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I Year Two Summative Report

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MSP Grant Project CoDE: I Year Two Summative Report

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This is the second report based on Year Two 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.
As was in the first report (Year One Summative Report), the focus is to examine the impacts of the professional development on teacher beliefs, practices, mathematics content knowledge, and student learning outcomes.

Changes from Year One to Year Two

Based on feedback from the MSP grant management team and our own analysis of data, several changes were made to the external evaluation plan from Year One to Year Two. First, an experimental design was added to the evaluation by the addition of a control group. Teachers who were randomly selected to be observed from each school system were given an incentive of one $20 gift card for finding a teacher at their school and in their grade level who were not participating in the professional development to serve as a control. This was a much more successful venture in System Two than in System One as System Two is much smaller. Although most teachers attempted to get a colleague to agree to be a control, most were unsuccessful. In System One the control group consisted of five teachers: two from Grade One and one from Grades Two, Three, and Four. In System Two the control group consisted of nine teachers; three from Grade Two and two from Grades Three, Four, and Five. Control group teachers were asked to give their students the same series of assessments as treatment group teachers and to return those assessments to a designated person within their school system whose duties include working with the MSP grant teachers. They were compensated by receiving a $20 gift card at the completion of each pre/post test pairing. Only three of the 14 total control group teachers completed the entire series of student assessments.

In addition to the experimental design, two new instruments were added to the group of teacher surveys. One, an elementary mathematics teacher self-efficacy scale, was added in an attempt to better understand the beliefs of treatment teachers with regard to mathematics. Although a Teacher Beliefs Questionnaire was already in use, the new scale is more aligned to theories of self-efficacy and asks teachers context-specific questions. The Teacher Beliefs Questionnaire is a more global evaluation of teacher beliefs regarding mathematics. The second new survey was a needs assessment survey that asked teachers to rate themselves as to their ability to perform specific tasks as referenced in the MSP grant proposal objectives. The purpose of adding this instrument was to measure the effectiveness of the professional development program as meeting its objectives. Both instruments were given to the entire cohort of teacher participants as a pre test at the beginning of the summer institute and a post test in February.

Changes in both teacher self-efficacy and needs were evaluated in order that professional development for Year Three could meet the needs of the final cohort of the project.

Another slight alteration was the use of online versions of all of the teacher survey instruments. Administrators in System Two indicated that they would prefer that their treatment teachers (n = 29) take the post test of all the teacher surveys online. The rationale behind this request was towards the purpose of giving teachers more contact with mathematics experts during professional development and leaving grant-related data collection for their free time. This change in administration was allowed for System Two only and proved to not be a more effective method of data collection as teachers had to be reminded repeatedly to complete the online surveys.

There were slight changes made to the student assessments this year as well. 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, 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 instead of 3, 6, and 8 as in Year One.

Kindergarten student assessments were also altered as the evaluation team realized that the Kindergarten unit tests were teacher-reported assessments of student mathematical understanding and were repeated throughout the curriculum. Therefore, Kindergarten teachers were asked in Year Two 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) this year 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.

The final major change in the MSP grant program occurred on the part of System One. As System One is quite large, it was determined that teacher participants in this system could create projects and conduct other professional development activities on their own time instead of attend 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 and created a more difficult situation for collecting data. System One teachers only met three times after the summer workshop ended in August (November, February, and June) and therefore, data collection with System One teachers had to occur at these times.

