CEME
Technical Report

CEMETR-2014-04
APRIL 2014

The Center for Educational Measurement and Evaluation

MSP End of Year Three Summative Report

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A PUBLICATION OF
THE CENTER FOR
EDUCATIONAL
MEASUREMENT
AND EVALUATION

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College of Education
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MSP Grant Project: Year Three Summative Report

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This is a summative report based on Year Three data from the MSP Grant Project entitled, "Content Development for Investigations" (CoDE:I). The purpose of the MSP grant program was to develop standards-based elementary mathematics teachers by giving teachers the tools to teach with a new standards-based mathematics curriculum, *Investigations in Number, Data, and Space (Investigations)*. The participants were teachers in two school systems located near a large metropolitan city in the southeastern United States. System One is a large, urban school system and System Two is a smaller suburban school system in a neighboring city. The two school systems conducted professional development separately and on different days throughout the grant program, but the overall content and focus of the professional development remained consistent. The professional development facilitators worked with both groups of teachers.

Since the MSP project is not a longitudinal design, teachers participants exit from the program at the end of the academic year. As a result, it is not necessary to combine the data from three years unless we want to examine the cohort effect. The focus of this report is to examine the impacts of the professional development on teacher beliefs, practices, mathematics content knowledge, and student learning outcomes.

Evaluation Design

Based on feedback from the MSP grant management team and our own analysis of data, an experimental design was added to the evaluation by the addition of a control group. Cluster random sampling was used to identify control group schools. Two schools were identified: one from a higher socioeconomic neighborhood and the other from a lower socioeconomic neighborhood. The evaluation team met with the principals and math coordinators/assistant principals in each school and gave the package of the instruments and gift cards to the math coordinators/assistant principals. The treatment group included observations in both districts of two teachers from each of the grade levels from kindergarten through fifth grade. There were 12 teachers from each district observed for a total of 24 teacher observations. The control group included observations of two teachers from each of the grade levels from kindergarten through fifth grade. The two teachers from each grade level included one from the higher socioeconomic neighborhood school and one from the lower socioeconomic neighborhood school for a total of 12 teacher observations. The control group received a ten dollar gift card for completing three surveys, another ten dollar card for completing the math content test, and a ten dollar gift card for each pre/post test assessment submitted.

All student assessments are unit tests from the Investigations curriculum. Specific units were chosen to be assessed by the professional development team as they would reflect concepts that teachers were to focus on during professional development and should reflect changes in their mathematical teaching practices and subsequent student performance. Three units from each grade level were chosen in Year One to be used as pre and post test measures. For Year Two and Year Three, all unit tests remained consistent with the exception of fourth grade. Fourth grade teacher leaders, after discussion with the professional development facilitators, indicated that they would prefer to assess students on Unit 1 instead of Unit 8 as Unit 1 maintained better alignment with the state standard course of study. Therefore, fourth grade assessed students on Units 1, 3, and 6 in Year Two and Year Three instead of 3, 6, and 8 as in Year One. Kindergarten teachers were asked in Year Two and Year Three to only give their students one pre test (Unit 2: Counting) at the beginning of the school year and then to administer the Unit 4: Counting and Unit 6: Counting assessment as post tests at the end of those units.

With regard to student assessments, more comprehensive grading rubrics were developed by the external evaluation team in cooperation with the professional development facilitators. For Year One, teacher participants created the rubrics that were to be used to score student assessments. As these rubrics were appropriate for use in the classroom by teachers, they were not appropriate to use to quantitatively score the assessments. Therefore, scoring of the student assessments was standardized throughout all units and grade levels and comprehensive rubrics were created. Moreover, pretests for all units were conducted at the beginning of the school year (August, 2010) in Year Two and Year Three instead of before each individual teacher taught the unit in Year One because the external evaluation team realized in Year One that not all teachers were moving from unit to unit at the same time and administering the pretest before each teacher teaches the unit creates a lot of communication and traveling due to large number of participants in Year Two and Year Three.

In Year Two and year Three, teacher participants in System One created projects and conducted other professional development activities on their own time instead of attending a series of follow-up workshops as they did in Year One. The teacher participants were compensated for completing a series of individualized activities and were provided with feedback as needed by professional development facilitators. As 80 contact hours were required by the grant, several activities were implemented. This did, however, limit the amount of contact that the external evaluation team had with all teacher participants in System One, but the collection of data was not interrupted because of the good communication between the evaluation team and the school district leaders. System One teachers met three times after the summer workshop ended in August (November, February, and June).

