Examining the Influence of a Curriculum-Based Elementary Mathematics Professional Development Program

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Abstract

This study presents findings from the evaluation of the first year of a U.S. Department of Education Mathematics Science Partnership (MSP) grant designed to support the use of a standards-based mathematics curriculum, *Investigations in Number, Data, and Space (Investigations)*. In line with the goals of the MSP program, the professional development focused on building teachers' knowledge of mathematics content, examining how the mathematics content is embedded into curriculum, and supporting teachers' enactment of reform-based pedagogies. Teacher participants had a positive gain in their content knowledge, but this increase did not have any statistically significant impact on student gains in the assessment of mathematics proficiency. Results about teacher beliefs were inconclusive, as more time is needed to change teacher beliefs. Teachers who changed their practices from teacher-centered to student-centered found their students with statistically more gains in their performance in curriculum-based mathematics assessments. Discussions and implications of these findings were also presented.

Overview

Preparing Teachers to Teach with a Standards-Based Mathematics Curriculum

Numerous studies have provided empirical evidence related to the influence of mathematics instruction on both student achievement measures and students' understanding of mathematics concepts (e.g., Heck, Banilower, Weiss, & Rosenberg, 2008; Hiebert & Stigler 2000; Stigler & Heibert, 1997; U.S. Department of Education [USDE], 2008). Students demonstrate deeper mathematical understanding when their teachers pose mathematically rich tasks, allow students to explore concepts, facilitate students' connection between mathematical ideas, and provide opportunities for students to communicate their mathematical thinking (e.g., Heck et al., 2008; Smith & Smith, 2006; Tarr, Reys, Reys, Chavez, & Shih, 2008). These pedagogies are frequently referred to as standards-based pedagogies (e.g., Bailey, 2010; National Council for Teachers of Mathematics [NCTM], 2000; USDE, 2008).

In the 1990's, the National Science Foundation funded the development of standards-based curriculum in order to provide students with greater access to standards-based pedagogies (Goldsmith, Mark, & Kantrov, 2000). These curricula were developed with the intent to develop students' conceptual understanding of mathematics concepts by providing ample opportunities to explore content by completing rich mathematical tasks and communicating about the mathematics in the tasks. While access to standards-based curricula supports teachers' instruction, the curricula alone cannot cause gains in student achievement (National Research Council, 2004).

Various researchers have found issues during the implementation of standards-based curricula. Frequently, teachers modify standards-based curricula in ways that decrease the rigor or difficulty of the tasks (Stein & Kim, 2009; Stein, Remillard, & Smith, 2007; Sutherland, Glanz, Denison, Silvestre, & Smith, 2006). When tasks are modified, they resemble computational exercises found in traditional curricular materials (Stein et al., 2007).

This dilemma also existed before standards-based curricula. Several studies found that teachers modified standards-based tasks and enacted either skill-based tasks or overly guided students so much that students were required to only follow along with the teachers' work on the board (Cognition and Technology Group at Vanderbilt ([CTGV]; 1997; Doyle, 1988; Henningsen & Stein, 1996). Remillard's (2005) large-scale synthesis found that numerous teacher characteristics were empirically linked to teachers' enactment of curricula. These characteristics included their mathematics content knowledge, beliefs about mathematics teaching and learning, and support from their administrators and colleagues. In order for teachers to effectively enact standards-based pedagogies, there is a need to provide ongoing learning opportunities that influence teachers' knowledge, beliefs, instructional practices, and also their students' achievement (Darling-Hammond, Wei, Andre, Richardson, & Orphanos, 2009).