Participants

The participants in Year Two were elementary school teachers from the same two school systems as in Year One. Of the 185 participants, 155 were from System One and 30 from System Two. In System One: 20(12.9%) participants taught Kindergarten, 23(14.8%) taught first grade, 25(16.1%) taught second grade, 29(18.7%) taught third grade, 26(16.8%) taught fourth grade, and 32(20.6%) taught fifth grade. In System Two: 9(30.0%) participants taught Kindergarten, 4(13.3%) taught first grade, 4(13.3%) taught second grade, 4(13.3%) taught third grade, 2(6.7%) taught fourth grade, 4(13.3%) taught fifth grade, and 3(10%) are teachers of exceptional children (EC) who provide support to the classroom teachers in rotations. In System One, participants' years of teaching experience ranges from 1 to 32 years, with the mode being 3 years (n = 14). In System Two, the participants' years of teaching experiences ranges from 1 to 35 years with the mode also being 3 years (n = 5). In System One, 142 (91.6%) of the participants are female and 13 (8.4%) are male. In System Two, all 30 participants are female. In System One, the ethnicity of the teachers is: 78(66.1%) Caucasian, 35(22.6%) African American (n = 35), 2(1.3%) Hispanic, 1(0.6%) Asian (n = 1), 2(1.3%) Other, 37(23.9%) Unspecified. Attempts were made to collect ethnicity data from teachers who did not specify. In System Two, the ethnicity of the teachers is: 29(96.7%) Caucasian and 1(3.3%) African American. Participants were also asked to indicate their content certification area, beyond general education. In System One, 64 (41.3%) indicated that they were certified in mathematics. This data is missing for 45 teachers in System One, meaning that they did not specify having or not having math certification. In System Two, 14(46.7%) indicated they were certified in math. Data were missing for five teachers in System Two, meaning that they did not specify having or not having math certification.

Participants also included 5070 students, of which 4184(82.5%) were from System One and 886 (17.5%) were from System Two. The distribution of grade levels in System One is: 415(9.9%) Kindergarten, 642(15.4%) first grade, 599(14.3%) second grade, 694(16.6%) third grade, 881(21.1%) fourth grade, and 951(22.7%) fifth grade. Also, 3852(92.1%) were students of teacher participants in Year Two only, 214(5.1%) were students of facilitators, who were teacher participants in Year One, and 116(2.8%) were students of the control group teachers. The distribution of grade levels in System Two is: 224(25.3%) Kindergarten, 100(11.3%) first grade, 117(19.3%) second grade, 163(18.4%) third grade, 159(17.9%) fourth grade, and 69(7.8%) fifth grade. Also, 510(57.6%) were students of teacher participants in Year Two only, 198(22.3%) were students of facilitators, who were teacher participants in Year One, and 178(20.1%) were students of the control group teachers. Gender and ethnicity were reported by teachers for their aggregate classrooms. In System One, 1293(51.2%) were females and 1234(48.8%) were males, 316(12.5%) were LEP and 157(6.2%) were IEP. Of the 2711 students, 981(36.2) were European American, 1066(39.3%) were African American, 453(16.7%) were Hispanic, 119(4.4%) were Asian, 3(0.1%) were Native American, and 89(3.3%) were identified with other ethnic background. In System Two, 271(52.0%) were females and 250(48%) were males, 130(25.0%) were LEP and 77(14.8%) were IEP. Of the 520 students, 207(39.8) were European American, 140(26.9%) were African American, 132(25.4%) were Hispanic, 4(0.8%) were Asian, and 37(7.1%) were identified with other ethnic background.

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." 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 five 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. One teacher dropped from this activity, so observation data were completed for 24 teachers. 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”.

Interviews. Participants also participated in a two-part interview. The protocol (see Appendix E) was sent to each participant via email. A follow-up phone interview was conducted with each participant.

Secondary data sources. Other data was also used to verify findings. Participants completed a Leadership Log (Appendix F), 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, 122 teachers completed the TBQ both at the beginning and end of Year Two. Of these teachers, 27(22.1%) changed from transmission to discovery/connectionist orientation, 73(59.8%) remained unchanged, and 22(18.0%) changed from discovery/connectionist to transmission orientation with respect to teacher beliefs about mathematics. As for teacher beliefs about learning mathematics, 18(14.8%) changed from transmission to discovery/connectionist orientation, 83(68.0%) remained unchanged, and 21(17.2%) changed from discovery/connectionist to transmission orientation. Finally, 27(22.1%) changed from transmission to discovery/connectionist orientation, 74(60.7%) remained unchanged, and 21(17.2%) changed from discovery/connectionist to transmission orientation with respect to teacher beliefs about teaching mathematics.

