USING COLLABORATIVE INQUIRY WITH STUDENT TEACHERS TO SUPPORT TEACHER PROFESSIONAL DEVELOPMENT

Ivan Cheng
California State University Northridge

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Abstract

One of the ongoing challenges of teacher preparation programs is providing authentic opportunities for student teachers to apply the theoretical principles learned in methods courses to the realities of actual classrooms. Research has shown that within the teacher preparation process, the one activity that seems to have a particularly strong effect on preservice teachers' practice is the student teaching experience, with mentor teachers playing a most influential role in that experience. However, many cooperating teachers are not prepared to take on the role of a mentor nor are many schools structured to effectively utilize the classroom as a site for learning to teach. Thus, it is critical to help schools develop structures that can take advantage of the classroom as a setting which can support professional learning for both student teachers and their mentors. This paper discusses some outcomes and implications of an innovative approach to professional learning that used the mentoring of student teachers as a lever for teacher professional development. Through daily meetings, a team of mentor and student teachers engaged in collaborative inquiry around their students' thinking. As a result, student achievement was positively affected while teachers developed a robust knowledge base for effective instruction.

Background

Recently, one educational issue that has become a growing concern for schools across the country is the improvement of instruction in algebra. This concern has also become a focal point for my university, which is one of the largest teacher preparation institutions in the state. In particular, my university is concerned about its own effectiveness in preparing new teachers to meet the challenges of teaching algebra in the secondary schools where our graduates work. At the same time, there is also great concern about how the educational settings in those schools support or limit teacher learning for both pre-service and in-service teachers.

Based on these concerns, my university engaged in a collaborative effort with a local high school to improve instruction in algebra through an innovative use of student teachers in a community of practice. Each day, this team of student teachers and their mentor teachers designed lessons together during a common planning period arranged by the principal of the high school. These meetings were structured to provide a job-embedded professional development experience for the mentor teachers while offering a situated apprenticeship learning opportunity for the student teachers.

Theoretical Framework

The challenges of helping all students learn algebra are prompting many educators to reexamine how mathematics should be taught. New understandings of how students learn now place a greater emphasis on conceptual understanding beyond the mere acquisition of procedural knowledge (National Council of Teachers of Mathematics, 1991). However, this reform goal of "teaching for understanding" (Carpenter, Blanton, Cobb, Franke, Kaput, & McClain, 2004) places many teachers in an unfamiliar role of planning, organizing, and implementing learning experiences to *facilitate* students' *own construction* of knowledge. Numerous studies suggest that most teachers are not adequately prepared to teach in this new way because they were taught in the very system they are now being asked to reform (Ball, 2003). However, teacher preparation programs must rely on these same teachers to *mentor* student teachers who are beginning to learn to teach. As a result, student teachers often experience conflicting messages between their university professors and their teacher mentors (Hammerness et al., 2005b). In fact, they are even sometimes explicitly instructed to abandon the "ivory tower" theories taught at the university (Thomas, et al., 1998) by mentor teachers who essentially apprentice new teachers into traditional norms (Cavanagh & Prescott, 2007). This situation substantially limits student teachers' opportunities to experience reform practices different from the traditional classrooms they experienced as students themselves (Hiebert, Morris, & Glass, 2003).

Research has also shown that within the teacher preparation process, the one experience that seems to have the greatest impact on pre-service teachers' practice is student teaching (Cavanagh & Prescott, 2007; Cooney, 1999), with cooperating teachers playing a most influential role that experience. However, most teachers—even the most effective ones—are often not adequately prepared for taking on the role of a mentor (Sudzina, Giebelhaus, & Coolican, 1997). Furthermore, the existing structure and culture of many schools often do not support novice teachers in learning to teach from their classrooms (Hiebert, Morris, & Glass, 2003) and that environment may actually hinder the professional growth of teachers (Elmore, 2002; Stigler & Hiebert, 1999; Lieberman, 1995).

The literature further suggests that the type of learning environment required for supporting generative change in teacher beliefs and practices must be one which allows teachers to think, discuss, experiment, and reflect (Swafford, Jones, Thornton, Stump, & Miller, 1999; Chapin, 1994; Little, 1993). Teachers need opportunities to examine and enact effective practices to address the specific challenges of their own classrooms. However, the current structure of most American schools simply do not afford teachers the time that they need in order to engage in this type collaborative learning (Darling-Hammond et al., 2009; Ball, 2002; Darling-Hammond, 1999). The challenge, then, is to locate an environment where teachers—both pre-service and in-service—have structured opportunities to learn from their classrooms (Baumert et al., 2010) while being supported in the generative learning process of reflection and lesson design (Hammerness et al., 2005a). Such a challenge was what prompted the development of a project called Student Improvement Through Teacher Empowerment (SITTE), which utilizes teachers' classrooms as the site for learning about teaching.

The SITTE approach for teacher learning provides a structure for teams of teachers to collaborate and conduct "practical inquiry" (Franke, Carpenter, Fennema, Ansell, & Behrend, 1998). It is based on a model of professional development called Cognitively Guided Instruction, or CGI (Carpenter, Fennema, Franke, Levi, & Empson, 2000). CGI helps teachers rehearse new strategies and reflect on their own practices based on careful examinations of student thinking (Franke, Carpenter, Levi, & Fennema, 2001; Carpenter, et al., 2000; Carpenter, Fennema, & Franke, 1996). Although CGI was designed primarily for elementary mathematics teachers, its approach is still applicable to high school teachers because it focuses on a collaborative inquiry of teachers' own understanding of mathematical ideas and of their students' understanding of those ideas (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). Research has shown that such forms of collaborative learning can improve student achievement and transform teachers' beliefs and practices (Berry et al., 2010; Darling-Hammond et al., 2009).

Because teachers' beliefs and practices are also often shaped by their *experiences* in the classroom (Loucks-Horsley, et al., 2003; Fennema, et al., 1996; Thompson, 1992) SITTE utilizes teachers' classrooms as the setting in which teachers engage daily in a *responsive teaching cycle* (RTC) that informs and is informed by evidence of student learning. This approach structures teacher reflection and instructional planning based on careful examination of their students' thinking. Research shows that such an approach is generative, in that analysis and reflection of practice allows teachers to experience ongoing improvement (Kilpatrick, Swafford, & Findell, 2001). With this approach, teacher learning comes from improvised practice rather than from a mandated agenda. Because SITTE empowers teachers be in charge of their own learning process, they are supported in taking additional risks to try new teaching methods. As a result, both student teachers and mentors are supported in getting through to their students rather than simply getting through a book.

It should be noted that the SITTE approach focuses on *daily* collaborative lesson planning around immediate analyses of student thinking, unlike "lesson study" activities (Lewis, Perry, & Murata, 2006; Stigler & Hiebert, 1999), which typically involve periodic meetings that focus on polishing one particular lesson over some extended period of time (Curcio, 2002; Stigler & Stevenson, 1991). A further distinction of SITTE is that the RTC process of collaborative lesson planning is not directed by formal protocols such as those used in "critical friends" groups (Curry, 2008). Instead, the teachers' discussions of mathematics and pedagogy are driven by their need to produce the *next day's* learning activities. Such concreteness and immediate applicability of the discussions have been suggested by research to be among the most effective in supporting teacher learning (Darling-Hammond et al., 2009) and improving student achievement (Berry et al., 2010).

While the use of collaborative learning for professional learning has been strongly advocated in many recent articles and reports, the inclusion of student teachers in such a community of practice has not yet been studied. Most of the research on student teaching has focused on the impact that mentors have upon their student teachers. However, the professional development of mentor teachers has rarely been examined, even though research has shown that teachers develop a deeper understanding of their own teaching while they mentor others (Murray & Stotko, 2004). In one study, Landt (2004) documented the changes in cooperating teachers' practices as a result of their work with student teachers. She found that student teachers had a direct influence on collaborative reflection and lesson refinement. Because such a collaborative relationship between mentors and teacher candidates can create the opportunity to use the classroom as a site for powerful and continuous learning about teaching (Graham, 2006), my university provided me release time, through funding from the *Teachers for a New Era* project (Carnegie Corporation, 2001), to implement and study the SITTE approach of collaborative inquiry at a local high school. Using the student teaching field assignment as the context for this study, five student teachers and four mentor teachers were provided a daily common planning period in which to conduct collaborative inquiry. This paper discusses the impact of SITTE on teachers' practices and the accompanying impact on their students' learning.