Influence of Professional Development

Characteristics of Learner-centered Professional Development. Large-scale syntheses of professional development research (e.g., Darling-Hammond et al., 2009; Loucks-Horsley et al., 2009; Yoon et al., 2007) have identified key components of effective professional development projects. These include: addressing deficits in student learning outcomes (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010; Wilson & Berne, 1999), providing teachers with ownership of their professional development activities (Loucks-Horsley et al., 2010; Author, in press), promoting collaboration among teachers, administrators and others (DuFour & Eaker, 1998; Penuel, Fishman, Yamaguchi, & Gallagher, 2007), developing teachers' knowledge of both content and pedagogy, (Garet, Porter, Desimone, Birman, & Yoon, 2001; Heck, et al, 2008; Supovitz, 2003), supporting reflection and connections to teachers' classroom practices (Desimone et al., 2009; Guskey, 2003), and including ongoing support through workshops and classroom-embedded experiences (e.g. Author, 2010; Loucks-Horsley et al., 2010). In essence, these reforms embody a learner-centered approach to professional development, which are grounded in the American Psychological Associations' *Learner-Centered Principles* (Alexander & Murphy, 1998; APA Work Group, 1997) and address teachers' individual needs and learning goals (Author, 2010; NPEAT, 2000).

Mathematics Professional Development Projects. Numerous mathematics professional development projects have been implemented that embody characteristics of learner-centered professional development (Borko, 2004; Darling-Hammond et al., 2009). The Cognitively Guided Instruction (CGI) project provided elementary school teachers with professional development about how children learn mathematics, how to examine students' mathematical thinking, and how to pose specific types of tasks to support children's development of mathematical concepts (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Fennema et al., 1996). Researchers found that students, whose teachers participated in the CGI project, outperformed their peers on a problem solving assessment. Students in CGI classrooms also reported that they were more confident in doing mathematics than their peers in non-CGI classrooms. The New Zealand Number Development Project found that intensive, multi-year professional development about number sense and how to address students' misconceptions of number and place value led to teachers' improved instructional practices and moderate gains in student learning outcomes (Higgins & Parsons, 2010). Another professional development project provided opportunities for teachers to videotape their teaching, and then meet with their peers and a professional developer to discuss their teaching, their students' learning, and plan future lessons. Research about these "video clubs" indicates that teachers' instruction includes more standards-based pedagogies (van Es & Sherin, 2008).

While a myriad of other professional development projects have examined the influence of teacher learning opportunities on teachers' instruction and student learning outcomes, the literature lacks studies focused on professional development that has been designed to support the implementation of standards-based curriculum. This professional development project, funded by the U.S. Department of Education Mathematics Science Partnership initiative, was designed to support Kindergarten through fifth grade teachers' implementation of standards-based mathematics curriculum, *Investigations in Number, Data, and Space* (Russell & Economopolous, 2007). This study shares the findings from the first year of the three-year project.

The present study was driven by the following research questions:

- To what extent did professional development influence participants' beliefs about mathematics teaching and learning?
- To what extent did professional development influence participants' reported instructional practices?
- To what extent did professional development influence student learning outcomes on curriculum-based assessments?

Methods

Professional Development Context

The professional development project was part of a Mathematics Science Partnership (MSP) grant funded by the state Department of Education. Teachers from two school districts participated in the professional development. District A is a large urban district that contains 102 elementary schools (Grades K-5) and employs over 3,600 elementary school teachers. District B is a small suburban district that contains 5 elementary schools (Grades K-4) and 1 intermediate school (Grades 5-6). Both districts are considered impoverished by the state's guidelines; 75% of the schools in District A qualify for Title I funding, while all of the schools in District B qualify for Title I funding.

Although the professional development materials were identical for both districts, each district had their own workshops. For all professional development, Kindergarten through 5^{th} Grade teachers met together, although time was given for teachers to work in small groups to examine state standards and the *Investigations* materials for their grade level. Both school districts were new to *Investigations*, although a few teachers had used individual units or lessons in previous years.