In System Two, 25 teachers completed the TBQ both at the beginning and end of Year Two. Of these teachers, 8(32.0%) changed from transmission to discovery/connectionist orientation, 14(56.0%) remained unchanged, and 3(12.0%) changed from discovery/connectionist to transmission orientation with respect to teacher beliefs about mathematics. As for teacher beliefs about learning mathematics, 3(12.0%) changed from transmission to discovery/connectionist orientation, 16(64.0%) remained unchanged, and 6(24.0%) changed from discovery/connectionist to transmission orientation. Finally, 2(8.0%) changed from transmission to discovery/connectionist orientation, 15(60.0%) remained unchanged, and 8(32.0%) changed from discovery/connectionist to transmission orientation with respect to teacher beliefs about teaching mathematics.

Influence on Teacher Practices

In System One, 124 teachers completed the TPQ for the beginning and end of Year Two. Of these teachers, 1(0.8%) changed from student-centered to teacher-centered, 55(44.4%) remained unchanged, and 68(54.8%) changed from teacher-centered to student-centered of their practices in the classroom, indicating a significant impact of the PD on teacher's practices. In System Two, 28 teachers completed the TPQ for the beginning and end of Year Two. Of these teachers, 2(7.1%) changed from student-centered to teacher-centered, 10(35.7%) remained unchanged, and 16(57.1%) 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.

The observation data of 24 randomly selected teachers; however, failed to show statistically significant changes at the end of the PD (M = 4.09, SD = 0.79) from the beginning of the PD (M = 3.96, SD = 0.84), $t(23) = 0.79$, $p = .44$. The observation indicated that the teacher practices in the classroom were consistent, $r = .48$, $p = .02$.

Influence on Mathematical Content Knowledge for Teaching

The Content Knowledge Test was completed by 114 teachers in System One and 25 teachers in System two at the beginning and end of the year. Descriptive statistics of teacher content knowledge are presented in Table 1.

Table 1
Descriptive Statistics of Teacher Content Knowledge in Mathematics

		Pre	Post	Gain
System One (*n* = 114)	*M*	33.49	35.81	2.32
	SD	8.43	9.57	5.37
System Two (*n* = 25)	*M*	33.16	34.84	1.68
	SD	6.86	6.27	6.32

Repeated measures analysis of variance revealed no statistically significant interaction effect between school system and time, $F(1, 137) = 0.27$, $p = .61$, partial $\eta^2 = .002$, 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, $F(1, 137) = 10.64$, $p = .001$, partial $\eta^2 = .07$, 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

Student assessment including gain scores (post-test minus pre-test) were presented in Table 2.

Table 2
Descriptive Statistics of Student Assessment in Mathematics

			First Round			Second Round			Third Round		
			n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
System One	Kindergarten		371	87.96	24.42	178	94.57	19.77	233	95.85	16.29
	Grades 1-5	Pretest	3008	51.03	33.73	2937	30.84	29.99	2926	20.65	24.69
		Posttest	2358	80.03	26.24	2308	74.04	28.95	2039	66.10	31.29
		Gain	2044	28.60	35.88	1896	41.25	34.08	1614	45.35	34.83
System Two	Kindergarten		195	78.55	31.11	157	92.36	19.92	165	96.16	13.35
	Grades 1-5	Pretest	379	43.11	34.73	472	38.24	31.67	322	31.03	32.51
		Posttest	386	72.33	28.20	372	73.43	29.01	308	68.00	32.04
		Gain	255	34.43	36.67	299	35.92	36.11	248	35.21	34.32

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.

Multivariate analysis of variance (MANOVA) noted statistically significant differences between the two school systems on the combination of all kindergarten student assessments, $F(3, 249) = 3.38$, $p = .02$, partial $\eta^2 = .04$. Tests of between-subjects effects showed that the students in the two school systems were statistically significantly different in the assessment during Round One, $F(1, 251) = 9.46$, $p = .002$, partial $\eta^2 = .04$, but not during Round Two, $F(1, 251) = 0.65$, $p = .42$, partial $\eta^2 = .003$, or Round Three, $F(1, 251) = 0.01$, $p = .94$, partial $\eta^2 < .001$. As for Grades 1-5 students, MANOVA also noted statistically significant differences between the two school systems on the combination of all student assessments, $F(6, 1222) = 15.40$, $p < .001$, partial $\eta^2 = .07$. Tests of between-subjects effects showed that the students in the two school systems were statistically significantly different in pretest, $F(1, 1227) = 31.48$, $p < .001$, partial $\eta^2 = .03$, and posttest, $F(1, 1227) = 16.21$, $p < .001$, partial $\eta^2 = .01$, during Round One. No statistically significant differences, however, was noticed between the two school systems during Round Two for either the pretest, $F(1, 1227) = 0.02$, $p = .90$, partial $\eta^2 < .001$, or the posttest, $F(1, 1227) = 2.31$, $p = .13$, partial $\eta^2 = .002$. During Round Three, statistically significant differences were found between the two school systems for the pretest, $F(1, 1227) = 18.79$, $p < .001$, partial $\eta^2 =$

