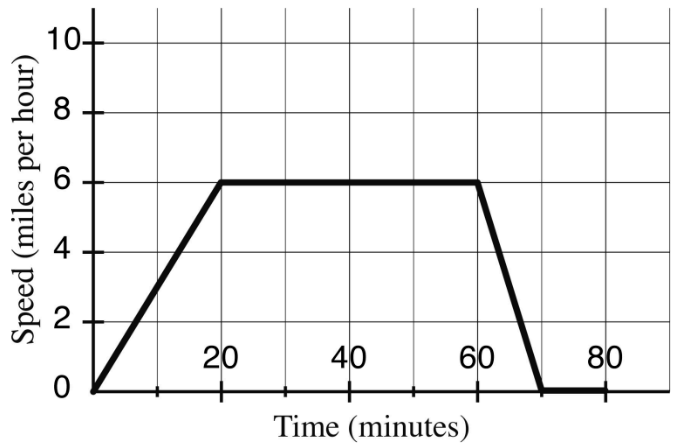
6. Consider the values in the table at right.
Find an equation that relates x and y.

x	y
-4	-10
-2	-4
0	2
2	8
4	14

Show your work.

Answer: ___________

7. The graph below represents Marissa's riding speed throughout her 80-minute bicycle trip. Use the information in the graph to describe what could have happened on the trip, including her speed throughout the trip.



a. During the first 20 minutes, describe Marissa's trip.

b. From 20 minutes to 60 minutes, describe Marissa's trip.

c. From 60 minutes to 80 minutes, describe Marissa's trip.

8. a. For all real numbers x and y is it true that $(x + y)^2 = x^2 + y^2$?

_____ Yes _____ No

b. Imagine that someone does not know the answer to part **a**. Explain how you would convince that person that your answer to part **a** is correct.

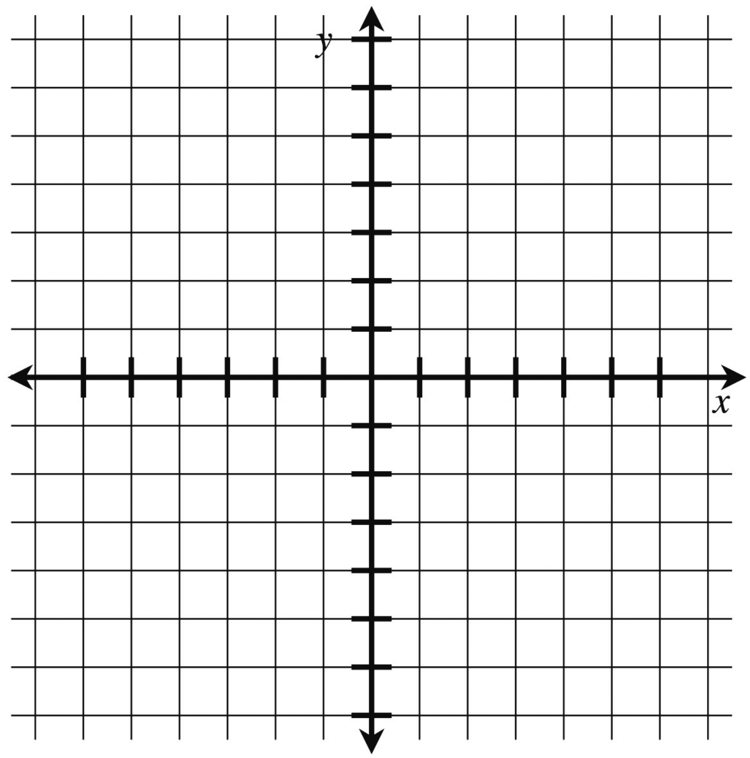
9. a. Make up a question about a real situation that can be answered by solving the equation

$$5x + 100 = 7x + 75.$$

Be sure to tell what x represents.

b. Answer the question you asked in part **a**.

10. a. On the axes below, sketch the graph of $3x + 2y < 12$.

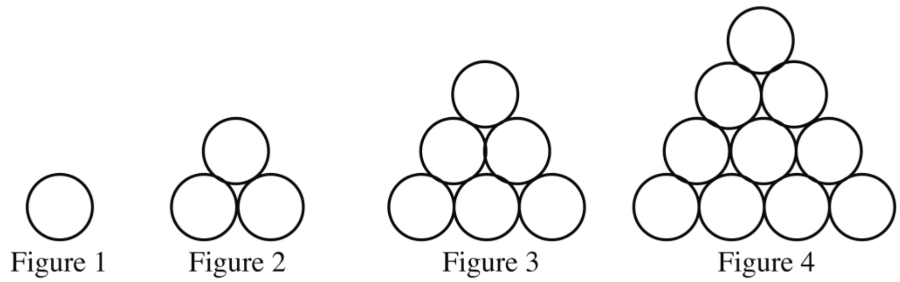


b. Is the point (100, -145) on the graph?

_____ Yes _____ No

Explain how you know.

11. The figures show four sets consisting of circles.



a. Complete the table below. First, fill in how many circles make up Figure 4. Then, find the number of circles that would be needed for the 5th figure if the sequence of figures is extended.

Figure	**Number of circles**
1	1
2	3
3	6
4	
5	

b. The sequence of figures is extended to the 7th figure. How many circles would be needed for Figure 7?

Answer: __________

c. The 50th figure in the sequence contains 1275 circles. Determine the number of circles in the 51st figure. Without drawing the 51st figure, explain or show how you arrived at your answer.

APPENDIX D: TEACHER INSTRUMENTS

University of Chicago School Mathematics Project
Pre-Transition Mathematics

CHAPTER 1 EVALUATION FORM

Teacher ______________________________ School______________________________

Date Chapter Began ______ Date Chapter Ended _______ No. Class Days (Including Tests) ___

1. Please complete the table below. In column A, circle the number of days you spent on each lesson. In columns B and C, rate the text and questions of each lesson using the following scale.

   1 = Disastrous; scrap entirely. (Reason?) 2 = Poor; needs major rewrite. (Suggestions?)
   3 = OK; some big changes needed. (Suggestions?) 4 = Good; minor changes needed. (Suggestions?)
   5 = Excellent; leave as is.

   In columns D and E, respectively, list the specific questions you assigned in the lesson and comment on any parts of the lesson text or questions you think should be changed. Use the other side or an additional sheet of paper if you need more space.

	A	**B**	**C**	**D**	**E**
		Rating			
Lesson	Circle the number of days you spent on the lesson	Lesson Text	Questions	Questions Assigned	Comments
1-1	0 0.5 1 1.5 2 2.5				
1-2	0 0.5 1 1.5 2 2.5				
1-3	0 0.5 1 1.5 2 2.5				
1-4	0 0.5 1 1.5 2 2.5				
1-5	0 0.5 1 1.5 2 2.5				
1-6	0 0.5 1 1.5 2 2.5				
1-7	0 0.5 1 1.5 2 2.5				
1-8	0 0.5 1 1.5 2 2.5				
Self-Test	0 0.5 1 1.5 2 2.5				
SPUR Review	0 0.5 1 1.5 2 2.5				

2. Overall rating of this chapter. (Use the same rating scale as at the top of the page.) _________

3. What comments do you have on the sequence, level of difficulty, or other specific aspects of the content of this chapter?