Teachers selected for participation in the MSP grant were given 84 hours of professional development between July, 2009 and April, 2010. The professional development was designed to include components of learner-centered professional development (Author, 2010; NPEAT, 2000). During the summer of 2009 teachers completed a 60 hour Summer Institute, in which they completed mathematical tasks focused on number sense and algebra, examined how mathematical concepts were taught in the curriculum, and developed skills related to posing questions to examine students' mathematical thinking. Teachers also shared ideas and concerns about teaching with the *Investigations* curriculum. During the school year, teachers attended 4, 6-hour follow-up sessions focused on issues related to teaching with *Investigations*. The primary focus of the follow-up sessions were pedagogical issues, such as setting up and teaching small groups, supporting struggling students while they were exploring tasks, and facilitating class discussions about mathematics concepts.

Participants

Fifty two elementary school teachers across both school districts participated in the project; however, only 35 completed all of the instruments. Students taught by these teachers also participated by completing three rounds of curriculum-based assessments in the year. There were 629 students during the first round of assessments. Due to attrition, 542 students completed the second round, and 450 students completed the third round of assessments.

Procedures

Teacher Beliefs Instrument. All teacher-participants completed three pre- and post 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 as a subject, how mathematics should be taught and how students learn mathematics (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. As Swan (2006) noted, there is a clear distinction between the transmission orientation and the remaining two orientations but not between discovery and connectionist orientation. Therefore, teacher beliefs data was coded into two categories instead of three: transmission versus discovery/connectionist. Teachers were coded as discovery/connectionist if they indicated at least 45% in either discovery or connectionist category.

Teacher Practices Instrument. The TPQ examined participants self-report about instructional practices related to their mathematics teaching (Swan, 2007). Each of the 25 items reflects either student-centered or teacher-centered pedagogies. Teachers indentified the extent their use of those instructional practices by rating each item on a 5-point Likert scale, where 0 represents “none of the time” and 4 represents “all of the time.” Following the same procedure as Swan (2007), a practice scale was constructed by reverse coding student-centered statements and summing the ratings obtained. The Cronbach’s alpha reliability coefficient was .79. 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 mathematics. The Content Knowledge for Teaching Mathematics assessments were developed as part of the Survey of Instructional Improvement at the University of Michigan. This project will use the Elementary Number and Operations assessments (see sample in Appendix C) that measure teachers’ knowledge of mathematics content and knowledge of students and content (e.g., knowledge related to pedagogy). These scales have been tested for validity and reliability, and have been employed to empirically link teachers’ knowledge to student achievement (Hill, Rowan, & Ball, 2005). For each teacher, a score of the number of correct items will be recorded.

The student achievement measures used in this study were end-of-unit assessments from the *Investigations in Number, Data, and Space* (Russell & Economopolous, 2007) elementary mathematics curricula. Three units 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). This short time period limits the amount of learning that could occur from pre to post test. Gain scores were used in the analyses.

Descriptive statistics were used to report the number of teachers with each category of teacher beliefs and practices at the beginning and end of the first year. Comparison of the frequency of these categories was used to look for the change of teacher beliefs and practices. Independent sample *t* –test was employed to examine the difference in teacher's content knowledge between the two school districts. The impact of the change of teacher content knowledge, beliefs, and practices on the change of student learning outcomes in mathematics were explored with hierarchical linear modeling (HLM). Two-level HLM was used because the student-level variable (gain scores in mathematics assessment) was nested within teacher-level variables (change in content knowledge, beliefs, and practices). Unconditional models were always run before conditional models to see if there was enough variance to be explained with additional variables of interests (Raudenbush & Bryk, 2002).

Results

Change of Teacher Beliefs and Practices

Thirty eight teachers completed both TBQ and TPQ for at the beginning and end of the year. Results from the TBQ showed that from the beginning to the end of the first year, 7 teachers changed their beliefs about teaching mathematics from discovery/connectionist orientation to transmission orientation whereas 22 remained unchanged. Of those 22 that were unchanged, 19 of the 22 were already discovery/connectionist. Meanwhile, 9 teachers changed their beliefs about teaching mathematics from transmission orientation to discovery/connectionist orientation. As for their beliefs toward learning mathematics, 26 teachers remained unchanged while 8 teachers changed from discovery/connectionist orientation to transmission orientation and 4 teachers changed from transmission orientation to discovery/connectionist orientation. Of the 26 that remained unchanged in their views of learning mathematics, 20 of the 26 were already discovery/connectionist. With respect to teacher's beliefs about mathematics, 25 teachers remained unchanged while 8 teachers changed from discovery/connectionist orientation to transmission orientation and 5 teachers changed from transmission orientation to discovery/connectionist orientation. Of the 25 teachers who remained unchanged, 22 were already discovery/connectionist.