The Study

This study began in Fall 2009 at a public high school in a large urban district. As the practitioner/researcher, I facilitated a team of student teachers and their mentors in daily collaborative inquiry around their students' thinking. For this study I focused on two questions:

1) What impact did SITTE have upon teachers' instructional decisions and practices?
2) What impact did SITTE have upon students' performance?

For the first question, I utilized a qualitative approach to examine the impact on the teachers' practice based on descriptive analyses of the lessons that they designed collaboratively. Hiebert et al. (2003) suggests using the lesson as the unit of analysis because it is both "a big enough unit of teaching to contain all of the complex classroom interactions that influence the nature of learning opportunities for students" and the "smallest natural unit" (p. 217) to capture those classroom interactions. This vital aspect of decision making and teaching practice was analyzed through the framework of the Performance Assessment for California Teachers (PACT). Additionally, I used my own notes reflections to provide contextual details to further explain the teachers' thinking behind the lessons.

For student performance, quantitative data was collected in the form of aggregate student scores on district benchmark assessments, and from the course grades of students. Although grades are not a validated measurement of student achievement, they are strong indicators of the teachers' mediational effect upon their students' performance. In fact, teacher practices are among the most significant factors affecting student achievement, including teacher assigned grades based on "point-in-time" tests (Wenglinsky, 2000).

Participants

The secondary education program at my university provides two semesters of student teaching for pre-service students. In their first semester, candidates assume full teaching responsibilities for one class period around the fifth or sixth week of the semester. In the second assignment, the candidate assumes responsibility for teaching on the first day of the semester. In Fall 2009, three of the student teachers upon which this study was based were enrolled in their first semester (A) of student teaching while the other two were in their second semester (B) of student teaching. These five student teachers were placed with six mentor teachers (see Table 1). However, due to scheduling conflicts, only four of the mentor teachers (MT-1, MT-2, MT-3, and MT-4) were able to participate in the SITTE collaboration. The other two teachers, like typical cooperating teachers, were willing to give up a class to a student teacher. However, neither were asked to implement the teaching strategies that were being developed in the SITTE meetings.

Table 1. Student Teacher (ST) assignments (A = 1st Semester ST, B = 2nd Semester ST).

	MT-1	**MT-2**	**MT-3**	**MT-4**	MT-5	MT-6
Per. 1	B-ST1				B-ST2	
Per. 2		B-ST1		B-ST2		
Per. 3	B-ST1		A-ST3		B-ST2	
Per. 4	*Common Planning Period*					
Per. 5				A-ST4		
Per. 6						A-ST5

The four cooperating teachers who did participate in SITTE all volunteered for the project as part of the school's effort to improve student achievement in algebra. In 2009, only 6% of 828 algebra students tested at the "proficient" or "advanced" level on the California Standards Test (CST). Thus, the principal was eager to implement the SITTE project to support student achievement in algebra. Three of the four participating mentor teachers were given an extra planning period by redistributing the students from their Period 4 algebra classes to one of their other periods. As a result, each of the other sections of algebra increased in enrollment by approximately 20% while Period 4 was freed up for daily collaboration.

The four participating mentor teachers ranged in experience from seven years (MT-1 and MT-3) to over 20 years (MT-4). Howard (MT-3) was a "lead teacher" for one of the school's "small learning communities" while Gabriel (MT-2) was serving as an instructional coach and had a master's degree in school administration. None of the four teachers had majored in mathematics; however Howard (MT-3) did have a master's degree in mathematics and Isaac (MT-4) had a master's in mathematics education. Furthermore, Isaac (MT-4) was National Board certified, and Howard (MT-3) was working on obtaining his National Board certification. In short, these four mentor teachers represented a highly seasoned group of veterans with strong content knowledge and pedagogical expertise.

The student teachers were selected primarily because of their preference for teaching in a high school during this semester. (Our program requires the candidate to teach one semester in a high school and one semester in a middle school.) Cassie (A-ST3) was a first-semester student teacher who had recently completed her BA degree in political science in 2008. She was enrolled in a rigorous "accelerated" interdisciplinary program where the candidates took all of their credential courses as a cohort. Her subject matter competence was established by passing the California Subject Examination for Teachers (CSET) in Foundational-Level Mathematics. Debbie (A-ST4) had graduated in 1987 with a degree in food science, and was entering the profession after raising her children. Ellen (A-ST5) was a mathematics major in her senior year at the university. She was part of an "integrated" program that awarded a teaching credential upon graduation with a bachelor's degree. Because Ellen was also a full-time undergraduate student, she also had to attend classes at the university during the day. Like Debbie, she had also taken my methods course during a previous semester.

The two second-semester student teachers had already completed their first semester of student teaching at a middle school. Alex (B-ST1) was in his senior year as part of the "integrated" program. He had begun as an engineering major and transferred into the education program in his junior year. Like Ellen, he also had undergraduate courses to attend during the day and frequently missed the daily collaboration. Finally, Brenda (B-ST2) was a theater major who had finished her bachelor's degree in 2003. Both Alex and Brenda had taken their methods course with me. However, all five student teachers had been brought up in "traditional" classrooms where the teacher lectured and the students took notes and practiced procedures.

In addition to completing their university course work, the five student teachers were also in the process of preparing their "Teaching Events" as part of the Performance Assessment for California Teachers (PACT). Thus, I used the PACT as a framework for analyzing the lessons.

Performance Assessment for California Teachers (PACT)

The PACT was developed by a coalition of teacher preparation institutions to provide an authentic assessment of teacher candidates' knowledge and skill for teaching. Candidates are assessed on their lesson planning, delivery of instruction, assessment of student work, and reflections of their own practice. Since classroom observations (and video records) are the most proximal indicators of classroom practice (Stecheer et al., 2006; Kennedy, 1999), the PACT assessments have "the potential to provide more direct evaluation of teaching ability" (Pecheone & Chung, 2006, p. 23).

The central feature of the PACT is the Teaching Event (TE), a summative assessment that is modeled after the assessments for the National Board for Professional Teaching Standards and the Interstate New Teacher Assessment and Support Consortium (Pechone & Chung, 2006). Besides the *Context for Learning* task, which is not scored, the TE is organized around four primary tasks: *Planning Instruction and Assessment*, *Instructing Students and Supporting Learning*, *Assessing Student Learning*, and *Reflecting on Teaching and Learning* (PIAR). The TE requires teacher candidates to select a "learning segment" for which they submit artifacts such as lesson plans, assessment materials, student work samples, and video clips of classroom teaching. They also submit commentaries to explain the context and content of their sequence of lessons, as well as the thinking behind their instructional decisions (Sato & Curis, 2005). Lastly, the TE includes commentaries in which the candidates analyze their own practice and reflect on the effectiveness of their lessons.

The scoring of the TE is based on multiple guiding questions and corresponding rubrics on a 4-point continuum (see Table 2). Based on pilot studies in 2002–2003 and 2003–2004, the TEs were found to have content validity for assessing the standards of California's Teaching Performance Expectations (TPEs) (Pechone & Chung, 2006). Factor analyses of the TEs further confirmed that the assessment tasks represent meaningful domains of teaching expertise. Bias and fairness reviews also found that there were no significant differences based on the race, ethnicity, or native language of the candidates. The only significant differences in scores were that females scored higher, and candidates in urban or inner-city schools scored lower than candidates in suburban schools. Scorer reliability was at 90% the first year and 91% the second year for score pairs to be exact matches or within 1 point. Further, there was strong agreement between holistic scores and analytic scores. In fact, 90% of non-PACT-calibrated faculty and supervisors agreed with the candidates' scores on 15 to 17 of the Guiding Questions in the rubrics. This agreement suggests that the TE is valid and credible for assessing teacher competence.