Participants

The participants in Year Three were elementary school teachers from the same two school systems as in Year One and Year Two. Of the 240 participants, 207 were from System One and 33 from System Two. In System One: 39(18.8%) participants taught Kindergarten, 43(20.8%) taught first grade, 35(16.9%) taught second grade, 36(17.4%) taught third grade, 36(17.4%) taught fourth grade, and 18(8.7%) taught fifth grade. In System Two: 1(2.9%) participants taught Kindergarten, 5(14.7%) taught first grade, 6(17.6%) taught second grade, 6(17.6%) taught third grade, 5(14.7%) taught fourth grade, 6(17.6%) taught fifth grade, and 4(11.8%) taught both first and third grades.

Participants also included 5161 students, of which 4692 (91%) were from the treatment group and 469 (9%) were from the control group. Of all the students, 4438(86.0%) were from System One and 723(14.0%) were from System Two. The distribution of grade levels in System One is: 660(14.9%) Kindergarten, 837(18.9%) first grade, 646(14.6%) second grade, 674(15.2%) third grade, 892(20.1%) fourth grade, and 729(16.4%) fifth grade. The distribution of grade levels in System Two is: 39(5.4%) Kindergarten, 64(8.9%) first grade, 116(16.0%) second grade, 182(25.5%) third grade, 115(15.9%) fourth grade, and 207(28.6%) fifth grade. The distribution of students in treatment and control groups is as follows. Kindergarten: 645(92%) treatment and 54(8%) control. First grade: 832(92%) treatment and 69(8%) control. Second grade: 673(88%) treatment and 89(12%) control. Third grade: 789(92%) treatment and 67(8%) control. Fourth grade: 903(90%) treatment and 104(10%) control. Fifth grade: 850(91%) treatment and 86(9%) control.

Purpose

Four key components of the PD were evaluated: (a) teacher content knowledge in teaching mathematics; (b) teacher beliefs about teaching and learning mathematics, (c) instructional practices in teaching mathematics; and (d) impact of teacher beliefs and practices on student learning outcomes in mathematics.

Data Collection Methods

Long-time engagement and multiple instruments were used to collect data for the formative and summative evaluations. Teacher beliefs, practices and mathematics content knowledge were measured using pre and post test instruments. Teachers' implementation of new knowledge and skills from the PD, as well as their experiences with the PD and their fidelity of implementation of Investigations were assessed using classroom observations, teacher interviews, and secondary data. Student achievement was measured using end of unit assessments from Investigations given before and after 3 specific units in the curriculum throughout the year.

Teacher instruments. All teacher-participants completed three pre-project and post-project instruments: a Teacher Beliefs Questionnaire (TBQ; Appendix A), a Teacher Practices Questionnaire (TPQ; Appendix B), and a Content Knowledge for Teaching Test (Appendix C). The TBQ examined teachers' espoused beliefs about mathematics, mathematics teaching and mathematical learning (Swan, 2006). For each of those three dimensions, teachers reported the percentage to which their views align to each of the transmission, discovery, and connectionist views. The sum of the three percentages in each section is 100. Teachers were coded as discovery/connectionist if they indicated at least 45% in either discovery or connectionist (Swan, 2006). The TPQ examined participants self-report about instructional practices related to their mathematics teaching (Swan, 2006). Each of the items reflects either student-centered or teacher-centered pedagogies. Teachers identified their instructional practices on a 5-point Likert scale, where 0 represents "none of the time" and 4 represents "all of the time." Items that reflect student centered practices (Items 5, 6, 7, 11, 12, 15, 16, 17, 20, 21, 24 & 25) were reversely coded so that teachers with a mean score of 2.00 or less were coded as "student centered" and teachers with a mean score of 2.01 or more were coded as "teacher centered." Content Knowledge for Teaching Test (see sample in Appendix C) measure teachers' knowledge of mathematics content and knowledge of students and content (Hill, Rowan, & Ball, 2005). For each teacher, the number of correct items was recorded.

