Abstract Title Page

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Title: Relations between Mathematical Knowledge for Teaching, Mathematics Instructional Quality, and Student Achievement in the Context of the *Responsive Classroom (RC*) Approach

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Abstract Body

Limit 4 pages single spaced.

Background / Context:

Description of prior research and its intellectual context.

Currently, only 39% of American fourth grade students perform at or above proficiency in mathematics and there are large disparities in achievement with regards to race and socio-economic status (Lubienski, 2002; 2006; NCES, 2009; Reardon, 2002). Given the current emphasis on accountability and standardized testing, schools and teachers face increased pressure to improve achievement for all students. Understanding which factors or constructs contribute to the variation in student math achievement has been a central issue to researchers, teachers, and policy makers. State and national policies have focused on the role of teachers for providing high quality math instruction to all students in order to reverse poor math achievement among American students. Although there is evidence to suggest that teachers are largely responsible for students' mathematics learning (Hiebert & Grouws, 2007; Nye, Konstantopolous, & Hedges, 2004; Rowan, Correnti, & Miller, 2002) there is a need for further research examining *how* teachers influence student achievement. Much work has been heavily focused on three main causal factors that appear to contribute to student achievement gains: (a) teacher knowledge; (b) instructional quality; and (c) interventions.

Despite over thirty years of theoretically based research investigating *how* teacher mathematical knowledge and instructional practice relate to student learning (Fennema & Franke, 1992; Hill et al., 2004; 2008; US Department of Education, 2008), it is still largely unclear *how* these constructs are related (Mewborn, 2007), and policy makers and practitioners are still situated in a context with insufficient data to make decisions. Thus, there is a need for further research that examines the credibility of such theories and understands the mechanisms behind *how* teacher knowledge (MKT) influences the mathematics instructional quality (MIQ) and promotes student achievement, particularly in large samples of teachers and children. In addition, although much work has been dedicated to testing the efficacy of social emotional learning (SEL) interventions for promoting academic growth, there is very little research that integrates SEL and math. One intervention, the *Responsive Classroom® (RC)* Approach is consistent with goals for creating high quality mathematical learning experiences for children, as exemplified by the NCTM (2000) standards. The *RC* Approach is designed to integrate social and academic learning and create optimal classroom learning environments that enhance children's ability to learn effectively. Through regular structured and engaging class meetings; clear rules and consequences for behavior; procedures that offer academic choice to children; specific recommendations for teachers that focus children's attention on the process of learning, problem-solving, and reflecting on their work; as well as methods for introducing new materials to students; the *RC* Approach offers teachers a set of strategies designed to create efficient classroom environments with fewer behavior problems and more opportunities to learn. *RC* has early evidence demonstrating improved classroom quality (effect size d = .50-.74), and gains in math achievement (effect size d = .16-.39) (blinded for review, 2011; 2007).

Purpose / Objective / Research Question / Focus of Study:

Description of the focus of the research.

This study has two goals. First, this study aims to validate existing theoretical frameworks and question and/or replicate initial findings about how mathematical knowledge for teaching, instructional practices, and student learning are related. Specifically, this study examines the direct and indirect relations of these constructs, as guided by the following four questions: (a) What is the relation between higher MKT and improved student achievement?; (b) What is the relation between higher MKT and higher quality of instruction?; (c) What is the relation between higher quality instruction and improved student learning?; and (d) Is MKT indirectly related to student mathematics achievement through instructional quality? To our knowledge, no large quantitative study to date has examined how teacher knowledge *and* MIQ collectively contribute to student achievement, or have tested the potential role of MIQ as a mediator between teacher knowledge and student achievement. This has largely been due to the complexity of reliably measuring the quality of instruction in the math classroom (Kersting, et al., 2010). This study addresses these gaps by using multiple methods (i.e. teacher-report, direct assessment, and classroom observations), which together can provide important information about the complex relations between these constructs. Second, this study examines the extent to which the *Responsive Classroom (RC)* approach strengthens the relations between MKT, MIQ, and achievement (compared to teachers delivering "business as usual" instruction). By looking at intervention and control schools simultaneously, this study is able to better understand the processes by which teacher knowledge and SEL interventions can facilitate higher quality instruction and student outcomes.

Setting:

Description of the research location.