Table 2: Rubric for Guiding Questions 1–4 (PACT Consortium, 2007; 2008)

Rubric 1 ***How do the plans structure students' development of conceptual understanding, procedural fluency, and mathematical reasoning skills?***			
Level 1	**Level 2**	**Level 3**	**Level 4**
• The standards, learning objectives, learning tasks, and assessments either have **no central focus or a one-dimensional focus** (e.g., all procedural or all conceptual).	• The standards, learning objectives, learning tasks, and assessments have an overall focus that is **primarily one-dimensional** (e.g., procedural or conceptual). This focus includes **vague connections** among computations/procedures, concepts, and reasoning/problem solving strategies.	• Learning tasks ***or* the set of assessment tasks** focus on multiple dimensions of mathematics learning through **clear connections** among computations/procedures, concepts, and reasoning/problem solving strategies. • A **progression** of learning tasks and assessments is planned to build understanding of the central focus of the learning segment.	• Both learning tasks ***and* the set of assessment tasks** focus on multiple dimensions of mathematics learning through clear connections among computations/procedures, concepts, and reasoning/problem solving strategies. • A progression of learning tasks and assessments guides students to build **deep understandings** of the central focus of the learning segment.

Rubric 2 ***How do the plans make the curriculum accessible to the students in the class?***			
Level 1	**Level 2**	**Level 3**	**Level 4**
• Plans **refer** to students' experiential backgrounds[1], interests, or prior learning[2] that have **little or no relationship** to the learning segment's standards/objectives. OR • There are **significant content inaccuracies** in plans that will lead to student misunderstandings.	• Plans **draw on** students' experiential backgrounds, interests, or prior learning to **help students reach** the learning segment's standards/objectives. • Plans for implementation of learning tasks include **support to help students** who often struggle with the content.	• Plans draw on students' prior learning **as well as** experiential backgrounds or interests to help students reach the learning segment's standards/objectives. • Plans for learning tasks include **scaffolding or other structured forms of support**[3] to provide **access to grade-level** standards/objectives.	All components of Level 3 plus: • Plans include **well-integrated** instructional strategies that are **tailored** to address **a variety of specific student learning needs**.

Rubric 3 ***What opportunities do students have to demonstrate their understanding of the standards and learning objectives?***			
Level 1	**Level 2**	**Level 3**	**Level 4**
• There are **limited** opportunities provided for students to learn what is measured by assessments. OR • There is a **significant mismatch** between one or more assessment instruments or methods and the standards/objectives being assessed.	• Opportunities are provided for students to **learn what is assessed**. • It is not clear that the assessment of one or more standards/objectives go beyond **surface-level** understandings.	• Opportunities are provided for students to learn what is assessed. • The assessments allow students to show **some depth of understanding or skill** with respect to the standards/objectives. • The The assessments **access both productive (speaking/writing) and receptive (listening/reading) modalities** to monitor student understanding.	All components of Level 3 plus: • Assessments are **modified, adapted, and/or designed** to allow students with special needs opportunities to demonstrate understandings and skills relative to the standards/objectives.

In addition to the administering the PACT for second semester candidates, my university has designed a formative assessment for candidates who are in their first semester of student teaching. This *Preliminary* Teaching Event (PTE) is a condensed version of the full TE in which candidates are asked to submit artifacts and commentaries for just one lesson rather than a series of lessons. Using the PACT TE as my framework for analysis, I focused on the three rubrics that assess *Planning Instruction and Assessment*, which is the first of four tasks (PIAR) assessed in the PACT rubric (PACT Consortium, 2007, 2008):

1) How do the plans structure students' development of conceptual understanding, procedural fluency, and mathematical reasoning skills?
2) How do the plans make the curriculum accessible to the students in the class?
3) What opportunities do students have to demonstrate their understanding of the standards and learning objectives?

Beyond using the PACT as a framework for analyzing the teachers' work, I also used my own notes and reflections to provide additional contextual details to further explain the teachers' work and rationale behind their decisions.

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[1] Cultural, linguistic, social, economic
[2] In or out of school
[3] Such as multiple ways of representing content; modeling problem solving strategies; relating pictures/diagrams/graphs and equations; strategic groupings of students.

Findings

Designing lessons based on student needs is generally considered difficult, if not impossible, by new teachers. In fact, even experienced teachers have a hard time applying research-based practices to actual classrooms in less than ideal situations (Clift & Brody, 2005). As a result, many teachers resort to a reliance on the textbook with lesson planning being reduced to simply determining which section of the book to present on any given day. Such lessons are often procedural in nature and treat different topics in mathematics discretely without making connections across the different representations of the concepts. Further, the progression of lessons are not guided by the developmental needs of learners. Instead the lessons typically follow the organizational structure of experts who already possess an advanced understanding of the subject (Nathan & Petrosino, 2003). Thus, it was important for me to examine the extent to which the teachers connected various types of knowledge based using a progression that is responsive to the learning needs of students.

Over the course of one semester, the teachers in SITTE generated over 100 lesson activities and assessment tasks. Therefore, the primary source of data for this study came from those lesson activities. My analyses focused on three guiding questions from the *Planning* task rubric. In particular, I examined the teachers' lesson activities for the following: 1) the degree to which the tasks connected procedures, concepts, and reasoning (i.e., a balanced focus); 2) the thoughtfulness of their sequencing of learning tasks to make content accessible and to promote understanding (i.e., access to content); and 3) the complexity and depth of the design of the assessment instruments (i.e., meaningful assessment).

Balanced Focus (Rubric 1)

Based on the PACT rubric, lessons which have a "balanced focus" have clear connections between concepts and procedures. Such lessons are aligned with the five strands of mathematical proficiency proposed by the National Research Council (Kilpatrick, Swafford, & Findell, 2001) and include facts and skills as well as higher order thinking skills such as adaptive reasoning. Furthermore, lessons with a balanced focus are strategically structured and sequenced coherently in order to build a deeper understanding of the content. Such an understanding of content necessarily goes beyond mere procedures learned in isolation. In short, the teachers are being asked to help students really learn the meaning in mathematics, rather than just the mechanics of computing correctly.

Early in the semester, the teachers began to grapple with the need to help students make connections between pictorial representations and symbolic representations of problems that were contextualized in real life situations. At the same time, the teachers also implemented guided discovery lessons using a set of carefully designed tasks that incorporated "progressive formalization" (Bransford, Brown, & Cocking, 1999, p. 125). In this process, students were encouraged to use their own informal representations before gradually incorporating more formal notations of mathematics. Furthermore, there was incredible synergy in the creation of various learning tasks throughout the semester. For example, Isaac built upon Howard's "Toll Road" problem and generated the "Anthony's Big Date" activity (Figure 1), which inspired Franklin to create the "Lawn Care" activity in Excel. This version used the formula feature of the Excel application to allow different versions of the problem to be created simply by changing values of the parameters. At the same time, Ellen developed "Noe's Problem," which led to yet another Excel activity from Franklin. The key point here is that student teachers emulated mentor teachers and mentor teachers extended their own thinking based on the contributions of the student teachers. Over the course of two weeks, the teachers generated over eight lesson activities that represented a clear and consistent emphasis on connecting various dimensions of understanding. In fact, problems like the "Toll Road" and "Anthony's Big Date" became the prototypes of a number of similar problems that focused on making connections.

Figure 1. "Anthony's Big Date" activity based on Howard's "Toll Road" activity.

Anthony's Big Date

Name ___________________
Period ____ **Date** ________

Traveling. Anthony decided to take his girlfriend out on a fancy date. He decided to go to the most expensive restaurant he could think of (McDonalds) and drive her around on his moped.

A) If he picked her up at the beauty salon which is 3 miles from his home and kept traveling away from home at the maximum speed of his moped (2 miles per hour):

How far will they be from his home after 1 hour? __________
How far will they be from his home after 3 hours? __________
How far will they be from his home after 5 hours? __________
How far will they be from his home after 7 hours? __________

Complete this table with Input (hours driving) and Output (how far from home).