4. As we revise the student materials for this chapter,
    a. What should we definitely not change?
    b. What should we definitely change? What ideas do you have for changes that should be made?

5. As we revise the Teacher's Notes for this chapter,
    a. What should we definitely not change?
    b. What should we definitely change? What ideas do you have for changes that should be made?

6. While teaching this chapter, did you supplement the text with any materials other than those in the text?

   Yes _____ No _____

   If yes, which materials did you use and when?

   Why did you use these materials? (If possible, please enclose a copy of the materials you used.)

7. a. Did you as the teacher demonstrate or use a calculator with this chapter? Yes _____ No _____

   b. If yes, how did you use the calculator?

   c. What comments or suggestions do you have about the way calculator technology is incorporated into this chapter?

8. a. Did your students use a calculator with this chapter? Yes _____ No _____

   b. If yes, how did they use the calculator?

9. a. Did you as the teacher demonstrate or use a computer with this chapter? Yes _____ No _____

   b. If yes, how did you use the computer?

   c. What comments or suggestions do you have about the way computer technology is incorporated into this chapter?

10. a. Did your students use a computer with this chapter? Yes _____ No _____

    b. If yes, how did they use the computer?

11. a. Did you check out the loaner calculators to your students? Yes _____ No _____

    b. For this chapter, what technology access did students have other than the loaner calculators?

12. Did this chapter help students adjust to the format of the book?

13. Lessons 2, 5, 6, and 8 have Activities built into the lessons? How did you use these Activities in your classroom?

14. Did you use the test for this chapter that we provided in the Teacher's Notes?

Yes ______ No ______ If yes, what suggestions do you have for improvement?

If no, what specific reasons influenced your decision not to use the test?

15. Other comments? Attach additional sheets as needed.

Please return this form, **along with a copy of the chapter test you administered to students if different from the provided Chapter Test**, to

Denisse R. Thompson

University of Chicago School Mathematics Project
***Transition Mathematics*: Third Edition**

CHAPTER 1 EVALUATION FORM

Teacher_____________________________________ School ____

Date Chapter Began _________ Date Chapter Ended __________ No. Class Days (Including Tests) ____

1. Please complete the table below. In column A circle the number of days you spent on each lesson. In columns B and C, rate the text and questions of each lesson using the following scale.
   1 = Disastrous; scrap entirely. (Reason?) 2 = Poor; needs major rewrite. (Suggestions?)
   3 = OK; some big changes needed. (Suggestions?) 4 = Good; minor changes needed. (Suggestions?)
   5 = Excellent; leave as is.

   In columns D and E, respectively, list the specific questions you assigned in the lesson and comment on any parts of the lesson text or questions you think should be changed. Use the other side or an additional sheet of paper if you need more space.

	A	B	C	D	E
		Rating			
Lesson	Circle the number of days you spent on the lesson	Lesson Text	Questions	Questions Assigned	Comments
1-1	0 0.5 1 1.5 2 2.5				
1-1 Activity	0 0.5 1 1.5 2 2.5				
1-2	0 0.5 1 1.5 2 2.5				
1-3	0 0.5 1 1.5 2 2.5				
1-4	0 0.5 1 1.5 2 2.5				
1-5	0 0.5 1 1.5 2 2.5				
1-6	0 0.5 1 1.5 2 2.5				
1-7	0 0.5 1 1.5 2 2.5				
1-8	0 0.5 1 1.5 2 2.5				
1-9	0 0.5 1 1.5 2 2.5				
Self-Test	0 0.5 1 1.5 2 2.5				
Chapter Review	0 0.5 1 1.5 2 2.5				

2. Overall rating of this chapter. (Use the same rating scale as at the top of the page.) __________

3. What comments do you have on the sequence, level of difficulty, or other specific aspects of the content of this chapter?

4. As we revise the student materials for this chapter,
   a. What should we definitely not change?
   b. What should we definitely change? What ideas do you have for changes that should be made?
6. As we revise the Teacher's Notes for this chapter,
   a. What should we definitely not change?
   b. What should we definitely change? What ideas do you have for changes that should be made?
6. Did you use any UCSMP Second Edition materials during this chapter (Lesson Masters, Computer Masters, etc.)? Yes _____ No _____
   If yes, how and when?
7. While teaching this chapter, did you supplement the text with any materials other than those mentioned in Question 6? Yes _____ No _____
   If yes, what materials did you use and when?
   Why did you use these materials? (If possible, please enclose a copy of the materials you used.)
8. a. Did you as the teacher demonstrate or use a calculator with this chapter? Yes _____ No _____
   b. If yes, how did you use the calculator?
   c. What comments or suggestions do you have about the way calculator technology is incorporated into this chapter?
9. a. Did your students use a calculator with this chapter? Yes _____ No _____
   b. If yes, how did they use the calculator?
10. a. Did you as the teacher demonstrate or use a computer with this chapter? Yes _____ No _____
    b. If yes, how did you use the computer?
    c. What comments or suggestions do you have about the way computer technology is incorporated into this chapter?
11. a. Did your students use a computer with this chapter? Yes _____ No _____
    b. If yes, how did they use the computer?
12. Did you check out the loaner calculators to students? Yes ______ No ______
    If no, why not?
    For this chapter, what technology access did students have other than the loaner calculators?
13. Did you use the test for this chapter that we provided in the Teacher's Notes? Yes ______ No ______
    If yes, what suggestions do you have for improvement?
    If no, what specific reasons influenced your decision not to use the test?
14. Other comments? Attach additional sheets as needed.

Please return this form, along with a copy of the chapter test you administered to students, to
Denisse R. Thompson
UCSMP

University of Chicago School Mathematics Project
Algebra: Third Edition

CHAPTER 1 EVALUATION FORM

Teacher ________________________________ School__________________________________

Date Chapter Began _______ Date Chapter Ended ________ No. Class Days (Including Tests) ____

1. Please complete the table below. In column A, circle the number of days you spent on each lesson. In columns B and C, rate the text and questions of each lesson using the following scale.

 1 = Disastrous; scrap entirely. (Reason?) 2 = Poor; needs major rewrite. (Suggestions?)
 3 = OK; some big changes needed. (Suggestions?) 4 = Good; minor changes needed. (Suggestions?)
 5 = Excellent; leave as is.

 In columns D and E, respectively, list the specific questions you assigned in the lesson and comment on any parts of the lesson text or questions you think should be changed. Use the other side or an additional sheet of paper if you need more space.

	A	**B**	**C**	**D**	**E**
		Rating			
Lesson	Circle the number of days you spent on the lesson	Lesson Text	Questions	Questions Assigned	Comments
1-1	0 0.5 1 1.5 2 2.5				
1-2	0 0.5 1 1.5 2 2.5				
1-3 Activity	0 0.5 1 1.5 2 2.5				
1-3	0 0.5 1 1.5 2 2.5				
1-4	0 0.5 1 1.5 2 2.5				
1-5	0 0.5 1 1.5 2 2.5				
Self-Test	0 0.5 1 1.5 2 2.5				
Chapter Review	0 0.5 1 1.5 2 2.5				

2. Overall rating of this chapter. (Use the same rating scale as at the top of the page.) __________

3. What comments do you have on the sequence, level of difficulty, or other specific aspects of the content of this chapter?