Observations. Twenty four of the participants were randomly selected and observed twice in order to examine the fidelity of curriculum implementation. Before and after the observation, teachers were asked to answer questions about their lesson (see Appendix D). These questions provided a framework for what would be occurring during the observation and hearing participants' reaction to the lesson. Observation protocol was followed closely in each observation, noting specific interactions between the teacher and student, levels of questioning used by the teacher, fidelity of implementation of the *Investigations* curriculum, and the classroom environment. The observation protocol had 11 questions (5-poin-Likert Scale) to measure the level of implementation of the PD where "1"stands for "minimal display of behavior associated with the goals of the PD" and "5" stands for "frequent display of behavior associated with the goals of the PD".

Secondary data sources. Other data was also used to verify findings. Participants completed a Leadership Log (Appendix E), exit tickets from the summer PD, email conversations, and face-face conversations between the researchers and the participant.

Student achievement measures. The student achievement measures were end-of-unit assessments from the *Investigations* curriculum (Russell & Economopolous, 2007). Three units, which were most closely associated with the professional development, were assessed from each grade level and each unit lasted between 3 and 5 weeks. Teachers administered these assessments before teaching the unit (pre-tests) and immediately after completing the unit (post-tests). One of the project evaluators used a teacher-created rubric to score each assessment and converted scores to a percentage. Gain scores were used in the analyses.

Data Analysis

The multiple sources of data listed above were used to triangulate the results. T-tests and analysis of variance (ANOVA) were used to examine group differences and Hierarchical linear modeling (HLM) were used to analyze the student data nested within teacher variables to account for the within- and between-group variances. The magnitude of effect, or proportion of variance explained by the complete model for HLM, was calculated by 1 minus the ratio between the estimated variance of the complete conditional model and that of the unconditional model. Constant comparison method was employed to identify emerging themes from observation field notes, transcribed interviews, and teacher on-line discussion, face-to-face conversations, and email communications.

Results

Influence on Teacher Beliefs

In System One, 162 teachers completed the TBQ both at the beginning and end of Year Three. Of these teachers, 31(19%) changed from transmission to discovery/connectionist orientation, 115(71%) remained unchanged, and 16(10%) changed from discovery/connectionist to transmission orientation with respect to teacher beliefs about mathematics. Of those 115 who remained unchanged, 47 were of discovery/connectionist orientation and 31 were of transmission orientation at the beginning of the program. As for teacher beliefs about learning mathematics, 31(19%) changed from transmission to discovery/connectionist orientation, 115(71%) remained unchanged, and 16(10%) changed from discovery/connectionist to transmission orientation. Of those 115 teachers who remained unchanged, 94 were of discovery/connectionist orientation and 21 were of transmission orientation at the beginning of the program. Finally, 36(22%) changed from transmission to discovery/connectionist orientation, 103(64%) remained unchanged, and 23(14%) changed from discovery/connectionist to transmission orientation with respect to teacher beliefs about teaching mathematics. Of those 103 teachers who remained unchanged, 71 were of discovery/connectionist orientation and 32 were of transmission orientation at the beginning of the program.

In System Two, 25 teachers completed the TBQ both at the beginning and end of Year Three. Of these teachers, 5(20%) changed from transmission to discovery/connectionist orientation, 12(48%) remained unchanged, and 8(32%) changed from discovery/connectionist to transmission orientation with respect to teacher beliefs about mathematics. Of those 12 teachers who remained unchanged, 2 were of discovery/connectionist orientation and 10 were of transmission orientation at the beginning of the program. As for teacher beliefs about learning mathematics, 6(24%) changed from transmission to discovery/connectionist orientation, 18(72%) remained unchanged, and 1(4 %) changed from discovery/connectionist to transmission orientation. Of those 18 teachers who remained unchanged, 11 were of discovery/connectionist orientation and 7 were of transmission orientation at the beginning of the program. Finally, 3(12%) changed from transmission to discovery/connectionist orientation, 14(56%) remained unchanged, and 8(32%) changed from discovery/connectionist to transmission orientation with respect to teacher beliefs about teaching mathematics. Of those 14 teachers who remained unchanged, 8 were of discovery/connectionist orientation and 6 were of transmission orientation at the beginning of the program.

