EMPOWERING TEACHERS TO EXPERIENCE TRANSFORMATIVE AND GENERATIVE LEARNING THROUGH AUTHENTIC COLLABORATION DURING SUMMER SCHOOL/INTER-SESSION

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Abstract

In order for mathematics teachers to revise their teaching approaches from that of mere content delivery to teaching for understanding, they need professional development that will both *change* their beliefs and practices as well as *empower* them to continue developing their own knowledge for teaching. However, teachers often lack time and space to engage in the types of professional development that research finds to be most effective. This paper discusses the impact of using summer school/inter-session as a setting for connecting professional development that combines actual classroom teaching with daily collaborative lesson planning. In such a setting the teachers are not bound to the routines and constraints of a traditional semester. Thus, they have the time to plan activities and engage in thoughtful inquiry of their practice around their deepening knowledge of student thinking. Such an approach to professional development helps teachers construct their own learning through practical experiences. As a result, the teachers are able to collaborate daily to design lessons which foster student engagement in conceptual understanding of mathematics. This collaboration then becomes a source of transformative and generative learning for the teachers. And by focusing on where students' understanding intersect with misconceptions, the teachers are able to find success in their teaching as well as provide successful experiences for their students. After three small pilot studies, this approach was found to impact teacher beliefs and practices while substantially improving the pass rates of students enrolled in algebra classes.

Introduction

Algebra has long been considered a "gateway" course to advanced mathematics and a pathway to postsecondary opportunities (ACT, 2005; Wu, 2001; Silver, 1995). In 2000, successful completion of first year algebra became a high school graduation requirement in California. Similar requirements also exist in many districts across the nation. However, statistics from Los Angeles Unified School District (LAUSD) indicate that as many as two-thirds of the students in first year algebra receive Ds and Fs (Ai & White, 2003). Failure to pass algebra or an algebra based high school exit test has been identified as a key factor in the high attrition rates of urban high schools (Allensworth & Easton, 2005; Viadero, 2005). The *Los Angeles Times* quoted former Los LAUSD Superintendent Roy Romer in saying that failure in algebra "triggers dropouts more than any single subject" (Helfand, 2006, p. A14). As a result, algebra is increasingly becoming a barrier, rather than a gateway, for students in accessing the knowledge and skills necessary to compete in the global economy.

To address this problem, school districts and professional developers have invested extensive resources to improve teachers' content knowledge and/or their knowledge of teaching strategies. However, most of these efforts have had limited success because teachers *lacked the time* to engage in learning experiences that change beliefs and practices *and* impact student learning (Ball, 2002; Stigler & Hiebert, 1999; Darling-Hammond, 1999a). In fact, the literature suggests that while teachers' beliefs may influence their classroom practice, those beliefs are also shaped by their experiences *in the classroom* (Thompson, 1992). Thus, California State University Northridge (CSUN) and Los Angeles Unified School District (LAUSD) designed a new approach to professional development called Student Improvement Through Teacher Empowerment (SITTE). In this model, teachers participate in daily collaborative inquiry *while* teaching a summer school/inter-session class in algebra. As a result, the teachers are afforded the time that they need to re-think their instructional practices and to rehearse those practices in the context of actual classrooms.

Theoretical Framework

Four main bodies of literature formed the conceptual framework in developing the SITTE model of professional development. First, I analyzed the extensive research emphasizing the practice of teaching for understanding (Swafford, Jones, Thornton, Stump, & Miller, 1999; McLaughlin & Talbert, 1993; Mosenthal & Ball, 1992). Research on student learning suggests that an understanding of mathematics is more likely to occur when it is constructed by learners. However, facilitating students' own construction of knowledge often places teachers in the unfamiliar role of planning, organizing, and implementing learning experiences where students must connect ideas by exploring them, testing them, and verifying them in a social and cultural context (Hiebert & Carpenter, 1992). Rather than explain a comfortable set of rules, teachers must now help students see that "the problem is not the question and the answer is not the solution" (Lampert, 1990, p. 40). This means the teacher must guide students in discussions where the trajectory can be uncertain and unpredictable (Ball, 1996; Lampert, 1990). Such an approach to teaching often make teachers feel vulnerable and out of control (Smith, 1996). And 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).

Thus, a second aspect of my theoretical framework focused on the professional knowledge that teachers need in order to teach for understanding. Such literature highlight the need for teachers to posses a repertoire of pedagogical tools, as well as an awareness of how students think about mathematics. Even though teaching for understanding requires students to construct their knowledge, the specific pedagogical tools a teacher uses can vary from lecturing to cooperative explorations (Schoenfeld, 1992). Just as a dance instructor must do "some telling, some showing, and some doing it with them" (Lampert, 1990, p. 58), a teacher must know when to let students ponder over a difficult problem and when to do some selective telling (Ball, 1996; Smith, 1996). It is this ability to know *what to do* and *how to do it* that allows a teacher to help students learn mathematics. This is what Shulman (1987) refers to as "pedagogical content knowledge," which is essentially a "cognitive roadmap" to guide the lesson activities and the questions asked (Bransford, Brown, & Cocking, 2000, p. 155).