INPUT: Hours Driving (after picking her up)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
OUTPUT: Miles From Home								

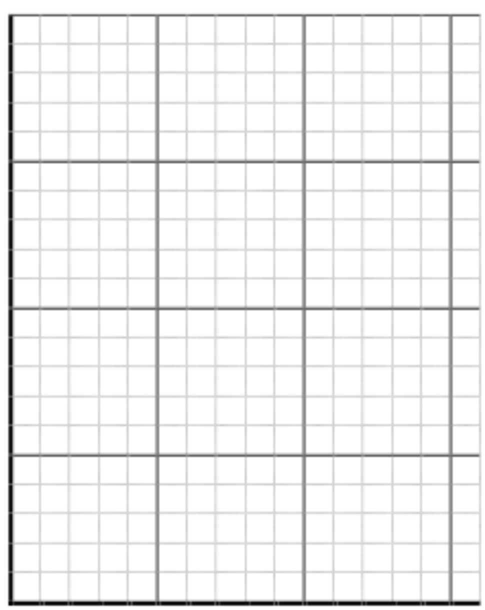
B) Describe what you need to do to figure out how far they are from his home if you know how many hours have passed since he picked her up?

C) Write a general rule that expresses the relationship between how far they are from home (y) in terms of how many hours they have been riding (x).

$\boxed{\text{Miles From Home}}$ = ______ + _____ • $\boxed{\text{Hours Driving}}$

y = ____ + ___ x

D) Plot the points you made in "A" here:



E) If Anthony drives for 25 hours,
how many miles from home will they be?

How long will it take them to be
33 miles from home?

The constant emphasis on making connections between different types of knowledge and different representations was motivated primarily by the teachers' explicit intention to teach algebra as *tools* rather than topics. In other words, equations and graphs were not treated as discrete topics to be addressed as part of an artificial pacing plan. Rather, equations, graphs, tables, words and pictures were all employed to make sense of contextualized problems and were addressed simultaneously so that students could see the mathematical connections between the various representations. For example, Ellen observed how her students were connecting their explanations, general rule, and algebraic equations in the "Toll Road" problem, "Vivian said, 'Oh! It's like a short way to write it!'" She went on to state that the students were beginning to think by themselves.

Such an approach to teaching algebra was not always well received by the students. For example, Debbie noted, "They are thinking more, but there is still a resistance to formalizing their math. They were intrigued by the Anthony's Date problem and what to do with the 3 miles. In some ways they like a challenge, on the other hand it confuses them." Alex added, "I am certain more than half of my students need additional instruction before they see the connection between the charts/tables/graphs and the algebra they are doing. Many students see all the parts to the problem, like the Custom T-Shirt problem, as individual exercises."

Figure 2a. "Custom T-Shirt" activity proposed by Howard.

CUSTOM T-SHIRTS

This past summer you were hired to work at Custom T-Shirts. When a customer places an order for a special design, Custom T-Shirts charges a one-time fee of $15 to set up the design plus $8 for each T-shirt printed.

1. Your first responsibility at Custom T-Shirts is to make a chart that shows how much a customer would be charged for various numbers of shirts. <u>Make a chart</u> that includes the total cost of up to 100 shirts. Include at least 10 rows on your chart.

2. How much should Custom T-Shirts charge for an order of 150 shirts? How much should they charge for an order of 750 shirts? Explain how you determined your answers.

3. If you have not done so already, write a variable expression that could be used to determine how much to charge a customer for any number of shirts.

4. Use your expression to write an equation that would help you figure out how many shirts are ordered if the total cost of the order is $1,935. You do not need to solve.

5. If a customer's total bill was $815, for how many shirts was he/she charged? Describe how you found your answer.

6. If a customer's total bill was $2,055, how many shirts did he/she get? Show your work.

In response to these concerns, the teachers made even more effort to provide a coherent progression of tasks that would lead students to understand the connections between the problems and their representations. First, the teachers set up problems to help students focus on intended learning objective. For example, Howard adapted a problem that was first presented by

Isaac (Figure 2a) to help students focus on translating a problem into algebraic expressions.

> *"Attached is the modified T-Shirt problem. I have intentionally left out graphing, as I think it detracts from what we are doing right now. I am planning to introduce graphing on the next one."*

Gabriel even went as far as to provide a graphic organizer to help students clarify their own thinking (Figure 2b).

> *"I took Isaac's idea for his posters and added a graphic organizer to help support the student's while they work out the various tasks in the T-Shirt problem. It should also make their work a little easier to check/grade. I also changed the font to make it look a little friendlier."*

Figure 2b "Custom T-Shirt" activity modified by Gabriel.

CUSTOM T-SHIRTS Name ________________________

1. Chart	2. 150 Shirts 750 Shirts Explanation:
3. Variable Expression	4.
5. Calculation: Description:	6.

The coherent progression of tasks was one of the most powerful aspects of the Responsive Teaching Cycle. Each day the teachers analyzed the progress that the students were making and then addressed their learning needs through a well-designed activity that considered things as specific as the choice of values to use so that students would not get sidetracked with cumbersome computations. Furthermore, the coherence in the sequence of tasks was the direct result of the teachers' constant adaptation of each other's contributions. Frequently, the modified worksheets from the mentor teachers were based on initial activities generated by the student teachers, such as Ellen's "Noe's Problem," or Cassie's "Baby Dinosaurs."

Finally, a balanced focus in lesson design must promote a deep understanding of mathematics. The teachers constantly pushed students beyond just learning the mechanics of a procedure. Their focus was on *understanding* the mathematics. For example, Gabriel noticed that students did not recognize the initial condition as an y-intercept and just treated the problem as a direct variation. Ellen added, "The students are beginning to understand the idea of a y-

intercept. Not that they know what a *y*-intercept is but that the equation doesn't always start at 0." Observations such as these resulted in frequent modification of activities, such as the one made by Brenda in her implementation of Ellen's "Noe's Problem."

> *"It looks great!* :D *I threw in a number 7 just for fun and to probe thinking, and just asked 'How might your equation in 5) change if Noe already had 10 points before the first day?' Just to see what would happen. Thank you all!* :D*"*

Furthermore, as mentioned earlier, the deep understanding of mathematics that was promoted by the teachers focused on teaching algebra as tools, rather as than topics. This meant students learned how to *use* algebra rather than just mechanically rehearse procedures. Ellen was particularly emphatic about promoting thinking in her students.

> *"Warm-Ups that include graphing and algebraic expressions can help the students. I think more group work and homework practices will strengthen their skills and help them understand how to use the table as a source for algebraic expressions."*

In the end, the students did make the connections, and they developed a deeper understanding of mathematics. Despite the frustrations that Debbie had felt earlier in the semester, she now saw how the lessons developed in SITTE brought everything together for the students.

> *"They are tying it all together-the contextual English problems the bar graphs the algebraic expression s and equations, the input-output charts and the graphs and solving the equations. It's very cool and intuitive and organic. Not one kid has asked when they would ever use this. I think it feels authentic to them."*

At the same time, Cassie realized that this approach was much more effective than using the textbook, which she tried to do in the third week of school.

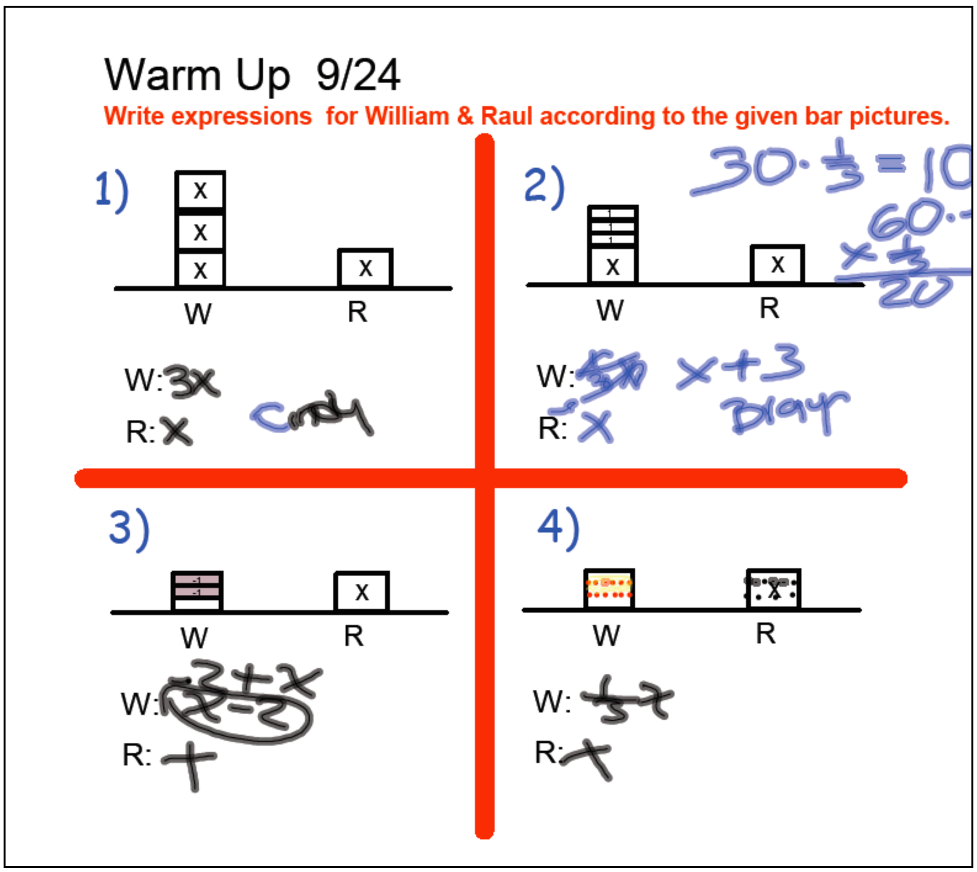
> *"TODAY was AWESOME. This was WAY different from Thurs/Fri, maybe it was because they have had two other worksheets with this type of problem, or maybe because these were problems that we wrote, instead of book problems. Either way, a few kids rolled up this worksheet and smoked it, and most others hacked their way through it, but got it done and didn't complain."*