4. As we revise the student materials for this chapter,

   a. What should we definitely not change?

   b. What should we definitely change? What ideas do you have for changes that should be made?

7. As we revise the Teacher's Notes for this chapter,

   a. What should we definitely not change?

   b. What should we definitely change? What ideas do you have for changes that should be made?

6. Did you use any UCSMP Second Edition materials during this chapter (Lesson Masters, Computer Masters, etc.)? Yes _____ No _____
   If yes, how and when?

7. While teaching this chapter, did you supplement the text with any materials other than those mentioned in Question 6? Yes _____ No _____
   If yes, which materials did you use and when?

   Why did you use these materials? (If possible, please enclose a copy of the materials you used.)

8. a. Did you as the teacher demonstrate or use a calculator with this chapter? Yes _____ No _____
   b. If yes, how did you use the calculator?

   c. What comments or suggestions do you have about the way calculator technology is incorporated into this chapter?

9. a. Did your students use a calculator with this chapter? Yes _____ No _____
   b. If yes, how did they use the calculator?

10. a. Did you as the teacher demonstrate or use a computer with this chapter? Yes _____ No _____
    b. If yes, how did you use the computer?

    c. What comments or suggestions do you have about the way computer technology is incorporated into this chapter?

11. a. Did your students use a computer with this chapter? Yes _____ No _____
    b. If yes, how did they use the computer?

12. Did you check out the loaner calculators to students? Yes ______ No ______
    If no, why not?

    For this chapter, what technology access did students have other than the loaner calculators?

13. Did you use the test for this chapter that we provided in the Teacher's Notes? Yes ______ No ______ If yes, what suggestions do you have for improvement?

    If no, what specific reasons influenced your decision not to use the test?

14. Other comments? Attach additional sheets as needed.

Please return this form, along with a copy of the chapter test you administered to students, to
Denisse R. Thompson

APPENDIX E: RESULT TABLES

Research Question 1a

Pre-Transition Mathematics

Table 32

ANOVA Table Using Pre-Transition Mathematics with Posttest 1 (CAT 17 Survey) Percent Correct as DV and OTL Measured by Lesson Coverage as IV

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	92949.263	2	46474.631	294.548	.000
	Residual	44810.292	284	157.783		
	Total	137759.555	286			

Note: The model is statistically significant at $p < .001$.

Table 33

ANOVA Table Using Pre-Transition Mathematics with Posttest 2 (UC) Percent Correct as DV and OTL Measured by Lesson Coverage as IV

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	62234.330	2	31117.165	262.808	.000
	Residual	33636.326	284	118.403		
	Total	95860.656	286			

Note: The model is statistically significant at $p < .001$.

Table 34

ANOVA Table Using Pre-Transition Mathematics with Posttest 3 (PSU) Percent Correct as DV and OTL Measured by Lesson Coverage as IV

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	104151.178	2	52075.589	262.452	.000
	Residual	56351.202	284	198.420		
	Total	160502.380	286			

Note: The model is statistically significant at $p < .001$.

Transition Mathematics

Table 35

ANOVA Table Using Transition Mathematics Posttest 1 (IAAT) Percent Correct as DV and OTL Measured by Lesson Coverage as IV

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	41888.203	2	20944.102	176.592	.000
	Residual	27752.801	234	118.602		
	Total	69641.005	236			

Note: The model is statistically significant at $p < .001$.

Table 36

ANOVA Table Using Transition Mathematics Posttest 2 (Algebra/Geometry Readiness) as DV and OTL Measured by Lesson Coverage as IV

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	39356.416	2	19678.208	156.268	.000
	Residual	29466.686	234	125.926		
	Total	68823.101	236			

Note: The model is statistically significant at $p < .001$.

Table 37

ANOVA Table Using Transition Mathematics Posttest 3 (PSU) as DV and OTL Measured by Lesson Coverage as IV

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	57533.045	2	28766.522	90.604	.000
	Residual	74294.122	234	317.496		
	Total	131827.167	236			

Note: The model is statistically significant at $p < .001$.

Algebra

Table 38

ANOVA Table Using Algebra Posttest 1 (Terra Nova) Percent Correct as DV and OTL Measured by Lesson Coverage as IV

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	57365.683	2	28682.841	133.970	.000
	Residual	49028.739	229	214.099		
	Total	106394.422	231			

Note: The model is statistically significant at $p < .001$.

Table 39

ANOVA Table Using Algebra Posttest 2 (UC) Percent Correct as DV and OTL Measured by Lesson Coverage as IV

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	76652.272	2	38326.136	268.364	.000
	Residual	32704.370	229	142.814		
	Total	109356.642	231			

Note: The model is statistically significant at $p < .001$.

Table 40

ANOVA Table Using Algebra Posttest 3 (PSU) Percent Correct as DV and OTL Measured by Lesson Coverage as IV

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	66737.925	2	33368.963	138.003	.000
	Residual	55371.991	229	241.799		
	Total	122109.916	231			

Note: The model is statistically significant at $p < .001$.

Research Question 1b

Pre-Transition Mathematics

Table 41

ANOVA Table Using Pre-Transition Mathematics Posttest 1 (CAT 17 Survey) Percent Correct as DV and OTL Measured by Teacher Reported Covered Items on Posttest 1 as IV

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	92558.456	2	46279.228	290.774	.000
	Residual	45201.099	284	159.159		
	Total	137759.555	286			

Note: The model is statistically significant at $p < .001$.

Table 42

ANOVA Table Using Pre-Transition Mathematics Posttest 2 (UC) Percent Correct as DV and OTL Measured by Teacher Reported Covered Items on Posttest 2 as IV

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	63074.073	2	31537.036	273.176	.000
	Residual	32786.583	284	115.446		
	Total	95860.656	286			

Note: The model is statistically significant at $p < .001$.

Table 43

ANOVA Table Using Pre-Transition Mathematics Posttest 3 (PSU) Percent Correct as DV and OTL Measured by Teacher Reported Covered Items on Posttest 3 as IV

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	108546.936	2	54273.468	296.671	.000
	Residual	51955.445	284	182.942		
	Total	160502.380	286			

Note: The model is statistically significant at $p < .001$.

Transition Mathematics

Table 44

ANOVA Table Using Transition Mathematics Posttest 1 (IAAT) Percent Correct as DV and OTL Measured by Teacher Reported Covered Items on Posttest 1 as IV

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	39583.474	2	19791.737	154.080	.000
	Residual	30057.530	234	128.451		
	Total	69641.005	236			

Note: The model is statistically significant at $p < .001$.

Table 45

ANOVA Table Using Transition Mathematics Posttest 2 (Algebra/Geometry Readiness) Percent Correct as DV and OTL Measured by Teacher Reported Covered Items on Posttest 2 as IV

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	39130.560	2	19565.280	154.189	.000
	Residual	29692.541	234	126.891		
	Total	68823.101	236			

Note: The model is statistically significant at $p < .001$.

