Journal of Mathematics Education
June 2016, Vol. 9, No. 1, pp. 69-87 

# Student and Teacher Factors' Impact on Fourth Grade Students' Mathematics Achievement: An HLM Analysis of TIMSS 2007

**Hongryun Woo**
*University of Louisville, USA*
**Malik S. Henfield**
*University of San Francisco, USA*

*Using TIMSS 2007, a large-scale international achievement assessment database, this study examined the relationships between contextual factors and fourth-grade student mathematics achievement in the U.S. Math achievement variation within and between schools was accounted for by a series of two-level HLM models representing student-level variables and teacher-level variables. Findings suggested that the strongest indicators of math achievement in 4$^{th}$ graders were student self-confidence in math and teachers' perceptions of their content-area knowledge. Implications for teachers and school administrators are addressed.*

**Keywords:** 4$^{th}$ grade students, math achievement, TIMSS 2007, HLM.

Public and scholarly discourse has been filled with information discussing the root causes of students' academic difficulties. In this era of accountability, particularly as measured by standardized test results, math scores are of utmost importance. Teachers are currently under tremendous pressure to raise scores in this academic area and close the achievement gap among diverse student populations. For quite some time, there has been a raging debate about which factors impact student math achievement the most. On the one hand, there is a great body of evidence suggesting that internal student factors significantly impact on their academic trajectories; on the other hand, external teacher and school factors have also been proven to be strongly related to student achievement. This article focuses on both internal and external factors by exploring the correlates of contextual variables with math achievement among 4$^{th}$ grade students in the U.S. Relationships varying in strength between student and teacher constructs were uncovered, providing better understanding of factors contributing to 4$^{th}$ grade students' achievement in math. Implications for teachers and school administrators will be discussed.

## Math Scores

Math standardized test scores have been considered to be accurate predictors of overall student academic achievement (National Center for Educational Statistics [NCES], 2008; Orfield, Losen, Wald, & Swanson, 2004). Furthermore, much literature has linked student math achievement with the country's future economic power and security (Akiba, LeTendre, & Scribner, 2007; Baker & LeTendre, 2005). For this reason, student underachievement in mathematics has often been viewed as a national issue rather than simple comparisons between individual students. In the U.S., the topic of how to improve math achievement has been passionately debated for decades. The No Child Left Behind Act, issued in 2001 (No Child Left Behind [NCLB], 2001), under former President Bush's administration, is one example of mathematics as an important school subject. Current U.S. president, Barack Obama, early in his administration, also called for a nationwide endeavor to help increase achievement scores in math and science. President Obama proposed a large amount of government funding for support to advance math and science education in American schools (The White House, 2012). In 2012, for example, the Obama Administration announced a plan to launch a national Science, Technology, Engineering, and Math (STEM) Master Teacher Corps, with one of its key parts being a rigorous selection of the best and brightest math and science teachers from across the country.

Results from math achievement assessments have been used for many purposes, including setting standards for student performance and making changes to educational policies (Baker & LeTendre, 2005; Rodriguez, 2004; TIMSS, 2007). Considering the importance of student math achievement on nationwide growth of economy and security and the foreknown rapid changes in the society in the 21st century, it is then crucial for scholars in the field of education to continuously conduct research to understand and identify variables related to student math achievement in order to maximize student learning and performance.

## Deficiency at the Elementary Level

The desire to identify factors that have meaningful relationships with students' math achievement has been frequently shared among national leaders, educators, and policy makers. The National Mathematics Advisory Panel (2008), organized to advise President Bush on the best use of scientific evidence-based research to improve mathematics education, reported that too many students in the U.S. have a poor understanding of core arithmetic concepts in the early stages of education, which directly hinders their ability to later learn algebra. This type of spiraling effect, derived from deficiencies early in elementary school, contributes to a substantive achievement gap in math among many students by the time they reach middle and high school. For example, math educators viewed algebra in early elementary education as a gateway to advanced levels of mathematical thinking and to more career choices, as it is a predictor of future college entrance (Choike, 2000; McCoy, 2005). Therefore, they have supported the implementation of algebra in the elementary school setting. In a quantitative study with eight teachers and 137 students from 2$^{nd}$ grade, Kulpa (2007) found that participating teachers perceived the early teaching and implementation of algebraic concepts to be important in the elementary school. Teacher participants believed that the early algebra education is the foundation for future academic success, and that it has been more critical for young learners.

In addition to predicting success in algebra in later grades, students' math achievement in the primary grades is likely to affect their selections and enrollment in math courses in high school (Singh, Grandville, & Dika, 2002). It is because math courses are usually sequential, and access to advanced high school math courses are based on students' performance at lower level math classes (Singh et al., 2002). For instance, at a local level, it has been reported that a student's fluency in math during the elementary grades predicts their success in later academic years when mathematics gets more abstract and complex (DDOE, 2009). Data from the Delaware Department of Education (DDOE) revealed that 310 out of 463 tenth graders at a local high school in the Colonial School District did not achieve a performance level standard of 3.0 or higher in the Delaware Student Testing Program in mathematics, and only three of those 310 students earned 3.0 or higher since third grade (DDOE, 2009).