Access to Content (Rubric 2)

One of the most important aspects of effective teaching is in making content accessible to students. The primary focus in PACT is on "structured forms of support" that draw on students' prior knowledge, experiences, and interests. Such structured support include the use of multiple representations and specific strategies to help students attain learning goals. However, designing lessons that provide the necessary scaffolds requires teachers to be aware of their students' interests and prior understandings. At the same time, teachers need to know how to help students engage in rigorous mathematical tasks while accommodating the diverse learning needs of the students. These are formidable tasks even for experienced teachers.

Working together, however, the teachers did quickly recognize the need to be sensitive to students' learning demands. As an English learner himself, Franklin was the first point out the need to be attentive to the language demands in word problems. This helped the teachers notice how one question asking for "how long" was potentially confusing to students because it could have been answered in terms of time or distance. This is due to the fact that in common speech, distance is often referenced by the time it takes to travel that distance (e.g., "the school is 10 minutes away"). A few days later, Brenda reflected that the challenge was not just in the academic language, but in the implications of the words in the problems. For example, Ellen noticed that students were confusing "3 more" with "3 times." Such observations led the teachers to incorporating pictorial representations of mathematical relationships by using bar models ("Middle school math," 2010; Hoven & Garelick, 2007). For example, in one Warm Up activity (Figure 3) the students were asked to identify the relationship between two quantities illustrated by the bar models. The extended use of bar models represents a deliberate effort on the teachers' part to help students *see* the mathematical relationships *visually* as they developed an understanding of symbolic representations. As a result, the teachers worked together to create tasks such as "More Expressions" (Figure 4a).

Figure 3. Warm Up activity on September 24, 2009.



In the process of designing the activities above, the teachers built on each other's contributions. Each teacher was asked to generate a set of problems that would bring out distinctions between various mathematical terms such as "3 times," "3 more," "3 less," and "1/3 as many." Brenda then added specific questions (Figure 4b) to help students recognize the numerical relationships. Her modification was so well received that even the math coach adopted them in his final revision.

"I really liked Brenda's problems. I'm going to use those. I changed the format to allow students space to write and draw their picture. I also changed some of the words."

As a result of using this type of structured support, students were able to gain a deeper understanding of what a variable represented in symbolic equations and how quantities were related based on the words being used. In her reflection after the activity, Cassie noted, "I felt that today's lesson with writing expressions went well. … Today the students were asking 'what's the difference between twice one and half another' for expressions such as 'two times as much...' They are already discovering the two different relationships, and now we need to teach them that this is called defining the variable, and differentiating between independent and dependent variables."

Figure 4a. "More Expressions" activity to build understanding of expressions.

More Expressions 1 Name ___________________

Draw bars to represent the relationships and write the correct algebraic expressions.

William has 3 times as many Pokemon cards as Raul.	William has 3 more Pokemon cards than Raul.
William has 1/3 as many Pokemon cards as Raul.	William has 3 less Pokemon cards than Raul.
Hannah has 7 more hats than Josh.	Hector has 7 times as many CDs as Joe.
Emily has 7 less sunglasses than Amy.	Oscar has 1/7 has many M&Ms as Michelle.

In addition to supporting the learning needs of students through the use of multiple representations, a second key strategy for making content accessible was through the use of group work. In fact, activities such as "More Expressions" and nearly all of the other tasks were designed to incorporate small group discussions. Ellen, for example, was very intentional in her own use of circulating during group work to support students in accessing the content.

"Students are still having difficulty understanding 3 more and times. Although, I explained it in class and had others come on the board and do the problem as I walked around I still saw incorrect answers on their

paper. Tomorrow we are going to put the students in groups of four. That way we can walk around and help and they will also have the support of their group members to understand the problems. By students helping one another and us leading the group the students will be able to understand the problems in one than one way as well as have many people helping them."

Figure 4b. "More Expressions" activity modified by Brenda.

More Expressions 2 Name ____________________

Draw bars to represent the relationships and write the correct algebraic expressions.

Leo has 2 times as many stamps as John.

1) If John has 5 stamps, how many does Leo have?
2) If Leo has 12 stamps, how many does John have?
3) If they have 18 stamps combined together, how many does each person have?

Leo has 2 more stamps than John.

1) If John has 15 stamps, how many does Leo have?
2) If Leo has 9 stamps, how many does John have?
3) If combined together they have 16 stamps, how many does each person have?

Leo has 1/2 as many stamps as John.

1) If John has 8 stamps, how many does Leo have?
2) If Leo has 6 stamps, how many does John have?

Leo has 2 less stamps than John.

1) If John has 14 stamps, how many does Leo have?
2) If Leo has 7 stamps, how many does John have?
3) If combined together they have 8, how many stamps does each person have?

Brenda has 3 more puppies than Sam.

1) If Sam has 4 puppies, how many does Brenda have?
2) If Brenda has 2 puppies, how many does Sam have?
3) If combine together they have 9 puppies, how many does each person have?

Brenda has 3 times as many trophies as Sam.

1) If Sam has 5 trophies, how many does Brenda have?
2) If Brenda has 21 trophies, how many does Sam have?
3) If combined together they have 20 trophies, how many does each person have?

Brenda has 1/3 as many cookies as Sam.

1) If Sam has 24 cookies, how many does Brenda have?
2) If Brenda has 4 cookies, how many does Sam have?

Brenda scored 3 less points than Sam.

1) If Sam scored 99 points, how many did Brenda score?
2) If Brenda scored 83 points how many did Sam score?
3) If combined they scored 187 points, how many did each person score?

Furthermore, the worksheets were designed to have identical problems with different numbers for each group member. This way students could discuss their strategies without being able to simply copy each other's answers. Debbie stated in her reflection, "I was really encouraged by the students on Friday. They really tried on the 4 version group quiz. There were kids who haven't tried yet and they were doing it. I was encouraged that they cared and that they felt like they could give it a try. They worked together, rather than just copying, and they were actually talking about the math and what made sense. It warmed my heart to see Miguel, who has been a very immature learner, telling his table mates about fractions and what makes sense. He actually cared and was a good team player. Many of the students got 15 or 16 out of 16. I was also happy that the quiz gave them a chance to learn as well as be assessed."

At the same time, the teachers tapped each others' expertise in structuring group work so that students would be actively engaged in developing their own understanding. Howard, for example, shared his strategies based on a Kagan Cooperative Group workshop that he had attended.