.02, but not for the posttest, $F(1, 1227) = 0.48$, $p = .49$, partial $\eta^2 < .001$. With respect to the gain scores, statistically significantly differences were noticed between the two school systems during Round One, $F(1, 1227) = 7.45$, $p = .01$, partial $\eta^2 = .01$, and during Round Three, $F(1, 1227) = 6.84$, $p = .01$, partial $\eta^2 = .01$, but not during Round Two, $F(1, 1227) = 1.30$, $p = .25$, partial $\eta^2 = .001$.

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 3.

Table 3
Parameter Estimates of Two-Level Hierarchical Liner Models

	First Round		Second Round		Third Round	
	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.
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.

As for Kindergarten students, three-level growth curve models were applied because these students were assessed the same content three times across the year. This is a change in Year Two. 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 4.

Table 4
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**
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.

Teacher's Anticipated Needs and Expectations for Professional Development

At the beginning of the summer workshop, teachers were asked to complete a "needs evaluation" survey. The first question on this survey is concerning teacher's anticipated needs for professional development for the upcoming year. As the grant participants are selected in various ways in both systems, with System Two's selection of participants being much more personalized, teachers in System One often indicated that they needed help with specific parts of the *Investigations* curriculum. These statements often indicated a potential misunderstanding in the actual objectives of the MSP grant project. For example one teacher stated, "I would like lessons/ways to implement the concepts from the state standard course of study that are not covered in *Investigations* ." In kind, another teacher responded, "[I need] resources to use to fill in the gaps of *Investigations* [in relation to the] North Carolina Standards and how grading should be conducted." Other teachers indicated various needs that were well beyond the scope of the MSP grant project; "[I would like] a set of rubrics per unit that are the same across the grade level and more footage to show how students interact with the games." They often also indicated other needs that were beyond the scope of the project such as how to better assess student learning; how to differentiate instruction; how to keep lower and higher students engaged; and how to prepare students for the EOG's. In System Two, comments about teacher needs from the professional development were much less specific. Teachers generally felt they needed help with all aspects of the curriculum, but made statements such as, "[I need] help with assessments-how to implement, use rubrics/checklists, and continued group planning/strategizing." One System Two teacher in particular mentioned needing help with understanding the foundations of the *Investigations* curriculum, "[I need help with] the background knowledge of *Investigations* and how it helps young learners be directors of learning." Other System Two teachers mentioned needing help with pacing guides and planning their implementation of the curriculum in whole.

When asked what their expectations of the professional development were, some System One teachers indicated that they didn't have any expectations, but "in the future sessions I would like some planning time." Planning time, meaning time to plan specific lessons for the upcoming school year, was never a part of the design of the professional development or an objective of the grant project, although several System One teachers indicated that this was something they felt they needed and an expectation of their professional development experience. Other teachers responded similarly, expecting that they could "bring ideas/lessons back to the classroom." Some System One teachers even indicated wanting to better understand "how to best teach and prepare for each topic or concept what we do in the lower grades impacts learning in the upper grades. " Some teachers were very specific, noting, "My expectation is that the sessions will cover my grade level curriculum and show me how to use *Investigations* for each unit." System Two teachers expected "real life help" or "protected time for grade level planning." Other System two teachers expected, "to gain an understanding of why *Investigations* is taught the way it is, to understand the layout for *Investigations* better, to change my way of thinking about it and how to approach it, and to receive ideas on how [to implement it]."