Influence on Teacher Practices

In System One, 164 teachers completed the TPQ for the beginning and end of Year Three. Of these teachers, 11(7%) changed from student-centered to teacher-centered, 129(79%) remained unchanged, and 24(15%) changed from teacher-centered to student-centered of their practices in the classroom, indicating a significant impact of the PD on teacher's practices. Of those 129 teachers who remained unchanged, 121 were student-centered and 8 were teacher-centered at the beginning of the program.

In System Two, 24 teachers completed the TPQ for the beginning and end of Year Three. Of these teachers, 3(13%) changed from student-centered to teacher-centered, 15(62%) remained unchanged, and 6 (25%) changed from teacher-centered to student-centered of their practices in the classroom, also indicating a significant impact of the PD on teacher's practices. Of those 15 teachers who remained unchanged, 13 were student-centered and 2 were teacher-centered at the beginning of the program.

The observation data of 22 randomly selected teachers; however, failed to show statistically significant changes at the end of the PD (M = 4.17, SD = 0.58) from the beginning of the PD (M = 4.07, SD = 0.80), $t(21) = 0.52$, $p = .61$. The observation indicated that the teacher practices in the classroom were not consistent, $r = .32$, $p = .14$.

Influence on Mathematical Content Knowledge for Teaching

The Content Knowledge Test was completed by 184 teachers in System One and 32 teachers in System Two at the beginning of the academic year; 164 teachers in System One and 26 teachers in System Two at the end of the academic year. Only 152 teachers in System One and 26 teachers in System two completed the tests both at the beginning and end of the academic year. Descriptive statistics of teacher content knowledge are presented in Table 1.

Table 1
Descriptive Statistics of Teacher Content Knowledge in Mathematics

		Pre (n = 184)	Post (n = 155)	Gain (n = 152)	Control (n = 9)
System One	*M*	26.51	27.14	1.02	25.78
	SD	7.20	6.81	3.86	6.20
		Pre (n = 31)	Post (n = 25)	Gain (n = 23)	
System Two	*M*	25.52	27.84	1.61	
	SD	7.40	6.90	6.18	

Note. Control group teachers only took the content test once and they are all in System One.

Repeated measures analysis of variance revealed no statistically significant interaction effect between school system and time, $F(1, 174) = 0.15$, $p = .70$, partial $\eta^2 = .001$, indicating that teachers in the two school systems did not differ with respect to their content knowledge in mathematics at the beginning or the end of the year. The main effect of change, however, was statistically significant, $F(1, 174) = 6.63$, $p = .01$, partial $\eta^2 = .04$, indicating that teachers in both school systems experienced significant gain in their content knowledge after participating in the PD. Gain scores were completed by subtracting pre-test scores from pos-test scores (Table 1). The large standard deviations of the gain scores suggested that the impact of the PD on teacher's content knowledge varied, some experiences large gains, some experiences less gains, and some experiences negative gains. In summary, these results suggest that the PD was successful in increasing teacher's content knowledge in teaching mathematics in general.

Influence on Student Learning Outcomes (Kindergarten Students only)

Student assessment including gain scores (post-test minus pre-test) were presented in Tables 2.1 and 2.2.

Table 2.1Descriptive Statistics of Student Assessment in Mathematics (Treatment Group)

		First Round			Second Round			Third Round		
		n	M	SD	n	M	SD	n	M	SD
Kindergarten		564	76.06	33.18	503	88.83	22.11	434	94.09	17.54
Grades	Pretest	2958	44.94	32.3	2951	34.13	30.56	2873	18.63	24.89
1-5	Posttest	2441	78.60	26.21	2381	75.28	29.43	2253	63.62	34.20
	Gain	2242	35.15	34.31	2227	40.28	35.9	2082	44.96	36.17
		First Round			Second Round			Third Round		
		n	M	SD	n	M	SD	n	M	SD
Kindergarten		39	75.21	30.32	36	95.37	14.15	36	98.15	11.11
Grades	Pretest	558	51.95	33.80	510	39.24	30.31	440	30.98	30.50
1-5	Posttest	447	72.60	27.08	438	67.76	30.78	349	59.73	30.72
	Gain	391	30.43	32.92	354	24.19	32.41	280	26.57	36.89

Note. Kindergarten students were assessed on the same content three times during the year whereas Grades 1-5 students were assessed pretest and posttest on three different content areas.