> *"As promised, here is a possible structure to use with the matching activity later this week:*
>
> *Assign students into groups of 2. Have them sit side by side. One student will be partner A, the other partner B. (To make it fun, you can say something like: 'Partner A will be the person wearing the most black')*
> 1) *Groups will start by selecting a set of matching cards together.*
> 2) *Partner A solves the equation while partner B watches and coaches as necessary.*
> 3) *Partner B checks the solution by plugging it into the equation.*
> 4) *Switch roles after each problem.*
>
> *It helps to quickly model the activity and discuss with them how to appropriately coach their partner. Remember, we are teaching students, not Algebra, so teaching appropriate social interactions is a must! Hope I didn't sound too preachy or too Dr. Kagan. Good luck!"*

Finally, a third key feature of making content accessible was the teachers' deliberate use of students' experiential backgrounds or interests in designing the tasks. One way this was done was to use the students' names in the problems along with contextualizing the problems in situations that were meaningful for students. For example, "Christina's Cookie" problem (Figure 5) was designed specifically to help students think of a variable as a "container" for an unknown quantity of something concrete. This deliberateness resulted from an extended conversation during a planning session to help students transition from concrete images to abstract symbolisms.

In summary, the teachers were intentional about their use of strategies to scaffold learning. They were attentive to the learning needs of their students and used their knowledge of students' prior learning and experiences to design activities that provided access to content. They realized that students needed support in making the transition to symbolic representations, but at the same time they did not want to "dumb down" the curriculum. Thus, they incorporated the use of bar models to help students understand what the symbols represented. As Ellen noted at the end of the week, "Today's class went really well. We had the students form groups of four in total eight groups. … Each group had one leader and we had white boards with markers. The students would write their work on the white board and the group would analyze their work.

Each group member had a chance to write their answer on the white board. … After the end of this lesson students were understanding the idea of the picture better than yesterday. They all had pictures on their paper and discussed the problems. We wrote a few problems to solve for. … The idea of drawing a picture before solving the problems will help students understand the problem."

Figure 5. "Christina's Cookie" problem in Quiz 1.

Quiz 1

Name ______________________

Period ______________________

Solve the problem below.

Christina baked 30 cookies and filled 2 boxes to take to school. After she filled the 2 boxes equally, she noticed that there were still 4 cookies left. How many cookies did she put into each box?

Represent the problem using pictures, or symbols, or tables, or charts, or equations.	***Explain what you might do to solve the problem.***
Solve the problem. What's the answer?	***Check the solution. How do you know the answer is correct?***

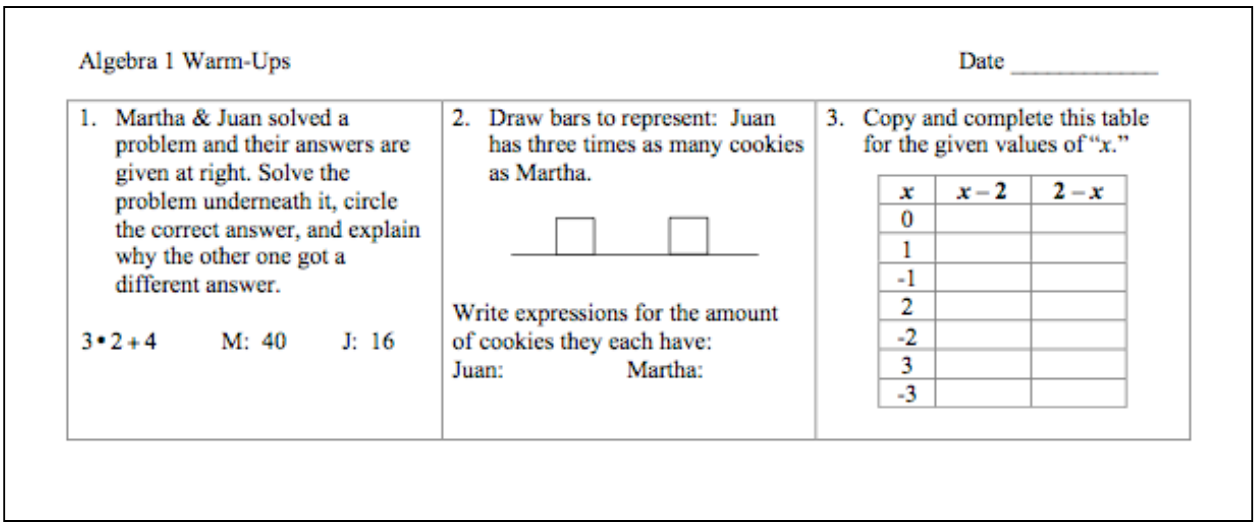
Meaningful Assessments (Rubric 3)

Designing quality assessments is a central feature of effective teaching practice (Black & Wiliam, 1998). However, one of the most challenging tasks of teaching is designing meaningful assessment instruments that measure student understanding beyond surface-level skills. The PACT, for example, asks teacher candidates to measure how well students understand what is communicated by others ("receptive modality") *and* how well they communicate their own understanding ("productive modality"). At the same time, the assessment instrument must be appropriate for the students' developmental level while being varied enough to accommodate special student needs.

The *Assessment Principle* of the National Council of Teachers of Mathematics identifies a number of effective techniques for making assessments a useful part of instruction (NCTM, 2000). However, quality assessment strategies are often not implemented because many teachers focus on grading for proficiency of rote skills rather than on learning about their students' thinking in order to inform instructional decisions. In contrast, the teachers in SITTE dedicated much of their energy to assessing students in order to be responsive to their learning needs and trajectories. In order to be able to analyze student work beyond simply marking answers right or wrong, the teachers had to design mathematical tasks that allowed student thinking to be demonstrated in multiple ways.

First, the teachers designed assessments that were complex. Not only were students provided multiple ways to demonstrate their understanding, they were also asked to demonstrate different levels of understanding. For example, Isaac shared a series of Warm Up activities (Figure 6) that provided insight on his students' misconceptions. Not only were students asked to compute correctly, they were also asked to explain their reasoning. For example, in this task as well as almost every other task, there are explicit opportunities for students to compare and contrast different possible answers, as in Problem 1. The teachers also provide opportunities to use multiple representations, as in Problem 2. And they frequently design problems to provide opportunities for students to notice patterns, such as the difference between $x - 2$ and $2 - x$ in Problem 3.

Figure 6. Sample Warm Up activity.



Algebra 1 Warm-Ups

Date ____________

1. Martha & Juan solved a problem and their answers are given at right. Solve the problem underneath it, circle the correct answer, and explain why the other one got a different answer.

$3 \cdot 2 + 4$ M: 40 J: 16

2. Draw bars to represent: Juan has three times as many cookies as Martha.

Write expressions for the amount of cookies they each have:
Juan: Martha:

3. Copy and complete this table for the given values of "x."

x	$x - 2$	$2 - x$
0		
1		
-1		
2		
-2		
3		
-3		

A second example of complex assessments is found in the first test the teachers gave (Figure 7a and 7b). At first Howard and Cassie were doubtful that the students would be able to perform well in such a complex activity. The students had to synthesize their understanding of two types of linear relationships, namely, direct variations and linear functions with a non-zero *y*-intercept. Further, the students were asked to extrapolate beyond the values in the tables or graphs. Finally, the students were asked to write the symbolic expression for the function. This was just on the first two pages. The students also had to illustrate mathematical relationships using the bar model and with algebraic expressions. And they still had to solve linear equations in one variable on the last page. However, the teachers found themselves pleasantly surprised. Ellen, for example, remarked:

> *"After grading half of the tests I am impressed by the results. I have a lot of perfect scores and students who even checked their answer for the naked equations. I was worried about the x – 4 problem however so far*

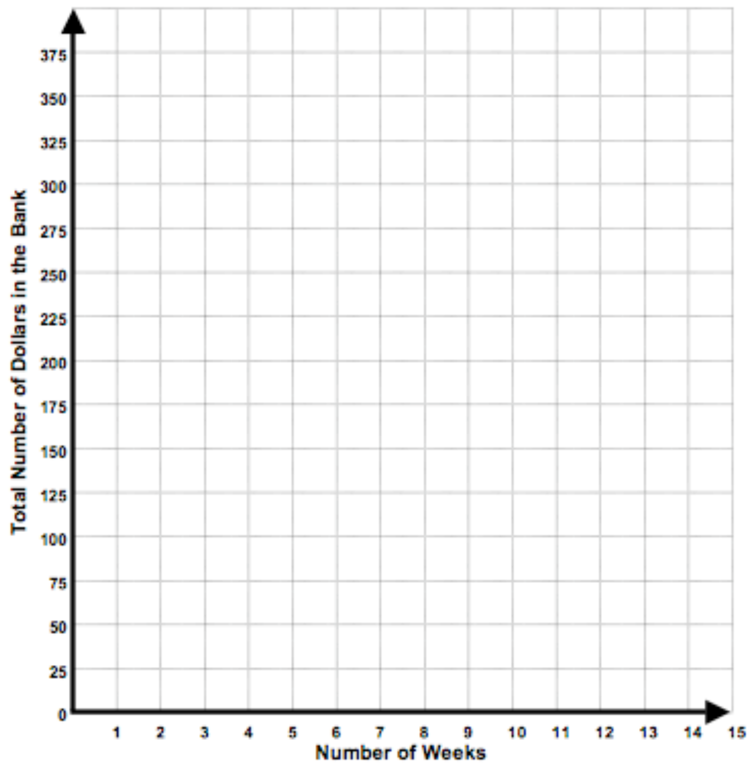
Figure 7a. Page 2 of Test 1.