Table 46

ANOVA Table Using Transition Mathematics Posttest 3 (PSU) Percent Correct as DV and OTL Measured by Teacher Reported Covered Items on Posttest 3 as IV

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	54916.254	2	27458.127	83.541	.000
	Residual	76910.913	234	328.679		
	Total	131827.167	236			

Note: The model is statistically significant at $p < .001$.

Algebra

Table 47

ANOVA Table Using Algebra Posttest 1 (Terra Nova) Percent Correct as DV and OTL Measured by Teacher Reported Covered Items on Posttest 1 as IV

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	58410.058	2	29205.029	139.378	.000
	Residual	47984.364	229	209.539		
	Total	106394.422	231			

Note: The model is statistically significant at $p < .001$.

Table 48

ANOVA Table Using Algebra Posttest 2 (UC) Percent Correct as DV and OTL Measured by Teacher Reported Covered Items on Posttest 2 as IV

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	76986.911	2	38493.455	272.322	.000
	Residual	32369.732	229	141.353		
	Total	109356.642	231			

Note: The model is statistically significant at $p < .001$.

Table 49

ANOVA Table Using Algebra Posttest 3 (PSU) Percent Correct as DV and OTL Measured by Teacher Reported Covered Items on Posttest 3 as IV

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	70110.944	2	35055.472	154.382	.000
	Residual	51998.972	229	227.070		
	Total	122109.916	231			

Note: The model is statistically significant at $p < .001$.

Research Question 2

Pre-Transition Mathematics

Output for Direct Effect of the Homework Types on *PTM* Posttest 1

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   Post1CAT
IV =   OTLbyLC
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= ZPretest

Sample size
        287

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .1470     .0461    3.1863     .0016
Applying     .5359     .0637    8.4143     .0000
Review       .9817     .1093    8.9796     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering     .0999     .1067     .9362     .3500
Applying     .3486     .0990    3.5210     .0005
Review      -.1055     .0455   -2.3197     .0211

Total Effect of IV on DV (c path)
            Coeff        se         t         p
OTLbyLC     .3082     .0626    4.9268     .0000

Direct Effect of IV on DV (c' path)
            Coeff        se         t         p
OTLbyLC     .2103     .0691    3.0416     .0026

Partial Effect of Control Variables on DV
             Coeff        se         t         p
ZPretest   14.7772     .8434   17.5204     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .7075     .7022  135.9059    5.0000  281.0000     .0000
```

Output for Indirect Effect for Homework Types on *PTM* Posttest 1

```
           BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL         .0979     .0966    -.0013     .0370
Covering      .0147     .0146     .0000     .0140
Applying      .1868     .1865    -.0003     .0507
Review       -.1036    -.1045    -.0009     .0461
C1           -.1721    -.1718     .0003     .0591
C2            .1182     .1191     .0009     .0459
C3            .2904     .2910     .0006     .0878

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL         .0294     .1750
Covering     -.0109     .0454
Applying      .0955     .2941
Review       -.2026    -.0185
C1           -.3005    -.0638
C2            .0333     .2175
C3            .1297     .4778

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effect of the Homework Types on *PTM* Posttest 2

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   Post2UCP
IV =   OTLbyLC
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= ZPretest

Sample size
        287

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .1470     .0461    3.1863     .0016
Applying     .5359     .0637    8.4143     .0000
Review       .9817     .1093    8.9796     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering     .0923     .0953     .9686     .3336
Applying     .1621     .0884    1.8341     .0677
Review      -.0347     .0406    -.8556     .3929

Total Effect of IV on DV (c path)
            Coeff        se         t         p
OTLbyLC     .1752     .0542    3.2319     .0014

Direct Effect of IV on DV (c' path)
            Coeff        se         t         p
OTLbyLC     .1088     .0617    1.7636     .0789

Partial Effect of Control Variables on DV
             Coeff        se         t         p
ZPretest   12.9348     .7528   17.1824     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .6651     .6591  111.6046    5.0000  281.0000     .0000
```

Output for Indirect Effects for Homework Types on *PTM* Posttest 2

```
           BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
             Data      Boot      Bias        SE
TOTAL        .0663     .0659    -.0005     .0328
Covering     .0136     .0136     .0000     .0125
Applying     .0869     .0872     .0004     .0426
Review      -.0341    -.0350    -.0009     .0380
C1          -.0733    -.0737    -.0004     .0505
C2           .0477     .0485     .0009     .0382
C3           .1209     .1222     .0012     .0718

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL        .0050     .1365
Covering    -.0082     .0423
Applying     .0080     .1756
Review      -.1144     .0354
C1          -.1776     .0219
C2          -.0228     .1282
C3          -.0139     .2685

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effect of Homework Types on *PTM* Posttest 3

```
DV =   PSUPerc
IV =   OTLbyLC
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= ZPretest

Sample size
        287

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .1470     .0461    3.1863     .0016
Applying     .5359     .0637    8.4143     .0000
Review       .9817     .1093    8.9796     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering     .1484     .1210    1.2265     .2211
Applying     .2512     .1122    2.2385     .0260
Review      -.0194     .0515    -.3761     .7072

Total Effect of IV on DV (c path)
            Coeff        se         t         p
OTLbyLC     .3361     .0702    4.7912     .0000

Direct Effect of IV on DV (c' path)
            Coeff        se         t         p
OTLbyLC     .1987     .0784    2.5359     .0118

Partial Effect of Control Variables on DV
             Coeff        se         t         p
ZPretest   15.7524     .9560   16.4766     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .6774     .6716  117.9965    5.0000  281.0000     .0000
```

Output for Indirect Effects of Homework Types on *PTM* Posttest 3

```
          BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL        .1374     .1366    -.0008     .0406
Covering     .0218     .0214    -.0004     .0140
Applying     .1346     .1352     .0006     .0529
Review      -.0190    -.0200    -.0010     .0505
C1          -.1128    -.1138    -.0009     .0608
C2           .0408     .0415     .0006     .0501
C3           .1537     .1552     .0015     .0937

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL        .0628     .2225
Covering    -.0026     .0532
Applying     .0348     .2444
Review      -.1211     .0789
C1          -.2384     .0046
C2          -.0560     .1413
C3          -.0233     .3423

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Transition Mathematics

Output for Direct Effects of the Homework Types on *TM* Posttest 1

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   IAATPerc
IV =   OTLbyLC
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainScor

Sample size
        237

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .0925     .0183    5.0421     .0000
Applying    -.1392     .0564   -2.4661     .0144
Review       .0482     .1293     .3724     .7100

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering    4.5044     .5501    8.1885     .0000
Applying     .4061     .1430    2.8392     .0049
Review      -.6242     .0924   -6.7571     .0000

Total Effect of IV on DV (c path)
            Coeff        se         t         p
OTLbyLC     .4722     .0920    5.1340     .0000

Direct Effect of IV on DV (c' path)
            Coeff        se         t         p
OTLbyLC     .1422     .0957    1.4860     .1387

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GainScor     .4903     .0725    6.7672     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .4326     .4204   35.2288    5.0000  231.0000     .0000
```