The present study is part of a larger three-year longitudinal cluster randomized controlled trial, the *Responsive Classroom* Efficacy Study (RCES), examining the impact of the *Responsive Classroom® (RC)* approach on classroom quality and student achievement in the third, fourth, and fifth grades. Twenty-four schools in a mid-Atlantic school district were enrolled into RCES because of their willingness to receive training in the *RC* approach and participate in a research study. Schools were matched and randomly assigned into intervention (*n*=13) and control (*n*=11) schools. After randomization, groups were compared across demographic and school characteristics. Free and reduced lunch and racial composition were fairly comparable across intervention (27.63% free and reduced lunch, 59% racial minority) and control schools (24.53 % free and reduced lunch, 53% racial minority). Data for the present study was collected from the third grade students, teacher, and classrooms in these 24 schools mentioned above.

Population / Participants / Subjects:

Description of the participants in the study: who, how many, key features, or characteristics.

Participants in the present study include 88 third grade teachers and their 1,533 students from 24 schools. 83 of the teachers in the present sample were female (83% white, 6.8% African American, 1.1% Hispanic, and 9.1% of another ethnicity) and had, on average, 9.27 years of teaching experience, with a range of 1 to 35 years (*SD*= 8.10). 95.4% of the teachers' had a bachelor's degree only and 54% held a masters or other graduate degree. Half (*n* = 44; 50%) of the teachers taught in schools receiving the *Responsive Classroom* intervention. 840 (50.8%) of the students were male and 812 (49.2%) were female. In terms of ethnicity, 636 (41.5%) were Caucasian, 165 (10.8%) were African-American, 338 (22 %) were Hispanic, 285 (18.6%) were Asian, and 6 (0.4%) were of other ethnicities. 208 (12.5%) of the students had an individualized education plan (IEP) and 661 (43.1%) were English Language Learners. 497 (32.4%) of the students received free or reduced lunch and 742 (48%) of the children attended schools which were trained in the *Responsive Classroom* Approach.

Intervention / Program / Practice:

Description of the intervention, program, or practice, including details of administration and duration. For Track 2, this may include the development and validation of a measurement instrument.

The *RC* approach (NEFC) is a social and emotional intervention that is designed to help teachers facilitate and create a safe and supportive classroom environment that encourages academic learning. This professional development program is unique in that it is not context or content and does not have a scripted curriculum. Rather, the *RC* approach provides teachers with practical strategies for bridging academic, social, and emotional learning throughout all aspects of the school day, including Positive Teacher Language, Collaborative Problem Solving, Guided Discovery, Academic Choice, Morning Meeting, Rules and Logical Consequences, Classroom Organization, and Working with Families (NEFC, 2003). Further, the program values equal emphasis on academic and social skills, the content and process of learning, the social interactions in cognitive development, understanding students as individuals, and the climate among school teachers and administrators.

During the summer of 2008, the 44 third grade teachers who were randomly assigned to the *RC* condition completed a one week long *RC* 1 training institute constituting 35 hours of instruction, where they were introduced to and taught *RC* practices, as described above. The training was provided in large groups by trained consultants from NEFC. During the 2008-2009 school year, these teachers also received three consultations and classroom visits by their *RC* coach, attended one-day workshops, as well as had access to email and phone communication. During the coaching visits, the teachers were observed and given feedback about their use of *RC* practices. In addition, the coach conducted a lesson in their class, held debriefing sessions and mini-workshops, and led meetings with teachers and administrators. The 44 control teachers received no training on *RC* practices and continued their instruction with "business as usual".

Research Design:

Description of the research design.

The data presented in this study are taken from one year of the RCES randomized controlled trial. We used multi-group path analysis techniques, which allowed for: (a) simultaneous testing of the direct and indirect effects of each variable for predicting student achievement for each group separately; and (b) a comparison of path coefficients (directionality and strength) across the two groups of teachers (Park & Huebner, 2005). All analyses used 2-level hierarchical linear modeling (HLM) (Raudenbush and Bryk, 2002) to account for the clustering effects and nesting of children within teachers and classrooms

Data Collection and Analysis:

Description of the methods for collecting and analyzing data.
For Track 2, this may include the use of existing datasets.

Data were collected from three sources: student achievement tests, online teacher-report questionnaires, and classroom observations conducted and coded by research assistants. Students' math achievement was assessed in both 2nd and 3rd grade. Students' 2nd grade math achievement was assessed using the Stanford-10. All third grade students were then given the state standardized math assessment a year later. Demographic information about the students was also collected at this time by the school administration. Teachers completed the MKT assessment (Hill et al., 2004) online (13 items, alpha=0.84). In addition, research assistants videotaped all 88 third grade teachers for three mathematics lessons (usually about 60 minutes each) during the third grade school year. Upon the completion of videotaping, tapes were sent to the laboratory for off-site observational coding using two different measures: *Classroom Practices Observational Measure (CPOM):* (Abry, et al., 2010); and the *Mathematics Scan (M-Scan)*(blinded for review, 2010). The M-Scan is a new valid and reliable classroom observational measure of mathematics instructional quality (alpha=0.93). A composite score was created for each teacher representing his or her average mathematics instructional quality.