As for teacher practices measured by TPQ, 40 teachers were identified with student-centered classroom practices and 12 teachers were identified with teacher-centered classroom practices at the beginning of the year. Only 39 out of the 52 teachers completed the post survey at the end of the year. Out of these 39 teachers, 34 were identified with student-centered classroom practice whereas 5 remained to be identified with teacher-centered classroom practice. Twenty-nine teachers remained student-centered and 5 changed from teacher-centered to student-centered classroom practices.

Change of Mathematical Content Knowledge for Teaching

The Content Knowledge for Teaching Mathematics test was completed by 35 teachers at the beginning and end of the year. Gain scores were computed by subtracting pre-test scores from post-test scores. The mean of the gain scores was 2.34 with a standard deviation of 5.37. The minimum gain score was -12.00 and the maximum gain score was 11.00. When the gain scores were compared between the two school districts, the mean gain score for teachers in School District A ($n = 17$, $M = 3.82$, $SD = 4.20$) was not statistically significantly different from that for teachers in School District B ($n = 18$, $M = 0.94$, $SD = 6.07$), $t\ (33) = 1.62$, $p = .11$. The effect size measured by Cohen's (1988) *d* was medium ($d = 0.55$).

Influence of Professional Development on Student Achievement

Student assessment gain scores (post-test minus pre-test) were presented in Table 1. Although there is a general trend of increasing average gains from the first round to the third round as the teacher participants are more exposed to the professional development, some negative gains were also observed.

Parameter estimates of HLM models were presented in Table 2. The gain of teacher content knowledge in mathematics was not statistically significantly related to student gains during the second or third round, but was negatively associated with student gains in the first round. This means that students taught by teachers with relatively less content knowledge at the beginning, who gained more content knowledge through the professional development had relatively less gains in curriculum-based assessments at the beginning of the professional development. This difference, however, diminished as teachers are more exposed to the professional development. Similarly, teachers who changed their practice from teacher-centered to student-centered at year-end found their students had relatively less gains at the beginning of the year. This difference also diminished as they were more exposed to the professional development.

Teachers who changed their beliefs about teaching mathematics from discovery/connectionist orientation to transmission orientation found their students had relatively more gains than students taught by other teachers during the third round of assessment, which occurred in March of the school year. This difference was not statistically significant during the first and second rounds of assessment. This finding is contradictory to our predictions as the professional development is designed to help teachers develop more discovery/connectionist orientation of beliefs in teaching. We were expecting more student gains for teachers who changed from transmission orientation to discovery/connectionist orientation. Consistent with this finding was that students taught by teachers who changed their beliefs about mathematics from transmission to discovery/connectionist orientation had relatively less gains than students taught by other teachers.

Discussion and Implications

Discussion of Findings

Teachers' Beliefs and Practices. In terms of reported instructional practices, prior to the professional development, 40 of 52 teachers (76.92%) were student-centered. By the end of the project, 34 of the 39 teachers (87.19%) reported to use primarily student-centered pedagogies. A majority of the professional development (over 60 of the 84 hours) focused on effective implementation of *Investigations* and related practices, which may explain the shift towards student-centered pedagogies. Prior pedagogical-specific professional development projects have found slight increases in teachers' practices within the first year (Garet et al., 2001; Heck et al., 2008; Penuel et al., 2007), but more significant increases after two years of comprehensive professional development (Fishman et al., 2003; Penuel et al., 2007).