Output for Indirect Effects of the Homework Types on Posttest 1

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL        .3300     .3357     .0057     .0640
Covering     .4166     .4164    -.0002     .0958
Applying    -.0565    -.0484     .0081     .0300
Review      -.0301    -.0322    -.0022     .0715
C1           .4731     .4648    -.0083     .0961
C2           .4466     .4486     .0020     .1579
C3          -.0265    -.0162     .0103     .0857

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL        .2113     .4616
Covering     .2596     .6406
Applying    -.1215    -.0080
Review      -.1904     .0959
C1           .3108     .6968
C2           .1892     .8181
C3          -.2114     .1284

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effects of the Homework Types on *TM* Posttest 2

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   AlgGeoPe
IV =   OTLbyLC
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainScor

Sample size
        237

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .0907     .0177    5.1217     .0000
Applying    -.1475     .0546   -2.7000     .0074
Review       .0343     .1251     .2741     .7843

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering    4.3906     .5705    7.6964     .0000
Applying     .4131     .1481    2.7901     .0057
Review      -.6204     .0956   -6.4879     .0000

Total Effect of IV on DV (c path)
            Coeff        se         t         p
OTLbyLC     .3648     .0911    4.0029     .0001

Direct Effect of IV on DV (c' path)
            Coeff        se         t         p
OTLbyLC     .0488     .0972     .5025     .6158

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GainScor     .5853     .0747    7.8363     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .3850     .3716   28.9173    5.0000  231.0000     .0000
```

Output for Indirect Effects of the Homework Types on *TM* Posttest 2

BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)

	Data	Boot	Bias	SE
TOTAL	.3160	.3237	.0077	.0669
Covering	.3982	.4011	.0029	.0943
Applying	-.0609	-.0526	.0084	.0331
Review	-.0213	-.0249	-.0036	.0694
C1	.4591	.4536	-.0055	.0965
C2	.4195	.4260	.0065	.1531
C3	-.0397	-.0277	.0120	.0849

Bias Corrected Confidence Intervals

	Lower	Upper
TOTAL	.1868	.4466
Covering	.2451	.6198
Applying	-.1301	-.0058
Review	-.1730	.1022
C1	.2929	.6805
C2	.1689	.7754
C3	-.2305	.1067

****

Level of Confidence for Confidence Intervals:
95

Number of Bootstrap Resamples:
10000

****

INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2

Contrast	IndEff_1	IndEff_2
C1	Covering	Applying
C2	Covering	Review
C3	Applying	Review

Output for Direct Effects of the Homework Types on *TM* Posttest 3

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   PSUPerc
IV =   OTLbyLC
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainScor

Sample size
        237

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .0785     .0177    4.4285     .0000
Applying    -.1741     .0552   -3.1564     .0018
Review      -.0622     .1239    -.5015     .6165

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering    4.5831     .5999    7.6398     .0000
Applying     .4199     .1564    2.6854     .0078
Review      -.5971     .1020   -5.8553     .0000

Total Effect of IV on DV (c path)
            Coeff        se         t         p
OTLbyLC     .3519     .0976    3.6069     .0004

Direct Effect of IV on DV (c' path)
            Coeff        se         t         p
OTLbyLC     .0279     .1029     .2715     .7862

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GainScor     .8833     .0536   16.4835     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .6434     .6357   83.3533    5.0000  231.0000     .0000
```

Output for Indirect Effects of the Homework Types for *TM* Posttest 3

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL        .3240     .3303     .0063     .0691
Covering     .3600     .3605     .0005     .0899
Applying    -.0731    -.0644     .0087     .0376
Review       .0371     .0342    -.0029     .0618
C1           .4331     .4248    -.0083     .0955
C2           .3229     .3263     .0034     .1392
C3          -.1102    -.0986     .0117     .0817

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL        .1899     .4604
Covering     .2181     .5770
Applying    -.1495    -.0072
Review      -.0850     .1591
C1           .2623     .6445
C2           .0979     .6496
C3          -.2997     .0247

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Algebra

Output for Direct Effects of the Homework Types on *Algebra* Posttest 1

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   Post1Ter
IV =   OTLbyLC
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GrainSco

Sample size
        232

IV to Mediators (a paths)
             Coeff        se         t         p
Covering      .3583     .0489    7.3283     .0000
Applying      .3862     .0756    5.1105     .0000
Review        .4821     .0781    6.1717     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering   -1.8900     .4137   -4.5684     .0000
Applying      .7125     .3832    1.8593     .0643
Review        .7555     .2132    3.5430     .0005

Total Effect of IV on DV (c path)
            Coeff        se         t         p
OTLbyLC      .5501     .0596    9.2286     .0000

Direct Effect of IV on DV (c' path)
            Coeff        se         t         p
OTLbyLC      .5878     .0772    7.6168     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GrainSco      .6183     .0660    9.3654     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .6140     .6055   71.9004    5.0000  226.0000     .0000
```

Output for Indirect Effects of the Homework Types on *Algebra* Posttest 1

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL       -.0378    -.0360     .0018     .0725
Covering    -.6771    -.6742     .0029     .1914
Applying     .2752     .2719    -.0032     .1742
Review       .3642     .3662     .0021     .1185
C1          -.9523    -.9461     .0062     .3541
C2         -1.0413   -1.0404     .0009     .2199
C3          -.0890    -.0943    -.0053     .2531

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL       -.1836     .1014
Covering   -1.1023    -.3395
Applying    -.0299     .6590
Review       .1698     .6513
C1         -1.7512    -.3424
C2         -1.5390    -.6671
C3          -.6123     .3855

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effects of the Homework Types on *Algebra* Posttest 2

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   Post2UCP
IV =   OTLbyLC
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GrainSco

Sample size
        232

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .3542     .0492    7.1958     .0000
Applying     .3790     .0761    4.9803     .0000
Review       .4699     .0796    5.9057     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering   -2.1121     .4415   -4.7841     .0000
Applying    1.2284     .3944    3.1147     .0021
Review       .3578     .2113    1.6931     .0918

Total Effect of IV on DV (c path)
            Coeff        se         t         p
OTLbyLC     .5574     .0607    9.1791     .0000

Direct Effect of IV on DV (c' path)
            Coeff        se         t         p
OTLbyLC     .6719     .0805    8.3505     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GrainSco     .8137     .0822    9.9000     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .5785     .5692   62.0328    5.0000  226.0000     .0000
```

Output for Indirect Effects of the Homework Types on *Algebra* Posttest 2

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL       -.1145    -.1118     .0027     .0732
Covering    -.7482    -.7464     .0018     .1993
Applying     .4656     .4642    -.0013     .1830
Review       .1681     .1704     .0022     .0945
C1         -1.2138   -1.2107     .0031     .3734
C2          -.9163    -.9168    -.0004     .2101
C3           .2974     .2939    -.0036     .2398

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL       -.2633     .0211
Covering   -1.2122    -.4063
Applying     .1685     .9134
Review       .0082     .3799
C1         -2.1078    -.5910
C2         -1.3997    -.5541
C3          -.1189     .8435