Table 2.2
Descriptive Statistics of Student Assessment in Mathematics (Control Group)

			First Round			Second Round			Third Round		
			n	M	SD	n	M	SD	n	M	SD
System	Kindergarten		54	91.36	20.67	51	96.73	15.28	51	98.04	10.35
One	Grades	Pretest	284	58.44	30.82	279	38.98	32.17	310	25.87	26.39
	1-5	Posttest	308	78.25	26.88	304	68.47	31.34	304	56.47	30.90
		Gain	241	22.34	34.44	220	30.12	38.39	227	31.15	32.94

Note. Control group students are from System One only.

Multivariate analysis of variance (MANOVA) failed to notice statistically significant differences between the two school systems on the combination of all kindergarten student assessments, $F(3, 458) = 1.55$, $p = .20$, partial $\eta^2 = .10$. Tests of between-subjects effects were consistent: students in the two school systems were not statistically significantly different in the assessment during Round One, $F(1, 460) = 0.64$, $p = .42$, partial $\eta^2 = .001$, during Round Two, $F(1, 460) = 2.38$, $p = .12$, partial $\eta^2 = .005$, or Round Three, $F(1, 460) = 1.73$, $p = .19$, partial $\eta^2 = .004$.

Three-level growth curve models were applied because these students were assessed the same content three times across the year. Due to missing data on one of the three assessments, only 15 teachers with their 228 students were used in the growth curve models. Descriptive statistics for the three assessments show that the students achievement followed a quadratic trend: Pretest1 (*M* = 85.98, *SD* = 17.88), Posttest1 (*M* = 94.42, *SD* = 17.87), and Posttest2(*M* = 96.53, *SD* = 13.26). As a result, a curve-linear model (quadratic) was used. The student performance within the two school systems were: Pretest (*M* = 91.15, *SD* = 20.70 for System One and *M* = 78.50, *SD* = 31.90 for System Two), Posttest1 (*M* = 94.48, *SD* = 19.25 for System One and *M* = 94.33, *SD* = 15.75 for System Two), and Posttest2 (*M* = 96.32, *SD* = 14.23 for System One and *M* = 96.83, *SD* = 11.77 for System Two). Moreover, independent samples t-test suggested statistically significant differences between the two school systems at pretest, $t(243) = -3.76$, $p < .001$, but not at posttest1, $t(243) = -0.06$, $p = .95$, or posttest2, $t(243) = 0.30$, $p = .77$. Therefore, the school system was dummy coded (0 refers to School System 2 and 1 refers to School System 1) and used as a predictor at Level 2. The influence of teacher content knowledge, practice, and beliefs were assumed to have the same impact on students within two school systems, so these impacts were fixed within school systems and used as predictors at Level 3. The parameter estimates of these models were presented in Table 3.

Table 3

Parameter Estimates of Three-Level Hierarchical Liner Models for Kindergarten Students

	Initial Status	Linear	Curve Linear

	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.
Null Model	81.59	1.90***	20.34	3.91***	-6.21	1.88**
Treatment						
System One	9.44	3.18**	-19.74	6.48**	6.81	3.11*
Content_Gain	-0.55	0.32	0.49	0.23*	-0.36	0.29
Teacher Practice						
T to S	-10.31	3.12**	3.43	2.25	-2.98	3.45
Belief in						
Teaching						
T to DC	-11.74	7.40	8.55	4.79	-9.62	8.18
Learning						
T to DC	-0.45	5.40	1.33	3.37	-1.29	5.76
Mathematics						
T to DC	4.19	4.53	-1.21	2.82	-0.20	4.81

Note. $*p < .05$; $** p < .01$; $*** p < .001$.

As is in the null model (without any predictors), both the linear and quadratic coefficients were statistically significantly different from zero, supporting the curve linear relationship between student achievement and time of assessment. The negative quadratic coefficient suggests that the growth of student achievement slowed down from the second to the third assessment. Students in System One performed significantly better than students in System Two at pretest, but students in System Two had significantly higher linear growth rates than students in System One. Furthermore, the positive quadratic coefficient for the difference between System One and System Two indicated that the slowing down trend between the second and third assessment was less observable in System Two than that in System One.