Furthermore, recent discussions around the "profound understanding of fundamental mathematics" (Ma, 1999) has led Deborah Ball and her colleagues at the University of Michigan to explore a more specific type of mathematical knowledge that *teachers* need (Ball, Hill, & Bass, 2005). In particular, this "mathematical knowledge for teaching" (MKT) represents a specialized knowledge of mathematical language, representations, and understanding of student thinking that goes beyond the knowledge of general pedagogical or mathematical skills. In studies exploring the relationship between the types of mathematical knowledge that teachers need and the achievement of their students, research suggest that an increase in MKT significantly predicts the size of student achievement gains (Hill, Rowan, & Ball, 2005). In short, teaching mathematics for understanding requires a specialized knowledge that goes beyond mere familiarity with mathematical algorithms.

Transformative and Generative Professional Development

The third aspect of my theoretical framework focused on the ideas of transformative and generative learning (Bransford, Brown, & Cocking, 2000; Franke, Carpenter, Levi, & Fennema, 2001). In this area of educational research, the literature suggests that traditional "sit and get" or "go and get" workshops, which typically focus on transmitting a set of skills to passive learners (Sparks, 2002; Koppich, 2001; Darling-Hammond, 1999) are not adequate in meeting the needs of current teachers (Sparks, 2002, 1994; Little, 1993). Despite research that indicates adult learners are self-directed and need learning experiences that allow *them* to construct knowledge (Knowles, 1990), professional development providers often seem to lack an understanding of how teachers learn (Lieberman, 1995). Thus, there seems to be great irony in that teachers themselves cannot access the very types of learning opportunities encouraged for their students—collaboration and building on prior knowledge to solve problems (Lieberman, 1995; Wilson, 1990; Cohen, 1990).

In contrast to the traditional "fill the empty vessel" model of many professional development workshops, researchers agree that the most effective types of professional development are *transformative* and *generative*. This means professional development must *change* teacher beliefs and practice as well as *enable* them to continue developing their professional knowledge. One way this occurs is through a socialization process that is not unlike the way that tailors in Liberia are apprenticed to become master tailors

(Lave & Wenger, 1991). Thus, professional development must provide teachers opportunities to discuss, reflect, and develop and try out their ideas in an atmosphere of collegiality that is closely connected to the teacher's own classroom context (Lieberman, 1995; Guskey, 1994). In other words, teachers need to be involved in "the *construction* and not mere *consumption* of subject matter teaching knowledge" in order for their learning to be transformative (Little, 1993, p. 135).

Transformative learning occurs when changes in beliefs and practices take place (Sparks, 2002, p. 2-1). Transformative learning is also described as "emancipatory" or "empowering" because it gives the learner freedom to make choices regarding his or her own learning experience (Cranton, 1994). However, transformative learning is a difficult and painful process because it often requires critical self-reflection. As the learner seeks to reconcile new ideas with past assumptions, there may be as much to unlearn as there is to learn (Ball, 1996; Cohen, 1990). Often, such a challenge to an individual's deeply held beliefs can result in the individual entrenching himself further in his prior beliefs and becoming hostile towards new ideas (Cranton, 1994). This common reaction to professional development efforts can often appear (and be misinterpreted) as teacher "resistance" (Fullan & Miles, 1992, p. 748). Thus, if professional development is to be transformative, teachers need a safe and secure environment in which they can re-examine their assumptions because learning often requires a radical change in attitudes and behaviors.

So, how does transformative learning take place? The first step is to recognize that it is a cognitive activity in which deeply embedded knowledge must be made visible (Schoenbach & Greenleaf, 2003). This means helping teachers become aware of their own understanding of how learning takes place and what their goals of instruction are. Only then can teachers be prepared to engage in the process of selecting appropriate teaching strategies, adapting instructional materials, and understanding students' thinking (Showers, Joyce, & Bennett, 1987). Such an approach to teacher learning, then, is *constructivist* because teachers develop knowledge based on their own contexts rather than receive knowledge from "experts" (Sparks, 1994). In other words, knowledge is transformed through the teachers' interaction with their students and the subject matter (Fennema & Franke, 1992).