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effects of the Homework Types on *Algebra* Posttest 3

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   PSUPerce
IV =   OTLbyLC
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GrainSco

Sample size
        232

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .3522     .0476    7.4046     .0000
Applying     .3757     .0731    5.1428     .0000
Review       .4670     .0767    6.0891     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering   -2.2485     .4262   -5.2751     .0000
Applying    1.4527     .3832    3.7909     .0002
Review       .2792     .1997    1.3982     .1634

Total Effect of IV on DV (c path)
            Coeff        se         t         p
OTLbyLC     .5585     .0603    9.2640     .0000

Direct Effect of IV on DV (c' path)
            Coeff        se         t         p
OTLbyLC     .6741     .0776    8.6836     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GrainSco     .7108     .0613   11.5934     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .6485     .6408   83.4015    5.0000  226.0000     .0000
```

Output for Indirect Effects of the Homework Types on *Algebra* Posttest 3

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL       -.1157    -.1155     .0002     .0708
Covering    -.7919    -.7938    -.0020     .1945
Applying     .5458     .5474     .0016     .1798
Review       .1304     .1309     .0006     .0874
C1         -1.3377   -1.3413    -.0036     .3661
C2          -.9222    -.9248    -.0025     .2023
C3           .4155     .4165     .0011     .2311

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL       -.2572     .0179
Covering   -1.2163    -.4445
Applying     .2478     .9658
Review      -.0212     .3230
C1         -2.1824    -.7149
C2         -1.3527    -.5625
C3           .0069     .9200

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Research Question 3

Pre-Transition Mathematics

Output for Direct Effect of the Homework Types on *PTM* Posttest 1

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   Post1CAT
IV =   OTLbyPos
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainScor

Sample size
        287

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .5908     .0551   10.7168     .0000
Applying     .8587     .0762   11.2687     .0000
Review      1.4699     .1292   11.3809     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering     .4336     .1444    3.0021     .0029
Applying     .3559     .1334    2.6674     .0081
Review      -.2516     .0640   -3.9309     .0001

Total Effect of IV on DV (c path)
             Coeff        se         t         p
OTLbyPos    1.0621     .1090    9.7413     .0000

Direct Effect of IV on DV (c' path)
             Coeff        se         t         p
OTLbyPos     .8702     .1333    6.5269     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GainScor     .5080     .0745    6.8141     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .4673     .4578   49.3038    5.0000  281.0000     .0000
```

Output for Indirect Effects of the Homework Types on *PTM* Posttest 1

```
           BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
             Data      Boot      Bias        SE
TOTAL        .1919     .1905    -.0014     .0890
Covering     .2562     .2565     .0004     .0789
Applying     .3056     .3031    -.0025     .1057
Review      -.3699    -.3691     .0008     .0926
C1          -.0494    -.0465     .0029     .1659
C2           .6260     .6256    -.0004     .1041
C3           .6754     .6721    -.0033     .1779

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL        .0169     .3689
Covering     .0964     .4048
Applying     .0992     .5123
Review      -.5575    -.1952
C1          -.3753     .2726
C2           .4251     .8351
C3           .3262    1.0225

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effects of the Homework Types on *PTM* Posttest 2

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   Post2UCP
IV =   OTLbyPos
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainScor

Sample size
        287

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .7031     .0517   13.5928     .0000
Applying     .8151     .0823    9.9018     .0000
Review       .9618     .1480    6.4989     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering     .1756     .1357    1.2942     .1966
Applying     .2477     .1161    2.1337     .0337
Review      -.1075     .0534   -2.0118     .0452

Total Effect of IV on DV (c path)
             Coeff        se         t         p
OTLbyPos    1.1398     .0923   12.3525     .0000

Direct Effect of IV on DV (c' path)
             Coeff        se         t         p
OTLbyPos     .9177     .1170    7.8469     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GainScor     .2919     .0686    4.2537     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .3974     .3867   37.0590    5.0000  281.0000     .0000
```

Output for Indirect Effects of the Homework Types on *PTM* Posttest 2

```
           BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

 Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
 TOTAL        .2220     .2223     .0003     .0720
 Covering     .1235     .1247     .0012     .0819
 Applying     .2019     .2013    -.0006     .0864
 Review      -.1034    -.1036    -.0003     .0480
 C1          -.0784    -.0766     .0018     .1486
 C2           .2268     .2283     .0015     .0859
 C3           .3053     .3049    -.0004     .1217

 Bias Corrected Confidence Intervals
             Lower     Upper
 TOTAL        .0830     .3653
 Covering    -.0441     .2806
 Applying     .0378     .3804
 Review      -.2052    -.0162
 C1          -.3859     .1996
 C2           .0558     .3926
 C3           .0788     .5552

 *****************************************************************

 Level of Confidence for Confidence Intervals:
   95

 Number of Bootstrap Resamples:
   10000

 *****************************************************************

   INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


   Contrast  IndEff_1  IndEff_2
   C1        Covering  Applying
   C2        Covering  Review
   C3        Applying  Review
```

Output for Direct Effects of the Homework Types on *PTM* Posttest 3

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   PSUPerc
IV =   OTLbyPos
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainScor

Sample size
        287

IV to Mediators (a paths)
             Coeff        se         t         p
Covering      .6117     .0845    7.2375     .0000
Applying     1.1460     .1094   10.4753     .0000
Review       1.1478     .2064    5.5614     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering      .7919     .1394    5.6805     .0000
Applying     -.1179     .1448    -.8148     .4159
Review       -.0186     .0620    -.2996     .7647

Total Effect of IV on DV (c path)
             Coeff        se         t         p
OTLbyPos     1.5167     .1574    9.6379     .0000

Direct Effect of IV on DV (c' path)
             Coeff        se         t         p
OTLbyPos     1.1888     .1744    6.8158     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GainScor      .5984     .0705    8.4937     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .5216     .5131   61.2754    5.0000  281.0000     .0000
```

Output for Indirect Effects of the Homework Types on *PTM* Posttest 3

```
           BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
             Data      Boot      Bias        SE
TOTAL        .3279     .3260    -.0019     .1065
Covering     .4844     .4875     .0032     .0831
Applying    -.1352    -.1409    -.0058     .1584
Review      -.0213    -.0205     .0008     .0661
C1           .6195     .6285     .0090     .2141
C2           .5057     .5081     .0024     .0957
C3          -.1139    -.1204    -.0065     .2069

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL        .1197     .5400
Covering     .3229     .6459
Applying    -.4516     .1689
Review      -.1566     .1047
C1           .1971    1.0411
C2           .3190     .6921
C3          -.5198     .2977

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Transition Mathematics

Output for Direct Effects of the Homework Types on *TM* Posttest 1

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   IAATPerc
IV =   OTLbyIAA
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainScor

Sample size
        237

IV to Mediators (a paths)
             Coeff        se         t          p
Covering     .1122      .0342    3.2802      .0012
Applying    1.0829      .0756   14.3205      .0000
Review      1.0000      .2252    4.4416      .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t          p
Covering    4.9822      .4844   10.2846      .0000
Applying     .5487      .2107    2.6041      .0098
Review      -.7065      .0993   -7.1180      .0000