Given the current policies of the Common Core State Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010), which draw stark attention to classroom practices and learning, an argument could be made that teachers are under stress trying to improve student achievement. As a function of the pressure associated with high stakes standardized testing, many teachers are being forced to "teach to the test", as opposed to operationalizing diverse educational interventions to support students' learning. The Common Core State Standards require students to graduate, adhering to high standards, being both college and career ready. Since teachers can not accomplish this goal alone, teachers, school administrators, and other helping professionals at school are under increasing scrutiny and, as such, should collaborate with one another to meet students' needs, which is inextricably linked to student success in math.

## Theoretical Framework

The present study was guided by the theoretical framework of three popular school learning models: Theory of School Learning (Bloom, 1976), A Model of School Learning (Carroll, 1963), and A School Learning Model (Biggs & Moore, 1993). These models commonly postulated three important factors theoretically related to students' academic success: (a) student characteristics such as motivation to learn, interest in task and ability to understand instruction; (b) opportunity to learn such as time allowed for learning and time spent on homework, and; (c) quality of instruction, such as teachers' expertise and method of teaching.

Frist, many existing research studies have discovered a positive relationship between student characteristics and math achievement. According to House (2006), higher self-confidence in math was a significant predictor of higher math performance among adolescents. Similarly, it was evident that self-efficacy in learning math was significantly associated with higher math achievement in middle school students (Pajeres & Graham, 1999). In another study, Koller, Baumert and Schnabel (2001) found that students with higher levels of interest in math learning were more likely to choose higher math courses. Second, much research has shown that having the opportunity to learn has a strong relationship with academic success. Specifically, in a comprehensive meta-analysis of 32 studies, investigating the correlations between time dedicated to math homework and achievement, Cooper and his colleagues (2006) uncovered 50 correlations in a positive direction with 19 in a negative direction. Based on their findings, they concluded that a positive relationship between time on homework and math achievement exists. Finally, a considerable amount of research has been conducted on teacher preparation and quality of instruction as related to student achievement (Darling-Hammond, 2000; Hill, Rowan, & Ball, 2005). In a research study examining 115 elementary schools over three years, Hill, Rowan, and Ball (2005) found that teachers' mathematical knowledge for teaching was significantly associated with student achievement in both the 1$^{st}$ and 3$^{rd}$ grades. Additionally, in an analysis of Texas school districts, Ferguson (1991) revealed that teachers' expertise and skills accounted for more inter-district variation in math and reading achievement from the 1$^{st}$ to 11$^{th}$ grade, rather than student factors such as socioeconomic status.

In assessing the need of 4$^{th}$-grade student population, the necessity for improved school learning environment, as well as standardized testing performance and perceptions of their characteristics and efforts is essential to gain a better understanding of the needs of this population. In addition, understanding the relationship between teachers' perceptions of quality of their instruction and their students' math achievement is critical. Therefore, this study had the following research questions: (a) To what extent are student variables (i.e., self-confidence in math, attitude toward math, and time spent on math homework) associated with 4$^{th}$-grade math scores in the U.S.? and (b) To what extent are teacher variables (i.e., frequency of collaboration among math teachers, perception of content-area knowledge, and content-related activities) associated with 4$^{th}$-grade math scores in the U.S.?

## Methodology

### Sample

TIMSS 2007 data was used in the study. The National Center for Education Statistics (2007) conducted an international, multilevel study entitled, "Trends in International Mathematics and Science Study (TIMSS) 2007" on the mathematics and science achievement of U.S. $4^{th}$- and $8^{th}$-grade students. Their achievement scores were compared to that of students in other countries, using information gathered from students, teachers, school principals, and curriculum specialists. This study focused on experiences and math achievement of the $4^{th}$ graders. The data in this study included 7,896 students from 257 schools. Because of the complex sampling design, sampling weights were applied when conducting actual data analyses in order to obtain unbiased population estimates and take any differential probabilities of selecting students into account (Joncas, 2008).

### Variables for Analysis

Using the aforementioned school learning models as the theoretical framework, this study examined a number of student and teacher variables related to students' learning. Mathematics achievement score (5 plausible values) was used as a dependent variable, and variables that reflected student characteristics, opportunity to learn, and quality of instruction, were created as predictors of math achievement. Specifically, variables selected to match with those variables identified in conceptual learning models were: (a) self-confidence in math (CM), (b) attitude toward math (AT), (c) time spent on math homework (HW), (d) frequency of collaboration among math teachers (FRC), (e) perception of content-area knowledge (CAN), and (f) content-related activities (CRA). The first three study variables were defined as student-level variables, while the rest was identified as teacher-level variables. A description of the results of principal components analysis that comprised the six study variables is provided in Table 1.