The gain of teacher content knowledge had a statistically significantly positive impact on the linear growth rate for all students, but had no statistically significantly impact on the quadratic growth rate. Students who were taught by teachers who changed their practice from teacher-centered to student-centered had statistically lower performance at pretest than students who were taught by teachers who were originally student-centered and remained student-centered from the beginning to the end of the PD program. This change of teacher practice had no statistically significant impact on the linear growth rate or the quadratic growth rate. The change of teacher beliefs in mathematics, learning mathematics, or teaching mathematics, had no statistically significant impact on either the initial status at the pretest, or the linear growth rate, or the quadratic growth rate. The magnitude of effect of the complete growth curve model was 5.98%, indicating that these teacher-level variables could only explain less than 6% of the changes of this kindergarten student achievement.

Influence on Student Learning Outcomes (Students in Grades 1-5)

MANOVA noted statistically significant differences between the two school systems on the combination of all student assessments, $F(6, 1898) = 13.69$, $p < .001$, partial $\eta^2 = .04$. Tests of between-subjects effects showed that the students in the two school systems were statistically significantly different in pretest, $F(1, 1903) = 4.74$, $p = .03$, partial $\eta^2 = .002$, and posttest, $F(1, 1903) = 6.15$, $p = .01$, partial $\eta^2 = .003$, during Round One. Statistically significant differences were noticed between the two school systems during Round Two for the pretest, $F(1, 1903) = 7.03$, $p = .01$, partial $\eta^2 = .004$, and the posttest, $F(1, 1903) = 6.44$, $p = .01$, partial $\eta^2 = .003$. During Round Three, statistically significant differences were found between the two school systems for the pretest, $F(1, 1903) = 51.36$, $p < .001$, partial $\eta^2 = .03$, but not for the posttest, $F(1, 1903) = 0.72$, $p = .40$, partial $\eta^2 < .001$. With respect to the gain scores, statistically significantly differences were noticed between the two school systems during Round One, $F(1, 1903) = 15.21$, $p < .001$, partial $\eta^2 = .01$, during Round Two, $F(1, 1903) = 17.97$, $p < .001$, partial $\eta^2 = .01$, and during Round Three, $F(1, 1903) = 19.08$, $p < .001$, partial $\eta^2 = .01$.

Two-level hierarchical linear models were used to examine the association between the change of teacher-level variables (teacher beliefs, practices, and content knowledge) and student gain scores for each round of assessments with Grades 1-5 students. Change of teacher practices were dummy coded so that a value of "1" refers to the change from student-centered practice or the change from transmission to discovery/connectionist orientation, as expected by the PD, and a value of "0" refers to no change in teacher practices or the change from discovery/connectionist to transmission orientation. Parameter estimates of these models were presented in Table 4.

Table 4
Parameter Estimates of Two-Level Hierarchical Liner Models for Grades 1-5 Students

	First Round		Second Round		Third Round	
	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.
Treatment						
System						
Knowledge	-0.43	0.37	-0.23	0.47	-0.59	0.41
Belief in						
Teaching						
T to DC	-11.49	5.04*	-9.14	4.42*	9.21	5.85
Learning						
T to DC	-8.54	6.11	4.72	6.66	-0.24	7.37
Mathematics						
T to DC	-0.80	5.88	1.31	4.72	-2.90	5.38

Teacher Practice						
T to S	11.37	4.35*	0.95	3.95	7.12	4.86

Note. (a) *$p < .05$; (b) T to DC means teacher beliefs changed from transmission orientation to discovery/connectionist orientation, and the comparison group was teachers whose did not report a change of their beliefs or teachers who changed from discovery/connectionist to transmission orientation; (c) T to S refers to teachers whose practice changed from teacher-centered to student-centered, and the comparison group was teachers whose practice stayed as teacher-centered or changed from student-centered to teacher-centered.

The gain of teacher content knowledge in mathematics is not statistically significantly related to student gains during either of three rounds of assessment. This means that the gain of teacher content knowledge during Year Two was not statistically significantly related to the gain of student achievement in mathematics. Teachers who changed their practice from teacher-centered to student-centered at year-end found their students had statistically significantly more gains during the first round in comparison to students taught by teachers who did not change their practice or changed their practice from student-centered to teacher-centered. This difference; however, was not statistically significant during the second and third rounds of assessment. Students whose teachers changed their beliefs about teaching mathematics from transmission to discovery/connectionist orientation had statistically significantly fewer gains during the first and second rounds of assessment than students whose teachers did not change this belief or whose teachers changed from discovery/connectionist to transmission. This difference; however, diminished during the third round of assessment, which means that teachers who changed their beliefs about teaching mathematics from transmission to discovery/connectionist orientation had a significantly positively impact on student achievement because their students were catching up students taught by other teachers. No statistically significantly impacts of the change of teacher beliefs about learning mathematics or mathematics were noticed on the gain scores of student achievement in any one of the three rounds of assessment.