Total Effect of IV on DV (c path)
             Coeff        se         t          p
OTLbyIAA     .1732      .1754     .9875      .3244

Direct Effect of IV on DV (c' path)
             Coeff        se         t          p
OTLbyIAA    -.2737      .2288   -1.1959      .2330

Partial Effect of Control Variables on DV
             Coeff        se         t          p
GainScor     .4919      .0731    6.7252      .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2          p
     .4307     .4184   34.9572    5.0000  231.0000      .0000
```

Output for Indirect Effects of the Homework Types on *TM* Posttest 1

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL        .4469     .4356    -.0113     .2726
Covering     .5592     .5546    -.0046     .1581
Applying     .5942     .5805    -.0138     .3203
Review      -.7065    -.6995     .0070     .1840
C1          -.0350    -.0259     .0092     .2973
C2          1.2657    1.2541    -.0116     .3287
C3          1.3007    1.2799    -.0208     .4621

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL       -.0736     .9890
Covering     .2724     .8973
Applying    -.0367    1.2243
Review     -1.1360    -.3945
C1          -.6080     .5616
C2           .6805    1.9963
C3           .4067    2.2402

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effects of the Homework Types on *TM* Posttest 2

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   AlgGeoPe
IV =   OTLbyAlg
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainScor

Sample size
        237

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .0494     .0273    1.8123     .0712
Applying     .5041     .0746    6.7556     .0000
Review       .0268     .1840     .1457     .8843

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering    3.7123     .5110    7.2642     .0000
Applying    -.1173     .1819    -.6446     .5198
Review      -.3653     .1082   -3.3761     .0009

Total Effect of IV on DV (c path)
             Coeff        se         t         p
OTLbyAlg     .7804     .1288    6.0607     .0000

Direct Effect of IV on DV (c' path)
             Coeff        se         t         p
OTLbyAlg     .6659     .1525    4.3659     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GainScor     .5646     .0717    7.8725     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .4312     .4189   35.0269    5.0000  231.0000     .0000
```

Output for Indirect Effects of the Homework Types on *TM* Posttest 2

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL        .1145     .1187     .0042     .1095
Covering     .1834     .1688    -.0146     .0759
Applying    -.0591    -.0553     .0038     .0868
Review      -.0098     .0053     .0150     .0775
C1           .2425     .2241    -.0184     .1090
C2           .1932     .1635    -.0297     .1474
C3          -.0493    -.0606    -.0113     .1109

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL       -.1054     .3277
Covering     .0466     .3155
Applying    -.2467     .1007
Review      -.1201     .1624
C1           .0551     .4456
C2          -.0864     .4306
C3          -.2120     .2358

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effects of the Homework Types on *TM* Posttest 3

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   PSUPerc
IV =   OTLbyPSU
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainScor

Sample size
        237

IV to Mediators (a paths)
             Coeff        se         t         p
Covering    -.1047     .0174   -6.0173     .0000
Applying    -.0565     .0569    -.9928     .3218
Review      -.8918     .1112   -8.0170     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering    4.5732     .5218    8.7641     .0000
Applying     .2747     .1741    1.5775     .1161
Review      -.5037     .1165   -4.3223     .0000

Total Effect of IV on DV (c path)
             Coeff        se         t         p
OTLbyPSU     .1341     .1011    1.3263     .1860

Direct Effect of IV on DV (c' path)
             Coeff        se         t         p
OTLbyPSU     .1794     .1124    1.5963     .1118

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GainScor     .8626     .0547   15.7747     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .6472     .6395   84.7406    5.0000  231.0000     .0000
```

Output for Indirect Effects of the Homework Types on *TM* Posttest 3

```
           BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

 Indirect Effects of IV on DV through Proposed Mediators (ab paths)
               Data      Boot      Bias        SE
 TOTAL       -.0452    -.0414     .0038     .0827
 Covering    -.4789    -.4739     .0050     .0794
 Applying    -.0155    -.0107     .0048     .0278
 Review       .4492     .4432    -.0060     .1084
 C1          -.4634    -.4632     .0002     .0719
 C2          -.9281    -.9171     .0110     .1679
 C3          -.4647    -.4539     .0109     .1275

 Bias Corrected Confidence Intervals
              Lower     Upper
 TOTAL       -.2000     .1231
 Covering    -.6548    -.3369
 Applying    -.1074     .0186
 Review       .2587     .6888
 C1          -.6240    -.3378
 C2         -1.3060    -.6360
 C3          -.7729    -.2548

 *****************************************************************

 Level of Confidence for Confidence Intervals:
   95

 Number of Bootstrap Resamples:
   10000

 *****************************************************************

   INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


   Contrast  IndEff_1  IndEff_2
   C1        Covering  Applying
   C2        Covering  Review
   C3        Applying  Review
```

Algebra

Output for Direct Effects of the Homework Types on *Algebra* Posttest

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   Post1Ter
IV =   OTLbyPos
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GrainSco

Sample size
        232

IV to Mediators (a paths)
             Coeff        se         t         p
Covering      .9241     .0372   24.8644     .0000
Applying     1.2944     .0608   21.2751     .0000
Review       1.3702     .0642   21.3294     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering    -1.1422     .3471   -3.2909     .0012
Applying     -.6050     .2937   -2.0602     .0405
Review       1.1627     .1947    5.9716     .0000

Total Effect of IV on DV (c path)
             Coeff        se         t         p
OTLbyPos      .8331     .0736   11.3261     .0000

Direct Effect of IV on DV (c' path)
             Coeff        se         t         p
OTLbyPos     1.0787     .1331    8.1053     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GrainSco      .6111     .0649    9.4154     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .6242     .6159   75.0672    5.0000  226.0000     .0000
```

Output for Indirect Effects of the Homework Types on *Algebra* Posttest 1

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data      Boot      Bias        SE
TOTAL       -.2456    -.2444     .0012     .1324
Covering   -1.0555   -1.0463     .0093     .3851
Applying    -.7831    -.7799     .0032     .4228
Review      1.5931    1.5818    -.0113     .2563
C1          -.2724    -.2664     .0061     .7626
C2         -2.6486   -2.6280     .0205     .4558
C3         -2.3762   -2.3617     .0145     .6096

Bias Corrected Confidence Intervals
             Lower     Upper
TOTAL       -.5118     .0055
Covering   -1.8096    -.2975
Applying   -1.6735     .0007
Review      1.1333    2.1439
C1         -1.7145    1.2959
C2         -3.5752   -1.7849
C3         -3.6551   -1.2558

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effects of the Homework Types on *Algebra* Posttest 2

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   Post2UCP
IV =   OTLbyPos
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainSco

Sample size
        232

IV to Mediators (a paths)
             Coeff        se         t         p
Covering    1.1949     .0842   14.1875     .0000
Applying    1.5414     .1357   11.3591     .0000
Review      1.4066     .1552    9.0639     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering   -1.2438     .4787   -2.5983     .0100
Applying    -.8269     .3270   -2.5288     .0121
Review      1.6815     .2547    6.6027     .0000