### Data Analysis

Because the TIMSS 2007 data was collected at different levels of the educational hierarchy (e.g., student, classroom, and school level), a hierarchical linear modeling (HLM) was employed in this study. This method accounts for the nested nature of the data and determines the error variance for the student-level, as well as the teacher-level variables (Raudenbush & Bryk, 2002). A two-level HLM analysis in which students are the level-1 units and teachers are the level-2 units was conducted.

In the first stage, the analysis constructed an unconditional model (Model 1 in this study) where none of the level-1 or level-2 variables were included. The regression equation used was as follows:

$Y_{ij}=\beta_{0j} + r_{ij}$ (at student-level)
$\beta_{0j} = \gamma_{00} + u_{0j}$ (at teacher-level)

In the equations, $Y_{ij}$ was student i's math score in school j, $\beta_{0j}$ was the regression intercept of school j, $\gamma_{00}$ was the overall average math score for all schools, $u_{0j}$ was the random effect of school j, and $r_{ij}$ was the random effect of student i in school j.

In the second stage, each of the student-level variables (i.e., CM, AT, and HW) were entered separately in the unconditional model, followed by those variables significantly related to math achievement retained to make the level-1 model (Model 2 in this study).

$Y_{ij}=\beta_{0j} + \beta_{1j}\, CM_{ij} +\beta_{2j}\, AT_{ij} +\beta_{3j}\, HW_{ij} + r_{ij}$
$\beta_{pj} = \gamma_{p0} + u_{pj}$ (where p= 0,1,2,3)

In the equations, $Y_{ij}$, $\beta_{0j}$, $\gamma_{00}$, $u_{0j}$, and $r_{ij}$ were defined as in the unconditional model noted above. $\beta_{1j}$ to $\beta_{3j}$ referred to regression slopes of school j. $\gamma_{p0}$ referred to the level-2 fixed effects, and $u_{pj}$ referred to the level-2 random effects.

Similarly, at level-2, each of the teacher-level variables (i.e., FRC, CAN, and CRA) was separately entered in Model 2, and finally, all level-2 statistically significant variables were retained to make the full model (Model 3 in this study).

$Y_{ij}=\beta_{0j} + \beta_{1j}\, CM_{ij} +\beta_{2j}\, AT_{ij} +\beta_{3j}\, HW_{ij} + r_{ij}$
$\beta_{pj} = \gamma_{p0} + \gamma_{p1}\, FRC + \gamma_{p2}\, CAN + \gamma_{p3}\, CRA + u_{pj}$ (where p= 0,1,2,3)

In the equations, $Y_{ij}$, $\beta_{0j}$, $\gamma_{00}$, $u_{0j}$, and $r_{ij}$ were defined as in the unconditional model noted above. $\beta_{1j}$ to $\beta_{3j}$ and $u_{pj}$ were defined in the level-1 model. $\gamma_{p0}$ to $\gamma_{p3}$ referred to the level-2 fixed effects, and $u_{pj}$ referred to the level-2 random effects. With statistical results obtained from the full model, Model 3, inferences were made about the extent of all statistically significant level-1 and level-2 variables related to TIMSS 2007 4$^{th}$ grade math achievement.

## Results

This study examined three of both student and teacher variables with respect to their effects on 4$^{th}$ grade math achievement, according to the TIMSS 2007 assessment. The descriptive statistics are presented in Table 2. The HLM started with the unconditional model with no level-1 (i.e., student variables) and level-2 (i.e., teacher variables) predictors included. According to the results of the unconditional model (see Table 3), the fixed effect for the intercept was 528.17 ($SE$ = 2.76, $p$ <.001). The average level of math achievement was significantly different across schools ($u_0$ = 1563.96, $SD$ = 39.55, $p$ <.001).

Within schools, the amount of unexplained variance was larger than that between schools ($r_{ij}$ = 4028.62, *SD* = 63.47). The computed intra-class correlation (ICC) was 0.28, indicating that approximately 28 % of the total variance in math achievement was attributed to the differences between schools.

The student-level model was developed to address the first research question regarding the extent to which 4$^{th}$-grade math achievement related to self-confidence in math (CM), attitude toward math (AT), and time spent on math homework (HW). As can be seen in Table 4, only CM and AT had statistically significant fixed effects. Whereas self-confidence in math ($\gamma$ = 44.10, *SE* = 1.19, $p$ <.001) was positively related to math achievement, an inverse relationship was observed between math achievement and positive attitude toward math ($\gamma$ = -6.63, *SE* = 0.97, $p$ <.001). This could be interpreted that for each unit increase in level of self-confidence in math, it was expected that students would improve 44.10 points in their math scores while controlling for other predictors in the model. However, it could also be inferred that for each unit increase in positive attitude, students were expected to score 6.63 points lower in their math scores. In terms of random effects, with the variance for the intercept of 1138.20 (*SD* = 33.74, $p$ <.001), it could be inferred that statistically significant differences existed across the school means of math achievement after adjusting for the three student-level variables in the model.