Test 1 (Form A) Name ____________________

Saving Money. Suppose you save 20 dollars each week from your part time job and put it in the bank. You already have 100 dollars in the bank.

1. If you save money for 3 weeks, how much money will you have in the bank?
2. If you save money for 7 weeks, how much money will you have in the bank?
3. If you save money for 12 weeks, how much money will you have in the bank?
4. Complete the table and plot the points from the table on the graph below.

Number of Weeks	Total Number of Dollars in the Bank
0	
1	
2	
3	
x	



5. How much money will you have in the bank if you save money for 21 weeks?
6. What did you do each time to find the number of dollars you have in the bank for each week?
7. Write an algebraic expression to show how much money you have in the bank for ***x*** number of weeks.

Figure 7b. Page 3 of Test 1.

<u>**Test 1**</u> **(Form A)** Name ____________________

Draw bars to represent the relationships and write the correct algebraic expressions.

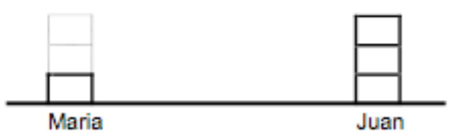
Cesar reads 4 times as many books as **Martin**.

Ceci reads 4 more books than **Mayra**.

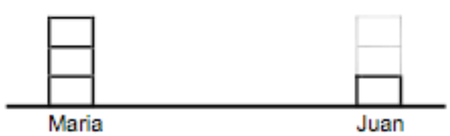
Maria has 3 times as many pencils as **Juan**. Which illustration below does ***not*** represent the relationship?

A) **3*x*** Maria **x** Juan

B)

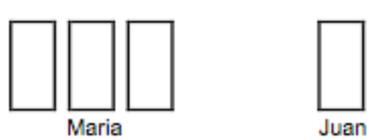


C)



D)

E)



Maricela has 4 less pencils than **Javier**.

only one student did not get that problem correctly. After the quiz I had not reviewed the idea of x – 4 instead of 4 – x so I am surprised and happy that my students were able to get this problem correctly."

Debbie noted that her students had missed the problem with a non-zero intercept, "I just finished grading test 1 and about 70% of the students passed. Only half caught the $100 in the bank. I think if the $100 was in bold they would have seen it. I should have had them circle the 'math words'." The inclusion of two types of linear functions illustrates the teachers' thoughtfulness in their design of the test. Assessing the students' understanding of a constant rate of change was purposely separated from assessing the understanding of the role of an initial value. And a multiple choice item was included to assess students' receptive modality (understanding) without the interference of their productive modality (i.e., *demonstration* of understanding).

The preceding example of a formal test did not preclude the use of informal assessments from a variety of mathematical tasks. One example was the "Linear Matching" activity designed by Debbie (Figure 8). Students were given a set of scrambled cards, each with one representation or description of a particular linear function in context. Working in pairs or groups, the students had to match the context with a linear equation, the associated graph, the table, as well as the descriptions of the slope and *y*-intercept. This activity was not only engaging for the students, but it provided teachers rich opportunities to observe how the students were thinking and to notice their misconceptions.

> *"I was checking their matched sets of cards and giving them a score on their worksheet. As I checked over their work, I had them help me check by looking for the pattern of the 'slope numbers' and the 'y-intercept number' in the four representations of the line (the contextual situation, the equation, the graph, and the table). Of course, I did not need their help to check their cards, but they were very interested at that moment to see whether or not they had a good match and I was taking advantage of their engagement to help them see the pattern and connection between the slope and y-intercept values and the multiple representations of the lines."*

In other words, Debbie used the opportunity to check her students' understanding and to help them check each other's work. And as a result, Debbie gained important insights about her students.

> *"My struggling students need mastery experiences or easy learning tasks that make hard concepts simpler to grasp. The Linear Matching Activity is designed to be a mastery experience for students who struggle. This activity allows students to focus on the patterns and connections between concepts rather than on computations and formulas. Also, students have two additional pathways to success-by trial and error and by the process of elimination-which increases the chances of student success and engagement."*

In summary, the teachers designed rich tasks that assessed students' understanding of content deeply and in a variety of ways. Students were able to demonstrate their understanding through various modalities. Most important, the assessments were powerful tools in advancing student learning *and* in informing instructional decisions. According to research, such a use of formative assessments produce significant learning gains (Black & Wiliam, 1998).

Figure 8. Sample cards from Linear Matching activity.