Total Effect of IV on DV (c path)
             Coeff        se         t         p
OTLbyPos     .7639     .1417    5.3918     .0000

Direct Effect of IV on DV (c' path)
             Coeff        se         t         p
OTLbyPos    1.1594     .2322    4.9930     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GrainSco     .8286     .0892    9.2882     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .5032     .4922   45.7879    5.0000  226.0000     .0000
```

Output for Indirect Effects of the Homework Types on *Algebra* Posttest 2
Output for Direct Effects of the Homework Types on *Algebra* Posttest 3

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data       Boot       Bias         SE
TOTAL        -.3955     -.4018     -.0062      .1962
Covering    -1.4862    -1.4673      .0189      .5922
Applying    -1.2745    -1.2890     -.0145      .5563
Review       2.3653     2.3546     -.0107      .4981
C1           -.2117     -.1783      .0334      .9661
C2          -3.8515    -3.8219      .0296      .9279
C3          -3.6398    -3.6436     -.0038      .9446

Bias Corrected Confidence Intervals
             Lower      Upper
TOTAL        -.7803     -.0046
Covering    -2.8239     -.4370
Applying    -2.5145     -.3043
Review       1.4910     3.4394
C1          -2.1797     1.6741
C2          -5.8868    -2.2202
C3          -5.7251    -2.0274

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

Output for Direct Effects of the Homework Types on *Algebra* Posttest 3

```
Dependent, Independent, and Proposed Mediator Variables:
DV =   PSUPerce
IV =   OTLbyPos
MEDS = Covering
       Applying
       Review

Statistical Controls:
CONTROL= GainSco

Sample size
        232

IV to Mediators (a paths)
             Coeff        se         t         p
Covering     .5967     .0443   13.4842     .0000
Applying     .7834     .0691   11.3306     .0000
Review       .8331     .0744   11.2005     .0000

Direct Effects of Mediators on DV (b paths)
             Coeff        se         t         p
Covering   -1.3849     .3529   -3.9242     .0001
Applying     .1668     .2999     .5561     .5787
Review       .7918     .1814    4.3640     .0000

Total Effect of IV on DV (c path)
             Coeff        se         t         p
OTLbyPos     .7426     .0621   11.9644     .0000

Direct Effect of IV on DV (c' path)
             Coeff        se         t         p
OTLbyPos     .7787     .0819    9.5104     .0000

Partial Effect of Control Variables on DV
             Coeff        se         t         p
GrainSco     .6924     .0599   11.5596     .0000

Model Summary for DV Model
      R-sq  Adj R-sq         F       df1       df2         p
     .6652     .6578   89.8199    5.0000  226.0000     .0000
```

Output for Indirect Effects of the Homework Types on *Algebra* Posttest 3

```
BOOTSTRAP RESULTS FOR INDIRECT EFFECTS

Indirect Effects of IV on DV through Proposed Mediators (ab paths)
              Data       Boot       Bias         SE
TOTAL       -.0361     -.0357      .0004      .0617
Covering    -.8264     -.8226      .0038      .2559
Applying     .1306      .1267     -.0040      .2553
Review       .6596      .6602      .0007      .1501
C1          -.9570     -.9493      .0077      .4864
C2         -1.4860    -1.4829      .0031      .3060
C3          -.5289     -.5336     -.0046      .3544

Bias Corrected Confidence Intervals
             Lower      Upper
TOTAL       -.1573      .0846
Covering   -1.3472     -.3464
Applying    -.3698      .6220
Review       .4001      .9998
C1         -1.9281     -.0314
C2         -2.1317     -.9266
C3         -1.2600      .1267

*****************************************************************

Level of Confidence for Confidence Intervals:
  95

Number of Bootstrap Resamples:
  10000

*****************************************************************

  INDIRECT EFFECT CONTRAST DEFINITIONS: Ind_Eff1 MINUS Ind_Eff2


  Contrast  IndEff_1  IndEff_2
  C1        Covering  Applying
  C2        Covering  Review
  C3        Applying  Review
```

APPENDIX F: PERMISSION TO USE INTRUMENTATIONS AND IRB APPROVAL

From: Denisse Thompson denisse@usf.edu
To: Dr. Zalman Usiskin z-usiskin@uchicago.edu, Yiting Yu yyu3@mail.usf.edu

Dear Zal,

Several students here at USF are going to do their dissertations related to some more detailed analysis of the UCSMP evaluation data.

Yiting Yu is the first person who has successfully defended her proposal and has submitted her study to the USF IRB review as using existing data, but with no names of students or teachers. She will use just the numerical codes to connect students and teachers with curriculum.

Her study is entitled, The Influence of Types of Homework on Opportunity to Learn and Students' Mathematics Achievement: Examples from the University of Chicago School Mathematics Project. She is using PTM, TM, and Algebra data, just from UCSMP (3rd) edition teachers, and looking at the extent to which the types of homework assigned (Covering, Applying, Review) mediates between teachers' lesson coverage and student achievement. She did a small study on this issue related to just TM and presented results via a poster at ICME 12. There was a lot of interest, and so she has built her dissertation around this, with some revised models and seeing if the same trends hold up across all three middle grades courses.

One issue that has come up from our IRB board is how she has permission from U of C to use the data. Would you provide a letter in your capacity as UCSMP Director for her to use the data and the instruments?

Thanks. Let me know if you need any further information.

Denisse

Denisse R. Thompson, Ph.D.
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Past-President, Florida Council of Teachers of Mathematics
fctm.net

From:Yiting Yu yyu3@mail.usf.edu
To: Dr. Zalman Usiskin <z-usiskin@uchicago.edu>

Hi Dr. Usiskin:

I am finishing revising my dissertation titled "The Influence of Types of Homework on Opportunity to Learn and Students' Mathematics Achievement: Examples from the University of Chicago School Mathematics Project". Please grant me permission to include the instrumentations from the UCSMP project as part of my Appendix. Thank you very much!

Sincerely,
Yiting Yu

From: Zalman Usiskin <z-usiskin@uchicago.edu> May 3rd, 2015
To: Yiting Yu <yyu3@mail.usf.edu>

Dear Yiting:

I am assuming that you have permission from Denisse Thompson, who ran the original studies, to include copies of the instruments you used in your dissertation studies. If this is the case, then I am happy to give permission for you to include the instruments used in the original UCSMP 3rd edition studies.

Zalman Usiskin
Professor Emeritus of Education
Director, University of Chicago School Mathematics Project
The University of Chicago
1225 East 60th Street
Chicago, IL 60637

From: eirb@reserach.usf.edu Jan, 8th, 2014
To: yyu3@mail.usf.edu

IRB Study Approved

To:	Yiting Yu
RE:	Types of Homework as Mediators on Influence of OTL on Achievement
PI:	Yiting Yu
Link:	Pro00015704
	You are receiving this notification because the above listed study has received Approval by the IRB. For more information, and to access your Approval Letter, navigate to the project workspace by clicking the Link above.

DO NOT REPLY: *To ensure a timely response, please direct correspondence to* ***Research Integrity & Compliance*** *either through your project's workspace or the contact information below.*

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