The teacher-level model aimed at addressing the second research question regarding the relationship between 4$^{th}$-grade math achievement and frequency of collaboration among math teachers (FRC), perception of content-area knowledge (CAN), and content-related activities (CRA). As evident in Table 5, the teacher-level model produced statistically significant level-2 fixed effects in the variable CAN. Specifically, there was a positive relationship between teachers' perception of their content area knowledge ($\gamma$ = 42.61, *SE* = 9.06, $p$ <.001) and 4$^{th}$ grade students' math scores. This could be inferred as students achieving 42.61 points higher with one unit increase in teacher's perception of preparedness with content area knowledge after controlling for other variables. Also, the level-1 slope variance of self-confidence in math (CM; $\gamma$ = 44.16, *SE* = 1.20, p <.001) and positive attitude toward math (AT; $\gamma$ = -6.81, *SE* = 0.96, $p$ <.001) were statistically significant in the model. In terms of random effects, with the variance for the intercept of 1049.34 (*SD* = 32.40, $p$ <.001), it could be inferred that statistically significant differences existed across the school regarding means of math achievement.

## Discussion

Because the educational literature on math education is consistent regarding student characteristics, opportunity to learn, and quality of instruction to be associated with student achievement, we expected all of the study variables to explain significant differences in student math achievement; however, this was not the case. For example, we observed that the strongest empirical support for student characteristics according to the school learning models was self-confidence. Confidence in math had a strong and positive association with high math scores among $4^{th}$ graders. This finding was similar to other research studies suggesting that self-perceived efficacy in math positively correlated with students' expectations and achievement outcomes (Koller, et al., 2001; House, 2006). Understanding self-confidence early in schooling is critical because it may be carried through middle/high school and therefore could influence future academic success (Gwilliam & Betz, 2001).

On the other hand, one result de-emphasized the importance of the relationship between having a positive attitude towards math and increased average math achievement. This result was inconsistent with findings from previously mentioned studies (Keith & Cool, 1992; Cooper, et al., 2006; Singh, et al., 2002). We use this result to remind readers about the risks of drawing causal inference from results using HLM statistical analysis. One's attitude toward math does not cause low math achievement, and numerous explanations for this relationship are reasonable. For instance, examination of the released items in the math assessment reveals that the assessment is designed to measure achievement in the three content domains (i.e., numbers, data display, and geometric shapes and measure) and three cognitive domains (i.e., knowing, reasoning, and applying). Therefore, it is possible that a student may manage to do quite well in one specific content area such as "numbers" because s/he enjoys that particular area. If the student thinks and reports that s/he likes math in general, her/his reported positive attitude towards math may not accurately predict his/her math achievement.

We found solid evidence to support the claim that teachers' positive perceptions of their expertise in math can foster student learning in mathematics. This result is consistent with previous research identifying teachers' expertise and knowledge as one of the most important factors associated with student learning and academic performance (Darling-Hammond, 2000; Hill, et al., 2005). At the elementary level, teachers are expected to teach various school subjects regardless of their major in college; professionals may assume that a teacher's undergraduate major and preparation would not appear to influence student math performance. However, this study suggests a strong relationship between teachers' perceptions of their preparation to teach and student learning in math. This finding may explain why in some disadvantaged schools where teachers may be more likely to lack training and resources to support high-quality teaching, students are at greater risk of underachievement. Our result suggests that teachers are more likely to contribute to student academic success, if they are professionally prepared and trained to provide high-quality instructional practices in math.

**Implications for Educators and Professionals in School**

The current study implies that to better serve the 4th-grade student population, teachers and schools should have a clear understanding of the challenges, as well as the positive factors that impact students' math achievement. Students' self-confidence was found to positively predict math scores. Bandura (1997) noted that the sources of self-efficacy judgments made by students reflect a complex interaction between internal and external factors. While educators have limited impact on students' home environments, math-friendly classroom and school environments can help students build proficiency in math. Specifically, teachers could be encouraged to create supportive and positive learning environments where elementary students are encouraged to have diverse educational activities, to accumulate success experiences through those activities, and in turn to increase academic self-confidence. Components for the positive learning environments can include: (a) restructuring math activities tailored to students' abilities and needs, (b) offering students stimulating math tasks and study materials that can support the development of students' competencies, and (c) assisting students with tutoring/resource centers and other community-based after-school programs (Huang & Cho, 2009; Jenner & Jenner, 2007).