Phone Plan A. **Each month, Phone Company A charges $3 plus $1 per call.**

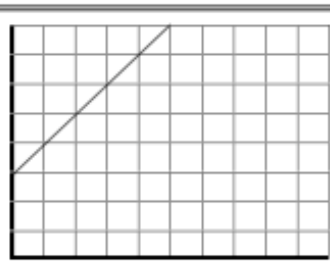
y = x + 3

13

Output (y) changes 1 for every 1 input (x) change 54

Slope is 1. 46

y-intercept is three. 29



85

x	0	1	2	3
y	3	4	5	6

91

Phone Plan B. **Each month, Phone Company B chares $5 plus $0.50 per call.**

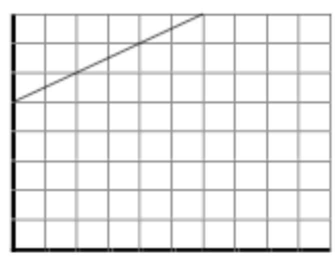
y = (1/2)x + 5

14

Output (y) changes 1 for every 2 input (x) change 36

Slope is 1/2. 83

y-intercept is five. 71



96

x	0	2	4	6
y	5	6	7	8

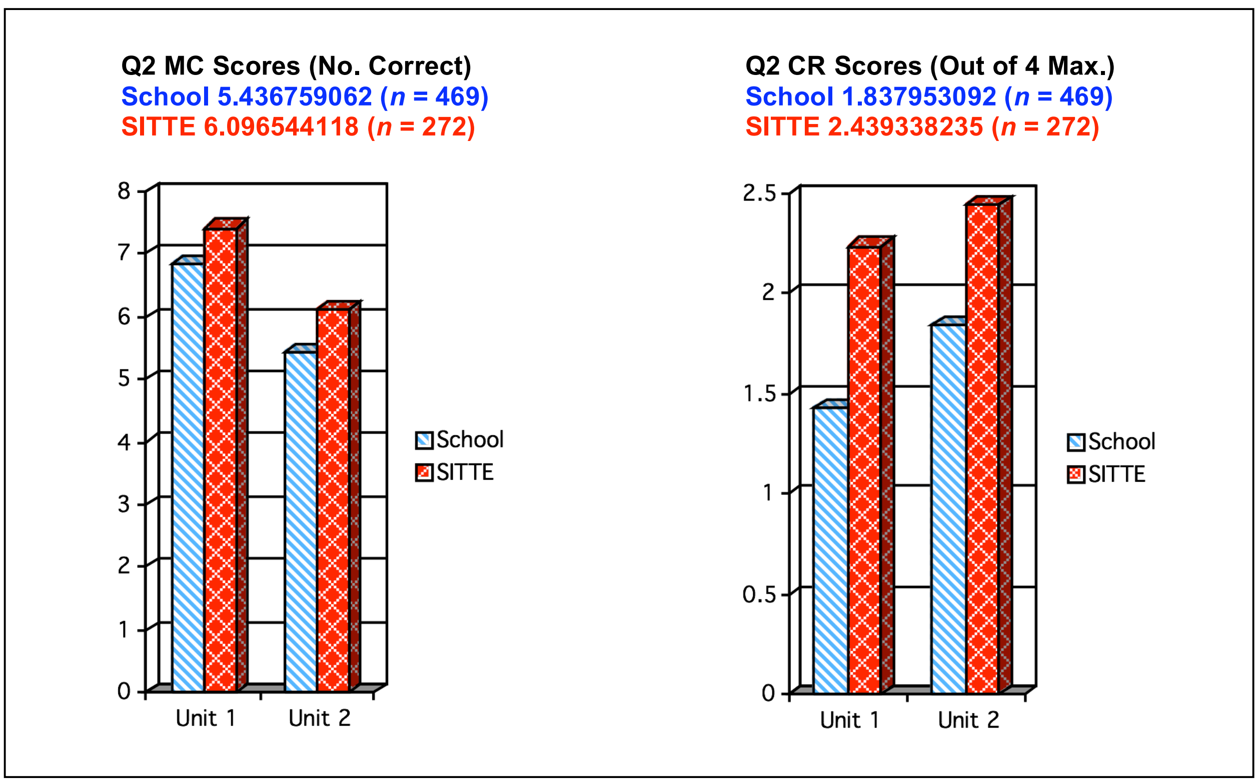
2

Student Performance

Since improved student outcomes is the ultimate goal of teachers' professional activities, it should be a major factor in determining the effectiveness of professional development. In fact, such a metric represents the highest level of complexity in evaluating the effectiveness of professional development (Guskey, 2002). For this study, student performance was assessed using Periodic Assessments given district-wide and teacher assigned course grades. Although grades are not a validated measurement of student achievement, they are strong indicators of the teachers' mediational effect upon their students' performance. In fact, teacher practices are among the most significant factors affecting student achievement, including teacher assigned grades based on "point-in-time" tests (Wenglinsky, 2000). Improved grades in algebra, when correlated with higher achievement in standardized tests, should provide a degree of assurance that the impact of SITTE was not random.

At the end of the semester, approximately 75% of the students (over 250) passed the course (mostly with an A), in contrast to algebra students from one year earlier, 75% of whom failed similar content material. Average grades ranged from 70% to 82% among the 9 classes. On the first Periodic Assessment, 48.1% of the students (in classes taught by participating SITTE teachers) scored "Proficient" or "Advanced," These students also scored 52% higher than their peers on the most difficult portion of the assessment (i.e., "constructed response"). In the second quarter, 23% the SITTE students scored "Proficient" or "Advanced," while only 16% of the rest of the school scored in those bands. This means there were 4½ times as many SITTE students scoring "Proficient" or "Advanced." A graphical comparison of the scores appear in Figure 9 below. In both Periodic Assessments, SITTE students scored significantly higher.

Figure 9. Comparisons of Periodic Assessment results.



Results and Significance

The results of this study are promising and suggest that the SITTE collaborative approach using the Responsive Teaching Cycle (RTC) can impact teacher practice and student performance substantially. Also, analyses of the teachers' lessons suggested that they enacted lessons that focused on deep understandings of mathematics even as they made the content accessible through thoughtfully scaffolded activities. This study also suggests that collaborating teachers would experience transformative and generative growth as they construct their own knowledge. The lessons learned so far suggest that structuring this type of collaboration can potentially have a powerful impact on student outcomes as well.

There is strong evidence that the cooperating teacher can plan a crucial role in either supporting or contradicting the university teacher education program (Conklin, 2009). What is not clear is the role that student teachers have in the professional growth of the mentor teachers. The SITTE experience, however, suggests that experienced teachers can be significantly affected as well. Gabriel, for example, has been a teacher for 18 years and has served as a district instructional coach. In his reflection, he said:

> *"Well let me say that this year, our team has developed several methods that I had never thought of before, nor ever seen before at any high school in my career. In fact, the discussions even triggered some ideas of my own that never would have surfaced if I had been working alone. I have known for some time now that teacher collaboration can be a powerful thing, but perhaps I never realized just how powerful and valuable it could be."*

Through this collaboration, teachers also developed a new identity of being innovative problem solvers as they addressed the learning needs of their students. This identity formation (Wenger, 1998) is an essential part of transformative learning that results from a collaborative effort such as SITTE. Franklin, for example, repeatedly stated that "this program works."

> *"In the past, I have heard many teachers vocally expressed their beliefs that there is no possibility of improvement given the constraints from students' background and lack of prior knowledge. The daily collaboration project shows that improvement is not only possible, but changes can occur within a quarter of a year, as demonstrated by the improvement in the periodic assessment."*

Along with a sense of empowerment, the mentor teachers also found practical benefits to the daily collaboration. Isaac stated that this program reminded him of the importance of listening to his students, which has helped him develop in his ability to "respond and adapt to best fashion curriculum and pedagogy to their needs." Echoing those remarks, Howard stated, "It has also been very insightful to have a student teacher in my classroom. It reminds me how much I've grown in my seven years of teaching. It also allows me to watch another teacher's delivery of a lesson and the interactions with the students. I am able to see what areas I can improve on in my own practice by watching the student teachers."

One clear outcome is that the teachers developed powerful approaches to teaching algebra. The positive impact on student learning is likely a result of the responsive adaptations made to instruction on a daily basis. Responsive teaching is the key skill that teachers need to develop in order to be effective. Consistent patterns of discussions seem to emerge from the Responsive Teaching Cycle. As a result, teachers can map out the likely trajectories of student learning that occurs in a class. The responsiveness to student understanding may possibly even be able to compensate for less developed skills in delivery of instruction.

While establishing causality is not possible with non-experimental data, this study does suggest a potentially fruitful site for further investigation. Further research needs to be conducted to determine the nature and extent of the impact of this type of collaboration between mentor and student teachers. At the same time, it is important to understand the affordances and hinderances that might affect teachers' beliefs and practices. Finally, this study should help address some policy implications for student teacher preparation programs and for mentor teacher professional development.

Some implications of this study, however, are clear. First, educational settings can be structured to support teacher learning through the strategic placement of student teachers with mentor teachers in collaborative inquiry. Student teachers can learn valuable lessons in a situated apprenticeship environment that connects theory with practice. At the same time experienced teachers can experience powerful professional development as they mentor others.

Second, the SITTE collaborative inquiry structure can provide much needed intervention for students. When teachers focus on getting through to students rather than on getting through a book, powerful learning results. As Gabriel describes it:

> *"Nothing was set in stone, aside from the academic goals for the year. How we taught our lessons was a direct result of how the students did on the previous assignments and instruction. I love the fact that this program allowed us to once again be creative individuals in the classroom. I think our students appreciated it as well. One student said it best when he asked me, "Is this class supposed to be this easy?" Considering the difficulty of what he was referring to, I knew then and there that we were doing something right."*

Last, the SITTE structure can powerfully prepare student teachers. By working with colleagues and by having equal status with their mentors, the student teachers have developed a new identity. Debbie captures the sentiments of many student teachers who have participated in this collaborative process:

> *"I began this semester with no experience and a brain stuffed full of theory and ideas. I knew enough to be scared. Would I be able to become something new? Would the experience of student teaching somehow magically make me into a teacher? How much was this going to hurt? What would a classroom full of students be like? Would they listen? Would they learn? Would I fail them? The SITTE collaborative group of teachers (better known as the fourth period Algebra 1 gang) met daily to discuss student learning, the Algebra 1 standards, and how to bring the two of these together. I struggled to stand in front of all those staring faces and make the math make sense to them. I monitored their work and learned to look for their misconceptions. And we met again to plan and create our next move. The teaching, monitoring, planning, and designing began to fall into a pattern, a rhythm, a dance, a two way conversation with the students."*

She concludes, "I love how they are expecting math to make sense now and I love how they talk math to each other and are engaged in the process. … I have come to enjoy teaching. I am empowered to make curriculum that my students need rather than weakly wish for a better book. I am proud of what we have accomplished, proud to have been part of a noble effort."

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