The results were more mixed with teacher beliefs, as teachers either remained constant, become more transmission (teacher-centered) or more connectionist/discovery (student-centered). At the beginning of the project, most of the teacher-participants reported having discovery/connectionist beliefs in each of the three constructs (teaching math, learning math, and math as a subject). Most participants still reported having discover/connectionist beliefs at the end of the project. However, there is concern that teachers moved towards transmission views of mathematics teaching and mathematics learning.

In our earlier work (Author, 2010), data analyses indicated a lot of teacher apprehension about whether these pedagogies will lead to student achievement, especially on standardized assessments. Upon further examination of teachers that moved to transmission views of mathematics, most participants taught Grades 3, 4 or 5, who were three weeks away from administering the high-stakes state test. For teaching mathematics, the number of Grades 3, 4 or 5 teachers who moved to transmission views were 6 of 7 (84.3%) for teaching mathematics, and 7 of 8 (87.5%) for both learning mathematics and mathematics as a subject. Perhaps, giving the post-surveys at a time farther away from the state tests would have led to different results.

Previous studies noted that in some cases teachers required many years to work on shifting their instructional practices before shifting their beliefs (Fennema et al., 1996; Penuel et al., 2007). In the seminal work of the Cognitively Guided Instruction project, researchers (Fennema et al., 1996) concluded that some teachers experienced a change in beliefs during workshops and then implemented new pedagogies, while others experimented with new pedagogies in their classroom before shifting their beliefs. In our earlier work (Author, 2010), data analyses of classroom observations shows a high degree of fidelity, indicating that teachers fit into the second category that Fennema et al. (1996) described. Teachers were more willing to use *Investigations* and experiment teaching lessons before their beliefs shifted. The project's focus on instructional practices and using the curriculum might be a possible cause for this finding. Regardless, data from this study supports prior work (e.g. Banilower, Boyd, Pasley, & Weiss, 2006; Fishman, Marx, Best, & Tal, 2003; Heck et al., 2008; Orrill, 2001; Richardson, 1990) that influencing teachers' beliefs and practices takes considerable amounts of time in workshops and multiple years of teaching.

Student learning outcomes. Gains in student learning outcomes had statistically significant links to some teacher-level variables. Teacher-participants who reported shifting from teacher- to student-centered practices had higher student learning outcomes on the first assessment than their peers. This supports work from prior studies that linked student-centered pedagogies with student learning outcomes (Author, 2008; Heck et al., 2008; Stigler & Hiebert, 1997; Tarr et al., 2008).

In regards to the influence of teacher beliefs on student learning, the results were mixed; students whose teachers shifted towards transmission views of mathematics teaching outscored peers whose teachers were discovery/connectionist. However, on the second round of assessments, students whose teachers had shifted from transmission to discovery/connectionist in regards to mathematics learning and mathematics as a subject area outperformed their peers. Various studies (e.g., Carpenter et al., 1996; Desimone et al., 2002; Heck et al., 2008) have also found that teachers who had embraced both student-centered beliefs and practices saw gains in student learning outcomes on problem solving measures. However, in this study there is not enough data to fully support that conclusion.

Limitations and Implications

Teachers were solicited to participate in this study as part of the professional development activities and were told that they could withdraw anytime during the study. Seventeen (33%) teachers did not complete the pre and post instruments or did not provide their student data and therefore were excluded from the study although they completed most of the professional development activities. Therefore, this study is limited in the representativeness of the teachers who participated in the professional development activities by including only 67%. Another limitation is that possible measurement errors exist. The instruments used in this study to measure teacher beliefs and practices were adapted from Swan (2006; 2007). We followed the same procedures as Swan to code the data; however, the validity information about these two instruments was not available. The cut-off percentage (45%) in either discovery or connectionist category is also arbitrary. The same is true for the use of 2.00 as the cut-off point in the teacher practice survey. A re-examination of the method to code the belief and practice surveys is necessary. Although the practice survey is reliable (Cronbach's alpha = .79), the use of reverse-keyed items is challenged and could possibly influence the validity of the instrument (Kim, Wang, & Ng, 2010). Further study is needed to examine the validity of the instruments and use structural equation modeling method to examine the relationships while considering the measurement error.