Teachers perceive school counselor-teacher communication and teamwork as essential to an effective school because they can come to expect support for classroom preparation and instruction from school counselors, as well as counselor validation of teachers (Clark & Amatea, 2004). As school counselors have the opportunity for face-to face interactions with students and understand the connection between students' lives, personal characteristics, attitudes and academic performance, they will be in a good position to identity 4th-grade students' needs and expectations in learning and effectively respond to them. Specifically, school counselors can help teachers motivate students and develop strategies that will positively affect students' educational aspirations in learning. One form of teacher-counselor collaboration could be formal/informal consultation, such as teacher in-service meetings, focusing on Common Core and its emphasis on college and career readiness (e.g., for STEM careers). Through these means, school counselors can help teachers create a supportive climate which would contribute to high math performance and successful career choices.

In order to create math-friendly classroom environments, school administrators could be encouraged to implement math programs designed to help young learners stay motived, meet learning standards for math, and be prepared for success in middle and high school. Education literature frequently addresses the effectiveness of using technology and multimedia software in math education to facilitate student learning in and out of the classroom, to increase students' self-confidence through mastery and vicarious experiences provided by math software, and to enhance teachers' instructional delivery (Neo & Neo, 2004; Roberson, 2001; Spence & Usher, 2007). For instance, school districts across Illinois have selected enVisionMath program that combined the elementary math curriculum with visual animations and graphic texts to help develop students' reasoning ability for problem-solving. Those school districts found that program to be effective in serving students with diverse academic needs, as well as in promoting the home-school learning partnership. By using computer software or any other forms of technology, math programs, and support systems, school could motivate young learners and promote their math achievement in elementary school.

Regarding teacher training in math, because teacher's readiness to teach, motivation, and perceived competencies play important roles in forming a teacher's vision and beliefs in teaching and learning, it can be implied that these variables are associated with student academic outcomes (Bankov, Mikova, & Smith, 2006; Shulman & Shulman, 2004). Considering the strong relationship between teachers' perceived expertise and elementary student achievement, it is imperative that elementary school teachers become more cognizant of training opportunities related to math and engage in ongoing professional development that influence their level of expertise and accordingly student academic success. According to Erskine (2010), elementary school teachers tended to avoid discussions about math and math education; they were not comfortable with the subject; and they struggled with the application of appropriate math interventions because of a dearth of a deep understanding of the subject, math. Therefore, school districts and educational administrators should provide elementary teachers with sustainable and long-term training programs with easy access and accountability, in order to help teachers continue to engage in professional development efforts in math teaching. Those training programs may include seminars per the Common Core and curriculum development, online communities including innovative math curriculum materials, summer workshops to increase teacher's ability in math instruction, and mentoring. It is also recommended that elementary schools create a professional community environment where teacher collaboration is encouraged about problem-solving math activities and formative evaluation. Furthermore, like STEM Master Teacher Corps that the Obama Administration recently announced to create elite teachers and ensure best education in the STEM fields, national attention to elementary teacher preparation in math, as well as local, state, and nation-wide support for high-quality instruction in math, is necessary. Overall, results of this study are significant and relevant for educators and researchers as they seek to provide more meaningful and enriching educational experiences for elementary school students in the U.S.

**Limitations and Future Research**

Findings of this study have to be interpreted in light of its limitations. Initially, the authors used an existing nationally representative database that provided rich contextual information; however, the nature of the secondary database may have limited this study with the lack of control over the items chosen from the student questionnaire. For instance, there was no questionnaire to measure student competence in learning each of the math topics (i.e., numbers, geometry, and data display), students' aptitude scores, or the amount of time a student was willing to actively engage in learning math, which may be a very important part of the student-related variables. Second, because self-reported data have a number of potential biases resulting from social desirability, selective memory, and recalling events that happened at one time as if they occurred at another time (Rosenberg, Greenfield, & Dimick, 2006), it is important to consider limitations when interpreting results from self-reported data.

Even though the authors applied an appropriate and powerful statistical analysis (i.e., factor analysis and HLM) to examine the research questions, future researchers may want to adopt an in-depth qualitative approach to expand on our findings. In addition, as addressed by researchers (Weiss, Pasley, Smith, Banilower, & Heck, 2003), teachers' preparedness and content-related activities may not be assessed without first observing the student-teacher interactions. Direct classroom observations may be more appropriate measures of teacher effects and provide better estimates of the relationships between teacher effects and student performance (Palardy & Rumberger, 2008). Further, the relationships of context, teachers' perspectives, and students' math achievement may vary across students' age, especially when students are relatively younger. To increase the generalizability of the study findings, research across ages of students is needed. Moreover, future research can be conducted utilizing different existing comprehensive international achievement databases, such as Progress in International Reading Literacy Study (PIRLS) and Program for International Student Assessment (PISA). As different datasets tend to offer different background and contextual variables, it will be meaningful to discover whether similar findings will be derived from the use of similar models with similar study variables but different indicators.

## References

Akiba, M., LeTendre, G. K., & Scribner, J. P. (2007). Teacher quality, opportunity gap, and national achievement in 46 countries. *Educational Researcher, 36*(7), 369 – 387.

American School Counselor Association. (2003). *The ASCA national model: A framework for school counseling programs.* Alexandria, VA: Author.