Appendix A: Teacher Beliefs Questionnaire

Teacher name: ________________________ Grade(s) taught: ________

Indicate the degree to which you agree with each statement below by giving each statement a percentage so that the sum of the three percentages in each section is 100.

A. Mathematics is: <u>Percents</u>

1. A given body of knowledge and standard procedures;
a set of universal truths and rules which need to be conveyed to students: _____

2. A creative subject in which the teacher should take a facilitating role,
allowing students to create their own concepts and methods: _____

3. An interconnected body of ideas which the teacher and the student create together through discussion: _____

B. *Learning is:* Percents

1. An individual activity based on watching, listening and imitating until fluency is attained: ______

2. An individual activity based on practical exploration and reflection: ______

3. An interpersonal activity in which students are challenged and arrive at understanding through discussion: ______

C. *Teaching is:* Percents

1. Structuring a linear curriculum for the students; giving verbal explanations and checking that these have been understood through practice questions; correcting misunderstandings when students fail to grasp what is taught: ______

2. Assessing when a student is ready to learn; providing a stimulating environment to facilitate exploration; avoiding misunderstandings by the careful sequencing of experiences: ______

3. A non-linear dialogue between teacher and students in which meanings and connections are explored verbally where misunderstandings are made explicit and worked on: ______

This questionnaire was adapted from Swan, M. (2006). Designing and using research instruments to describe the beliefs and practices of mathematics teachers. *Research in Education, 75,* 58-70. Permit for use was obtained on May 29, 2009.

Appendix B: Teacher Practices Questionnaire

Indicate the frequency with which you utilize each of the following practices in your teaching by **circling** the number that corresponds with your response.

	Practice	Almost Never	Sometimes	Half the time	Most of the time	Almost Always
1.	Students learn through doing	0	1	2	3	4

	exercises.					
2.	Students work on their own, consulting a neighbor from time to time.	0	1	2	3	4
3.	Students use only the methods I teach them.	0	1	2	3	4
4.	Students start with easy questions and work up to harder questions.	0	1	2	3	4
5.	Students choose which questions they tackle.	0	1	2	3	4
6.	I encourage students to work more slowly.	0	1	2	3	4
7.	Students compare different methods for doing questions.	0	1	2	3	4
8.	I teach each topic from the beginning, assuming they don't have any prior knowledge of the topic.	0	1	2	3	4
9.	I teach the whole class at once.	0	1	2	3	4
10.	I try to cover everything in a topic.	0	1	2	3	4
11.	I draw links between topics and move back and forth between topics.	0	1	2	3	4
12.	I am surprised by the ideas that come up in a lesson.	0	1	2	3	4
13.	I avoid students making mistakes by explaining things carefully first.	0	1	2	3	4
14.	I tend to follow the textbook or worksheets closely.	0	1	2	3	4
15.	Students learn through discussing their ideas.	0	1	2	3	4
16.	Students work collaboratively in pairs or small groups.	0	1	2	3	4
17.	Students invent their own methods.	0	1	2	3	4
18.	I tell students which questions to tackle.	0	1	2	3	4
19.	I only go through one method for doing each question.	0	1	2	3	4

20.	I find out which parts students already understand and don't teach those parts.	0	1	2	3	4
21.	I teach each student differently according to individual needs.	0	1	2	3	4
22.	I tend to teach each topic separately.	0	1	2	3	4
23.	I know exactly which topics each lesson will contain.	0	1	2	3	4
24.	I encourage students to make and discuss mistakes.	0	1	2	3	4
25.	I jump between topics as the need arises.	0	1	2	3	4

This questionnaire was adapted from Swan, M. (2004). Designing and using research instruments to describe the beliefs and practices of mathematics teachers. *Research in Education*, *75*, 58-70. Permit for use was obtained on May 29, 2009.

Appendix C: Sample of Content Knowledge for Teaching Mathematics (CKT-M)

Ms. Dominguez was working with a new textbook and she noticed that it gave more attention to the number 0 than her old book. She came across a page that asked students to determine if a few statements about 0 were true or false. Intrigued, she showed them to her sister who is also a teacher, and asked her what she thought.