Teachers were also asked how they expected to benefit from professional development sessions. System One teachers indicated that they expected to learn and become more confident in their mathematics teaching and more effective mathematics teachers. Some expected to benefit by understanding more about student understanding of mathematics by "target[ing] under lying problems with the child's ability to learn or move on in second grade."Some teachers in System One showed an interest in increasing their content knowledge while others mentioned wanting to "increase trust" in the curriculum and why it was adopted. In System Two, some teachers had specific goals such as, "[to create] long range plans…strategies for small group interventions." Others shared the expected benefits of increasing content knowledge and increasing their confidence with the material.

Meeting Teacher's Needs and Expectations

In general, a majority of teachers felt that their needs had been met by the professional development. Although some teachers had to realize that the professional development was going to meet different objectives than they originally thought, such as working on increasing the teacher's content knowledge and giving the teacher new ways to think about mathematics, most thought it was productive. One System One teacher stated that her needs were met, "Since I changed grades this year, the workshop was extremely beneficial. Collaborating with other teachers from other schools has really helped prepare me for what to expect." Other teachers indicated that the professional development also, "helped look deeper into the units." In addition to feeling that the professional development did meet their needs, teacher also responded that their confidence had increased and they appreciated having materials to take back into their classrooms.

While more teachers felt that the professional development met their needs, even if it was in a different way than they expected, some teachers indicated that they were unsatisfied, "I would like to have spent more time going through the Investigations Units and identifying what could be skipped/elaborated on, etc." Another teacher responded in kind, "I could still use more strategies other than working problems myself. Many of my kids cannot work these problems."

When asked if the professional development met their expectations, most teachers responded positively, “Yes! I was able to take a "deep dive" into a lot of the Investigations units prior to teaching them, which made me more confident/knowledgeable. This was exactly what I was hoping to get from this.” Other commented about the positive relationship they had formed with the facilitators, peer teachers who were experts at implementing the material, “loved our facilitators they ensured that our time was spent wisely.” Some teachers indicated how their perceptions of participation in the professional development had changed:

> I wasn’t quite sure of the pd sessions at first. I honestly expected that it would be boring and not show me anything I had not been exposed to yet. I was wrong! The workshops have surpassed any and all expectations I had. I love come to the sessions to learn what others are doing in their classroom and share ideas.

In general most teachers agreed that their “[expectations] for professional development were met as well. The instructors were excellent and exemplified knowledge.” Many teachers made very positive comments about the outcome of the professional development:

> Yes [my expectations were met]. My questions were always answered. The class discussions were extremely helpful with the many suggestions from other teachers and the many ideas, handouts, games, and websites. I drew from my notes on these sessions often to understand and plan.

Several teachers often made comments during the professional development sessions about how they were able to utilize their new knowledge and skills in their classroom. Most felt that overall they benefitted from this experience.

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: Percents

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 exercises.	0	1	2	3	4
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	0	1	2	3	4

	worksheets closely.					
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. <u>Class Characteristics</u>

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 any similarity is incidental		The teacher displays the behavior of interest occasionally but has not completely integrated it into practice.		The teacher frequently displays the behavior of interest and it is a well-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: Interview Protocol
Evaluation of Professional Development for the CoDE: I project, an MSP Grant project
Interview Protocol for Participants

1. What were your needs for professional development to implement the *Investigations* curriculum before last summer (2010)?
2. What were your expectations of the professional development sessions? Did they meet your needs?
3. Of the professional development you've received this year, which session(s) were most helpful to you?
    - Summer 2010 (Overview of Investigations & Math Content)

- September 2010
- November 2010
- February 2011
- April 2011

4. How have you benefited by participating in these professional development sessions?
5. Do you think that Investigations have any impact on your teaching methods or the student learning process? If so, how do you think your teaching methods or your students been impacted by Investigations?
6. What barriers have you encountered when implementing *Investigations*?
7. How have you (your practice or philosophy) been impacted by participating in this grant?
8. What needs do you have for future professional development for this grant?
9. What else do you need to keep working with *Investigations?*
10. What suggestions would you provide for professional development for next year's cohort?

Appendix F: 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