Baker, D. P., & LeTendre, G. K. (2005). *National differences, global similarities-world culture and the future of schooling*. Stanford, CA: Stanford University Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.

Bankov, K., Mikova, D., & Smith, T. M. (2006). Assessing between-school variation in educational resources and mathematics and science achievement in Bulgaria. *Prospects, 36*(4), 447–473.

Biggs, J., & Moore, P. (1993). *The process of learning*. Sydney: Prentice Hall.

Bloom, B. S. (1976). *Human characteristics and school learning*. New York, NY: McGraw Hill.

Bodenhorn, N., Wolfe, E. W., & Arien, O. (2010). School counselor program choice and self-efficacy: Relationship to achievement gap and equity. *Professional School Counseling, 13*(3), 165–174.

Braucht, S., & Weime, B. (1992). The school counselor as consultant on self-esteem: An example. Special issue: Consultation. *Elementary School Guidance and Counseling, 26*(3), 229–236.

Carroll, J. (1963). A model for school learning. *Teacher College Record, 64,* 723–733.

Choike, J. R. (2000). Teaching strategies for "algebra for all". *Mathematics Teacher, 93*(7), 556–560.

Clark, M. A. & Amatea, E. (2004). Teacher perceptions and expectations of school counselor contributions: Implications for program planning and training. *Professional School Counseling, 8*(2), 32–140.

Cooper, H. (1989). *Homework*. New York: Longman.

Cooper, H., Robinson, J. C., & Patall, E. A. (2006). Does homework improve academic achievement? A synthesis of research. *Review of Educational Research, 76,* 1–62.

Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. *Education Policy Analysis Archives, 8*(1).

Delaware Department of Education [data file]. www.doe.k12.de.us

Erskine, B. M. (2010). *Raising mathematical achievement starts with the elementary teacher* (Doctoral dissertation). Retrieved from ProQuest. (UMI No. 3423320).

Ferguson, R. F. (1991). Paying for public education: New evidence on how and why money matters. *Harvard Journal on Legislation, 28*(2), 465–498.

Galassi, J. P., & Akos, P. (2012). Preparing school counselor to promote academic development. *Counselor education and Supervision, 51,* 50–63.

Gitomer, D. H. (2007). *Teacher quality in a changing policy landscape: Improvements in the teacher pool*. Princeton, NJ: Educational Testing Services.

Gwilliam, L. R., & Betz, N. E. (2001). Validity of measures of math- and science-related self-efficacy for African Americans and European Americans. *Journal of Career Assessment, 9,* 261–281.

Gonzales, P., Williams, T., Jocelyn, L., Roey, S., Kastberg, D., & Brenwald, S. (2008). *Highlights from TIMSS 2007: Mathematics and science achievement of U.S. Fourth-and-eighth-grade students in an international context* (NCES 2009-001). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Hill, H. C., Rowan, B., & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371–406.

Hipolito-Delgado, C. P. & Lee, C.C. (2007). Empowerment theory for the professional school counselor: A manifesto for what really matters. *Professional School Counseling, 10,* 327–332.

Hoff, D. J. (2001). Introduction to algebra: It's elementary. *Education Week*, 1–3.

House, J. D. (2006). Mathematics beliefs and achievement of elementary school students in Japan and the United States: Results from the third international mathematics and science study. *The Journal of Genetic Psychology, 167*(1), 31–45.

Huang, D., & Cho, J.. (2009). Academic enrichment in high-functioning homework afterschool programs. *Journal of Research in Childhood Education, 23*(3), 382–392.

Jenner, E., & Jenner, L. (2007). Results from a first-year evaluation of academic impacts of an after-school program for at-risk students. *Journal of Education for Students Placed at Risk, 12*(2), 213.

Joncas, M. (2008). TIMSS 2007 sample design. In Olson, J. F., Martin, M. O., & Mullis, I. V._(Eds.). *TIMSS 2007 Technical Report*. (pp.77-92). Chestnut Hill, MA: Boston College.

Keith, T. Z., & Cool, V. A. (1992). Testing models of school learning: Effects of quality of instruction, motivation, academic coursework, and homework on academic achievement. *School Psychology Quarterly, 7,* 207–226.

Koller, O., Baumert, J. & Schnabel, K. (2001). Does interest matter? The relationship between academic interest and achievement in mathematics. *Journal for Research in Mathematics Education, 32*(5), 448–470.

Kulpa, C. S. (2007). Algebra and the elementary school: Teacher math anxiety and its impact on student achievement. (Doctoral dissertation). Retrieved from ProQuest. (UMI No. 3273908).

Martin, D., Martin, M., Gibson, S., & Wilkins, J. (2007). Increasing prosocial behavior and academic achievement among adolescent African American males. *US: Libra Publisher, 42*(168), 689–698.

McCoy, L. P. (2005). Effect of demographic and personal variables on achievement in eight-grade algebra. *Journal of Educational Research, 98*(2), 131–135.