Which statement(s) should the sisters select as being true? (Mark YES, NO, or I'M NOT SURE for each item below.)

	Yes	No	I'm not sure
a) 0 is an even number.	1	2	3
b) 0 is not really a number. It is a placeholder in writing big numbers.	1	2	3
c) The number 8 can be written as 008.	1	2	3

Appendix D: Observation Protocol

Name: _______________ School: ____________Gd: _______ Date: ___________

A. Class Characteristics

1. Document the time the class begins and what kind of instruction is occurring at each transition:

	Time	Type of Instruction *(ie. direct, small group, individual)*
Math Starts		
transition1		
transition2		
transition3		
Math Ends		

2. What type of lesson are you observing?(check all that apply) ☐ Math Workshop ☐ 10-Minute Math ☐ Inv. Lesson w/o Math Wkshp ☐ Other: ___
3. Does the teacher read from the manual? ☐ Yes ☐ No
4. Is this class grouped in any way? ☐ Yes ☐ No
   Please explain: ____
5. Number of Students Present: ___________ females __________ males
   Does the teacher mention any special needs students? _______________________
4. Is there an assistant in this class? ☐ Yes ☐ No
5. Are there other adults in this class? ☐ Yes: _____________ ☐ No
6. Are there noted interruptions to the "normal" schedule today? Explain: __________

B. Characteristics of an Investigations Lesson:

Use the following scale to make your ratings.

1 – Minimal	**2**	**3 – Developing**	**4**	**5 – Advanced**
The teacher does not demonstrate the behavior of interest and		The teacher displays the behavior of interest occasionally but has not		The teacher frequently displays the behavior of interest and it is a well-

any similarity is incidental	completely integrated it into practice.	developed and intentional part of practice.

The teacher…

1	Engages students in an open-ended discussion about their use of different strategies for solving mathematics problems.	1	2	3	4	5
2	Through modeling or discussion, encourages the use of multiple strategies for solving mathematics problems.	1	2	3	4	5
3	Creates a classroom environment where student-led discussions are welcome.	1	2	3	4	5
4	Asks high level cognitive questions to check for student understanding. Please list one example:_____________	1	2	3	4	5
5	Asks high level cognitive questions to extend student learning. Please list one example:________________	1	2	3	4	5
6	Provides opportunities for solving complex problems and/or tasks.	1	2	3	4	5
7	Provides opportunities for students to develop appropriate mathematical representations using manipulatives or other materials.	1	2	3	4	5

The lesson overall…

8	Provided opportunities for students to make conjectures about mathematics ideas.	1	2	3	4	5
9	Fostered the development of conceptual understanding.	1	2	3	4	5
10	Gave opportunities for students to explain their responses or solution strategies.	1	2	3	4	5
11	Was concluded with a clear summary of new learning and ties to prior mathematics knowledge.	1	2	3	4	5

Field Notes

Document at least one scenario in the classroom where the teacher and students interact while completing a mathematics task.

- *This is a narrative account which includes the description of the mathematics problem, conversations between teacher and student with respect to giving directions, question and answer while working on the problem, and presentation of the solutions. Layout of the room may also be relevant here, feel free to sketch.*

Provide one example of how the teacher checks for understanding during the mathematics lesson or extends student thinking by asking high level questions.

Appendix E: Leadership Log

Please evaluate the frequency and impact of each of the activities that are listed by placing a check mark for the appropriate statement under “frequency” and “impact.”

	Frequency					**Impact**			
	Very often (at least once a week)	Sometimes (once or twice a month)	Very seldom (a few times a year)	Never		Very helpful	Somewhat helpful	Seldom helpful	Not helpful
1. Facilitating collaborative planning with other teachers									
2. Teaching a model lesson while other teachers watch.									
3. Co-teaching a lesson with another teacher.									
4. Collaboratively examining student work.									
5. Observing a colleague’s teaching and providing feedback.									
6. Facilitating a workshop									

about Investigations.									

Please use this space to elaborate on any leadership experiences mentioned above.

References

Swan, M. (2004). Designing and using research instruments to describe the beliefs and practices of mathematics teachers. *Research in Education, 75*, 58-70