Descriptive statistics and bivariate correlations were calculated to determine the variation of and relation between variables for the *RC* and control group participants. (ICCs= 0.30 (intervention) and 0.24 (control). Next, a 2-level multi-group path analysis was performed in Mplus (Muthen & Muthen, 2007) to examine the relations between constructs and test for group differences. Level 1 controlled for student level characteristics, including free and reduced lunch, English Language Learner, and minority status, and 2nd grade achievement. Level 2 variables included MKT, M-Scan, and CPOM.

Findings / Results:

Description of the main findings with specific details.

Two major findings emerged from this study. First, this study provides empirical evidence supporting two of the three direct links, and initial evidence for an indirect link between MKT, MIQ, and student achievement; however, such findings were only evident in the intervention group (please insert figure 1 here). On average, *RC* teachers who scored one point higher on the MKT showed a 0.42 point gain on mathematics instructional quality (roughly 1/3 of a standard deviation). Further, teachers who integrated more *RC* practices into their teaching provided higher quality mathematics instruction ($p<0.05$). In addition, students who had *RC* teachers who scored one point higher on the M-Scan performed, on average, 5.95 points higher on their mathematics assessment (p=0.04). MKT was not directly related to student mathematics achievement in the intervention or control groups ($p>0.05$), but was indirectly related in the *RC* group. Second, group differences suggest that training in the *Responsive Classroom* Approach strengthens the relations among teacher knowledge, instructional quality, and student achievement (please insert figure 2 here).

Conclusions:

A current push in policy and teacher education is to improve teachers' content knowledge and effectiveness (U.S Department of Education, 2008; 2010). However, solely focusing on increasing the amount of pedagogical content knowledge teachers hold without helping teachers understand how to *translate* their knowledge and create *classroom environments* (Grossman, Schoenfeld, & Lee, 2005; Hiebert, et al., 1997) which foster higher quality instructional practices (Fennema & Franke, 1992) is unlikely to improve teacher quality or raise student achievement. Only teachers who are skilled at organizing their classrooms can create the type of social classroom interactions conducive to high quality mathematics instruction. For example, skilled teachers give feedback that is specific and elaborates on children's mathematical thinking, focuses feedback on the process of learning as opposed to only the outcomes, creates opportunities for children to reflect on their work, teaches students how to use mathematics manipulatives as intended, teaches children turn-taking skills to support small-group work, and offers children a sense of safety and security in the classroom—all strategies that have been linked to children's learning. Social emotional learning interventions (such as *RC*) may provide teachers with the necessary organizational and pedagogical skills that allow them to effectively translate their knowledge into high quality practices (Kazemi & Franke, 2000) and support student learning.

Two limitations require mentioning. First, despite the randomized design and large sample of students, statistical power in the current study was limited. Future research should investigate these direct and indirect paths in more detail, emphasizing mechanisms, and using larger samples. A second limitation is that mathematics instructional quality for each teacher was only observed for an hour on three days during the school year. However, these concerns are ameliorated by the established reliability and validity of the measure (blinded for review, 2010) and the ability for the M-Scan to predict student outcomes.

Appendices

Not included in page count.

Appendix A. References

References are to be in APA version 6 format.

Abry, T., Brewer, A., Nathanson, L., Sawyer, B., Rimm-Kaufman, S.E. (2010). Classroom Practices Observation Measure. University of Virginia, Unpublished measure.

xxxx. (2010). *The Mathematics-Scan Coding Guide*. Unpublished measure. xxx.

Hamre, B. K., & Pianta, R. C. (2001). Early teacher-child relationships and the trajectory of children's school outcomes through eighth-grade. *Child Development*, 72, 625–638.

Hiebert, J., Stigler, J. W., Jacobs, J. K., Givvin, K. B., Garnier, H., Smith, M., et al. (2005). Mathematics teaching in the united states today (and tomorrow): Results from the TIMSS 1999 video study. *Educational Evaluation and Policy Analysis, 27*(2), 111-132.