National Center for Education Statistics. (2008). *The condition of education 2008*. Washington, DC: U.S. Department of Education.

National Center for Education Statistics. (2007). *Trends in International Mathematics and Science Study (TIMSS) 2007*. Retrieved from http://nces.ed.gov

National Governors Association Center for Best Practices, & Council of Chief State School Officers. (2010). *Common Core State Standards*. Washinton DC: Author.

National Mathematics Advisory Panel (2008). *Foundations for Success: The Final Report of the National Mathematics Advisory Panel.* Washington, DC: U.S. Department of Education.

Neo, T. & Neo, M. (2004). Classroom innovation: Engaging students in interactive multimedia learning. *Campus-Wide Information Systems, 21*(3), 118.

No Child Left Behind. (2001). *No Child Left Behind Act of 2001*. Pub. L. 107-110. Washington, DC: U.S. Department of Education.

Orfield, G., Losen, D., Wald, J., & Swanson, C. (2004). *Losing our future: How minority youth are being left behind by the graduation rate crisis.* Cambridge, MA: The Civil Rights Project at Harvard University.

Pajares, F., & Graham, L. (1999). Self-efficacy, motivation constructs, and mathematics performance of entering middle school students. *Contemporary Educational Psychology, 24,* 124–139.

Palardy, G. J., & Rumberger, R. W. (2008). Teacher effectiveness in the first grade: The importance of background qualifications, attitudes, and instructional practices for student learning. *Educational Evaluation and Policy Analysis, 30,* 111–140.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis models* ($2^{nd}$ Ed.). Thousand Oaks: Sage.

Roberson, Lee. (2001). Integration of computers and related technologies into deaf education teacher preparation programs. *American Annals of the Deaf, 146*(1), 60–66.

Rodriguez, M. C. (2004). The role of classroom assessment in student performance on TIMSS. *Applied Measurement in Education, 17*(1), 1–24.

Rosenberg, A. L., Greenfield, M. V. H., & Dimick, J. B. (2006). *Secondary data analysis: Using existing data to answer clinical questions*. In J. T. Wei (Ed.) Clinical Research Methods for the Surgeons. Totowa, NJ: Humana Press.

Seeley, C. L. (2004). A journey in algebraic thinking. *NCTM News Bulletin, 41*(2), 3.

Singh, K., Grandville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest, and academic engagement, *The Journal of Educational Research, 95*(6), 323–332.

Spence, D. & Usher, E. (2007). Engagement with mathematics courseware in traditional and online remedial learning environments: Relationship to self-efficacy and achievement. *Journal of Educational Computing Research, 37,* 267–288.

Stigler, J. W., Gonzales, P., Kawanaka, T., Knoll, S., & Serrano, A. (1999). *The TIMSS videotape classroom study: Methods and findings from an* *exploratory research project on eighth-grade mathematics instruction in Germany, Japan, and the United States.* U.S. Department of Education. National Center for Education Statistics NCES 1999-074. Washington, DC: U.S. Government Printing Office.

Taylor-Cox, J. (2003). Algebra in the early years? Yes! *Young Children*. Retrieved May, 1, 2013 from http://www.earlychildhoodconnections.com/documents/Algebra.pdf

TIMSS. (1999). *Mathematics Benchmarking Report: TIMSS 1999*. Retrieved from http://nces.ed.gov

The White House, Office of the Press Secretary. (2012). *President Obama Plans for a New, National Corps to Recognize and Reward Leading Educators in Science, Technology, Engineering, and Math* [Press release]. Retrieved from http://www.whitehouse.gov/the-press-office/2012/07/17/president-obama-announces-plans-new-national-corps-recognize-and-reward-

Weiss, I. R., Pasley, J. D., Smith, P. S., Banilower, E. R., & Heck, D. J. (2003). *Looking inside the classroom: A study of k-12 mathematics and science education in the United States*. Chapel Hill, NC: Horizon Research.

## Appendix

*Table 1*
**Study Variables and Contextual Questions**

| Study Variables | Contextual Questions |
|---|---|
| Student level | |
| CM: Self-confidence in math | I usually do well in mathematics*<br>Mathematics is harder for me than many of my classmates<br>I am just not good at mathematics<br>I learn things quickly in mathematics* |
| AT: Attitude toward math | I would like to do more mathematics in school*<br>I enjoy learning mathematics*<br>Math is boring<br>I like mathematics* |
| HW: Time spent on math homework | When your teacher gives you homework, about how many minutes do you usually spend on your homework? |
| Teacher level | |
| FRC: Frequency of collaboration among math teachers | How often do you have discussions about how to teach a particular concept with other teachers?<br>How often do you work on preparing instructional materials with other teachers?<br>How often do you visit another teacher's classroom to observe his/her teaching?<br>How often do you have informal observations of your classroom by another teacher? |
| CAN: Perception of content-area knowledge | How well prepared do you feel you are to teach following mathematics topic?<br>A. Number<br>a) Whole numbers including place value and ordering<br>b) Adding, subtracting, multiplying and/or dividing with whole numbers<br>c) Fractions (parts of a whole or a collection, location on a number line)<br>d) Fractions represented by words, numbers, or models<br>e) Comparing and ordering fractions |