With the limitations in mind, the findings in this study warrant consideration for future studies. First, as indicated earlier, the time that the post-assessments are administered should be modified to avoid a high-stress time, in which teachers in Grades 3, 4 and 5 have modified their instructional practices to drill for state tests. One possible alternative is to collect data on practices and beliefs multiple times during the school year, such as before the project, immediately after the intensive summer workshop, and at a few points during the school year. For example, collecting teacher data on practices and beliefs periodically when we collect student assessment data would allow us to track both student performance and teacher change together. We also predict that collecting data longitudinally will provide more valid data related to teachers' beliefs and practices.

Further, there is a need to reconsider how students' curriculum-based assessments are scored. For the purposes of this study, the researchers scored the assessments numerically, assigning scores to student answers based on rubrics developed by project staff and teacher-leaders. The rubric scores were then converted to percentages. There was a substantial difference in the weight of each item, as some assessments had 2 multi-step tasks, and others had as many as 8 tasks. It is possible that the present way of scoring the assessments does not properly assess the level of student growth in mathematics achievement. One alternative would be to collect alternative student achievement data that is more formative in nature, such as student interviews.

Concluding Thoughts

Elementary school teachers participated in a year-long, 84-hour professional development project focused on the implementation of standards-based mathematics curriculum. Data analysis indicates moderate growth in teachers' content knowledge, a shift towards student-centered instructional practices, and gains on curriculum-based assessments. Further, there was an empirical association between student-centered instructional practices and gains in student learning outcomes on the first round of curriculum-based assessments, as well as a link between shifts towards discovery/connectionist views of how students learn mathematics and student learning gains on the second round of assessments. Teachers' change in beliefs was mixed, indicating a lack of influence of the professional development on teachers' beliefs, or the confounding context of high-stakes testing.

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Table 1

Descriptive Statistics of Student Assessment Gain Scores

	Minimum	Maximum	*M*	*SD*
First Round (*n* = 629)	-83.33	100	18.74	30.59
Second Round (*n* = 542)	-44.44	100	22.40	31.51
Third Round (*n* = 450)	-44.44	100	25.25	30.30

Table 2

Parameter Estimates of Two-Level Hierarchical Liner Models about the Impact of Teacher Knowledge, Belief, and Practice on Student Performance in Mathematics Assessments

	First Round		Second Round		Third Round	
	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.
Knowledge Gains	-1.53	0.57*	-0.38	0.45	0.55	0.66
Belief in						
Teaching						
DC to T	-10.31	7.91	3.20	7.43	24.31	4.95***
T to DC	-1.33	7.78	5.93	8.09	19.10	10.53
Learning						
DC to T	-6.00	6.34	2.52	9.17	-17.80	13.54
T to DC	1.89	6.71	-14.77	6.77*	-6.81	19.80
Mathematics						
DC to T	-8.44	7.03	17.48	10.97	-14.88	9.57
T to DC	5.37	6.01	-13.12	3.62**	-34.06	19.48
Teacher Practice						
T to S	-10.90	4.72*	-4.55	6.14	4.07	9.78
T to T	9.15	13.99	-9.07	5.71	4.30	8.50
T to S vs. T to T	-20.08	13.37	4.36	5.77	-0.44	9.66

Note. (a) *$p < .05$; ** $p < .01$; ***$p < .001$. (b) DC to T means teacher beliefs changed from discovery/connectionist orientation to transmission orientation; T to DC means teacher beliefs changed from transmission orientation to discovery/connectionist orientation; the comparison group was teachers whose did not report a change of their beliefs. (c) T to S means that teacher practice changed from teacher-centered to student-centered; T to T means that teacher practice stayed as teacher-centered; the comparison group was teachers whose practice stayed as student-centered. (d) T to S vs. T to T means a comparison between teachers whose practice changed from teacher-centered to student-centered versus teachers whose practice stayed as teacher-centered.

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

Name: ____

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 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.