Hill, H. & Ball, D..(2004). Learning mathematics for teaching: results from California's mathematics professional development institutes. *Journal of Research in Mathematics Education, 35*(5), 330-351.

Hill, H. C., Blunk, M. L., Charalambous, C. Y., Lewis, J. M., Phelps, G. C., Sleep, L., et al. (2008). Mathematical knowledge for teaching and the mathematical quality of instruction: An exploratory study. *Cognition and Instruction, 26*(4), 430 – 511.

Kersting, N., GIvvin, K., Sotelo, F., & Stigler, J. (2010). Teachers' analyses of classroom video predict student learning of mathematics: Further explorations of a novel measure of teacher knowledge. *Journal of Teacher Education, 61,* 172-181.

Lubienski, S. T. (2002). A closer look at black-white mathematics gaps: Intersections of race and SES in NAEP achievement and instructional practices data. *The Journal of Negro Education, 71*(4), 269-287.

Lubienski, S.T. (2006). Examining Instruction, Achievement, and Equity with NAEP Mathematics Data." Education Policy Analysis Archives 14 (14).

Mewborn, D. (2003). Teaching, teachers, knowledge, and their professional development. In J. Kilpatrick, W. Martin, & D Schifter, (Eds.). *A research companion to principals and standards for school mathematics* (pp. 45-52). Reston, VA: The National Council of Teachers of Mathematics.

Muthen, L. K. & Muthen, B. O. (2010). Mplus user's guide (6th ed.). Los Angeles, CA: Muthen & Muthen.

National Center for Education Statistics (2009). The Nation's Report Card: Mathematics 2009 (NCES 2010–451). Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Northeast Foundation for Children, Inc. (2003): Turners Falls, MA

Nye, B., Konstantopoulos, S., & Hedges, L. V. (2004). How large are teacher effects? *Educational Evaluation and Policy Analysis, 26*(3), 237-257.

xxx (In Review). *The Contribution of Teachers' Self-Efficacy for Teaching Mathematics and the Impact of a Social and Emotional Learning Intervention on Mathematics Instructional Quality.*

Raudenbush, S.W., Bryk, A.S, & Congdon, R. (2004). HLM 6 for Windows [Computer software]. Lincolnwood, IL: Scientific Software International, Inc.

Roeser, R., Eccles, J., & Sameroff, A. (2000). School as a context of early adolescents' academic and social-emotional development: A summary of early research findings. *Elementary School Journal, 100*(5), 443-471.

Rowan, B., Correnti, R., & Miller, R. (2002). What large-scale survey research tells us about teacher effects on student achievement: Insights from the prospects study of elementary schools. *The Teachers College Record, 104*(8), 1525-1567.

Schoenfeld, A.H. (2006). Mathematics teaching and learning. In Alexander, P. & Winne, P. (Eds.), *Handbook of educational psychology (2nd ed.)*.

Skibbe, L., Decker, L., and Rimm-Kaufman, S. (June 2006). *The contribution of the responsive classroom approach to classroom quality and teaching practices*. Poster presented at the Institute for Education Sciences, Washington, D.C.

Virginia Department of Education (2009). Spring 2009 Released test: Grade 3 mathematics.

Xxx (In Review). *Introducing an observational measure of mathematics instructional quality: Evidence of validity and score reliability.*

Wenglinsky, H. (2004). Closing the racial achievement gap: The role of reforming instructional practices. *Education Policy Analysis Archives, 12*(64).