| | |
|---|---|
| | f) Adding and subtracting with fractions<br>g) Adding and subtracting with decimals<br>h) Number sentences (finding the missing number, modeling simple situations)<br>i) Number patterns (extending number patterns and finding missing terms)<br>j) Relationships between given pairs of whole numbers<br><br>B. Geometric Shapes and Measures<br>a) Comparing and drawing angles<br>b) Elementary properties of common geometric shapes<br>c) Relationships between two-dimensional and three-dimensional shapes<br>d) Finding areas and perimeters<br>e) Estimating areas and volumes<br>f) Using informal coordinate systems to locate points in a plane<br>g) Reflections and rotations<br><br>C. Data Display<br>a) Reading data from tables, pictographs, bar graphs, or pie charts<br>b) Drawing conclusions from data displays<br>c) Displaying data using tables, pictographs, bar graphs, or pie charts |
| CRA: Content-related activities | In teaching mathematics, how often do you usually ask them to do following?<br>a) Practice adding, subtracting, multiplying, and dividing without<br>b) Work on fractions and decimals<br>c) Measure things in the classroom and around the school<br>d) Make tables, charts, or graphs<br>e) Learn about shapes such as circles, triangles, rectangles, and cubes<br>f) Write equations for word problems<br>g) Explain their answers<br>h) Relate what they are learning in mathematics to their daily life<br>i) Memorize formulas and procedures |

Note. *=reverse coded.

*Table 2*

**Descriptive Statistics for Student-level and Teacher-level Variables**

| Variables | M | SD | Min | Max |
|---|---|---|---|---|
| Student-level | | | | |
| Math achievement | 528.92 | 75.53 | 261.77 | 772.36 |
| CM | 3.15 | 0.73 | 1.00 | 4.00 |
| AT | 3.03 | 0.91 | 1.00 | 4.00 |
| HW | 1.71 | 0.84 | 1.00 | 4.00 |
| Teacher-level | | | | |
| FRC | 2.04 | 0.45 | 1.00 | 3.50 |
| CAN | 3.87 | 0.18 | 3.05 | 4.00 |
| CRA | 2.63 | 0.28 | 1.78 | 3.56 |

*Table 3*

**HLM Result of the Fixed and Random Effects of the Unconditional Model**

| Model | Fixed effect | Coefficient | *SE* | *p* |
|---|---|---|---|---|
| 1 | ICC | .28 | | |
| | Intercept | 528.17 | 2.76 | <.001 |
| | Random effect | Variance Component | *SD* | |
| | Between school ($u_0$) | 1563.96 | 39.55 | <.001 |
| | Within school ($r_{ij}$) | 4028.62 | 63.47 | |

Note. ICC = Intra-class correlation coefficient; *SE* = standard error; *SD* = standard deviation.

*Table 4*

**The Effects of Student-Level Variables on Mathematics Achievement**

| Model | Fixed effect | Coefficient | *SE* | *p* |
|---|---|---|---|---|
| 2 | Intercept | 532 | 2.38 | <.001 |
| | CM | 44.10 | 1.19 | <.001 |
| | AT | -6.63 | 0.97 | <.001 |
| | HW | 1.43 | 0.97 | .14 |
| | Random effect | Variance Component | *SD* | |
| | Between school ($u_0$) | 1138.20 | 33.74 | <.001 |
| | Within school ($r_{ij}$) | 3013.94 | 54.90 | |

Note. *SE* = standard error; *SD* = standard deviation.

*Table 5*
**The Effects of Teacher-Level Variables on Mathematics Achievement**

| Model | Fixed effect | Coefficient | *SE* | *p* |
|---|---|---|---|---|
| 3 | Intercept | 532.31 | 2.28 | <.001 |
| | Student-level | | | |
| | CM slope | 44.16 | 1.20 | <.001 |
| | AT slope | -6.81 | 0.96 | <.001 |
| | HW slope | 1.40 | 0.98 | .15 |
| | Teacher-level | | | |
| | FRC | -4.86 | 4.70 | .30 |
| | CAN | 42.61 | 9.06 | <.001 |
| | CRA | 4.83 | 9.86 | .63 |
| | Random effect | Variance Component | *SD* | |
| | Between school ($u_0$) | 1049.34 | 32.40 | <.001 |
| | Within school ($r_{ij}$) | 3005.36 | 54.82 | |

**Authors:**

*Hongryun Woo,*
*University of Louisville.*
*Email: h0woo001@louisville.edu*

*Malik S. Henfield*
*University of San Francisco.*
Email: mshenfield@usfca.edu