Appendix B. Tables and Figures

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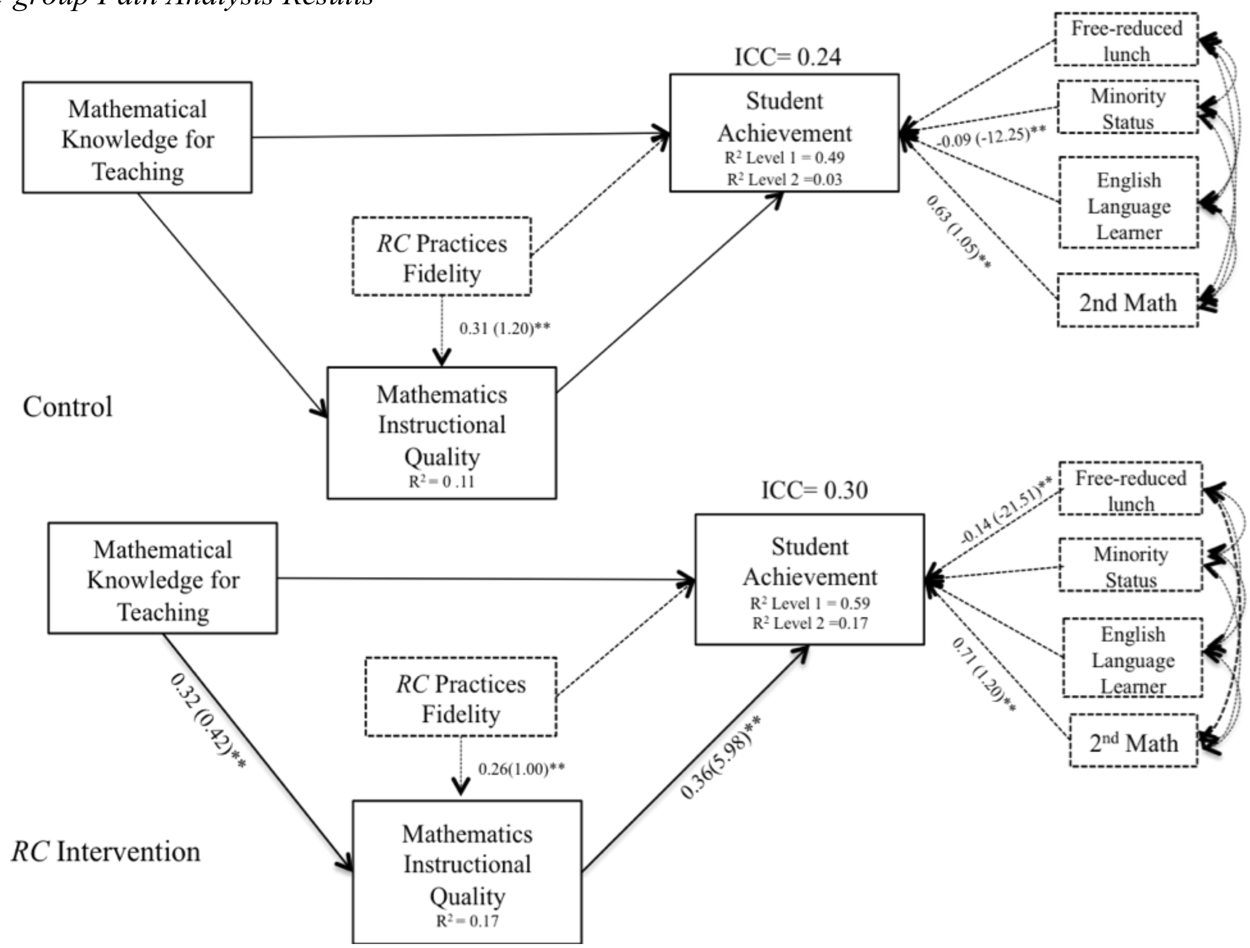
Table 1.
Unstandardized and Standardized Path Coefficients for the M-Scan Multi-Group Model

	M-SCAN					
	RC Intervention			Control		
	ß	S.E	St. B	ß	S.E	St. B
Level 1 Predictors						
FRL to 3rd Achievement	-	5.13	-0.14	-7.01	5.33	-0.05
ELL to 3rd Achievement	0.06	4.73	0.00	6.43	4.35	0.05
Minority to 3rd Achievement	0.22	4.40	0.00	-12.25**	4.60	-0.09
2nd Achievement to 3rd	1.20**	0.05	0.71	1.05**	0.06	0.63
Predictors of Quality						
MKT to Quality	0.42**	0.19	0.32	0.16	0.18	0.14
CPOM to Quality	1.00**	0.56	0.26	1.20**	0.61	0.31
Predictors of 3rd Achievement						
MKT to 3rd Achievement	-0.15	3.39	-0.01	-0.15	3.39	-0.01
CPOM to 3rd Achievement	-21.19	12.96	-0.32	-0.01	19.45	0.00
Quality to 3rd Achievement	5.98**	3.42	0.36	3.92	4.58	0.16
Total Effects	2.35	3.46	0.11	0.47	3.49	0.02
Indirect Effects	2.50 *t*	1.85	0.12	0.62	1.01	0.02
ICC		0.30			0.24	
% Child Level Variance Explained		59%			45%	
% Teacher Level Variance		17%			3%	

S.E.= Standard Error, ***p*<0.05, *t*= *p*<0.08

Figure 1.
Multi-group Path Analysis Results



All estimates are reported standardized (unstandardized). $**p<0.05$. Dashed lines represent covariates.