Because current reforms in education often call for a constructivist approach to teaching, it is crucial for teachers to learn how to model appropriate behavior in guiding student learning rather than just telling (Sparks, 1994). Therefore, a second key step in transformative professional development is to help teachers "construct constructivism" (Mosenthal & Ball, 1992, p. 353). In other words, teachers need to experience the types of instruction that they are being asked to provide. By experiencing what their students might experience, teachers can gain insight into how their students think. Research also suggests that teachers must often experience a change in practice before they will change their beliefs (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003; Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996; Thompson, 1992). Again, this supports the idea that professional development that cannot merely focus on the acquisition of information, but the application of new knowledge and understandings.

At the heart of a constructivist approach to teacher professional development is teacher inquiry (Little, 1993), or "second order learning," which Cousins (1996) describes as "the search for and exploration of alternative routines, rules, technologies, goals, and purposes, rather than learning how to perform current routines more

efficiently" (p. 618). For example, it is this inquiry process that allowed teachers who participated in Content-Based Collaborative Inquiry (CBCI) professional development to "see themselves as constructors of their knowledge" (Zech, Gause-Vega, Bray, Secules, & Goldman, 2000, p. 214). Thus, the third step of professional development that is transformative is to shift from a content model to a process model, where the emphasis is no longer the transmission of content but the facilitation of inquiry-based learning (Knowles, 1990). This inquiry is what leads to generative learning.

Generative learning occurs when teachers develop new ideas based on the examination of practice beyond simply identifying what works and what does not work (Franke, Carpenter, Fennema, Ansell, & Behrend, 1998). Observing the effectiveness of a lesson or new technique is the first level of inquiry. But generative learning requires a second level of inquiry that involves analyzing why an activity works the way it does. When teachers reflect on their actions they can clarify their understanding of their own rationales and alternatives (Thompson, 1992). This is generative because it allows the teacher to apply existing knowledge to continually build new knowledge. At the same time, this knowledge is not a set of isolated skills or pieces of information. Rather, it is knowledge that is situated in the teachers' own classrooms and integrated and into an evolving structure of understanding (Franke, Carpenter, Levi, & Fennema, 2001; Fennema & Franke, 1992). Such knowledge influences the teachers' instructional decisions and serves as a basis for continuous improvement (Kilpatrick, Swafford, & Findell, 2001). This type of generative learning is what allows teachers to move from being novices to becoming experts (Bransford, Brown, & Cocking, 2000).

Expert teachers are distinguished by their ability to flexibly retrieve relevant information during interactive teaching. At the same time, experts can notice meaningful patterns not apparent to novices (Bransford, Brown, & Cocking, 2000; Fennema & Franke, 1992; Borko & Livingston, 1989). As a result, expert teachers can predict misconceptions and anticipate learning trajectories, which then allow them to improvise their lessons to maximize student learning (Borko & Livingston, 1989). Research suggests that paying attention to student learning allows the teacher to expand upon a continually developing network of relevant information. This is an iterative process because the more an expert understands a pattern of student learning, the more that she will notice in her students; and the more she notices, the more she can add to her knowledge structure. Generative professional development, then, allows teachers to add to their understanding and reorganize their knowledge to solve new and unfamiliar problems in teaching (Franke, Carpenter, Levi, & Fennema, 2001).

Knowledge About Effective Professional Development

The final aspect of my theoretical framework focuses on the current understanding of what constitutes effective professional development, including some underlying assumptions about learning pathways (Sparks & Loucks-Horsley, 1989; Showers, Joyce, & Bennett, 1987). In particular, I will highlight one particular model of professional development, Cognitively Guided Instruction, which has been found effective in promoting transformative and generative learning in teachers (Carpenter, Fennema, Franke, Levi, & Empson, 2000; Rhine, 1998). Finally, I will discuss several current studies in how the effectiveness of professional development could be measured (Cwikla, 2002; Porter, Garet, Desimone, Yoon, & Birman, 2000; Guskey, 2003, 1994).

Together, this body of literature serves as the foundations for the design of the SITTE professional development program.

There is widespread agreement that effective professional development should be focused on student learning (Guskey, 2003; Kennedy, 1999; Darling-Hammond, 1998) and connected to teachers' own classrooms (Rényi, 1998; Corcoran, 1995; Sparks & Loucks-Horsley, 1989). However, effective professional development must also address social factors such as teacher ownership, trust and relationship building (Marsh, et al, 2005). This then engages teachers as a community of learners (Cwikla, 2002; Koppich, 2001; Porter, Garet, Desimone, Yoon, & Birman, 2000; Lieberman, 1995). At the same time, professional development must also be teacher driven and allow for individualized learning trajectories while honoring teacher expertise (Ball, 1995; Corcoran, 1995; Sparks & Loucks-Horsley, 1989). Last, but not least, effective professional development must provide ongoing assistance in the form of resources and time (Peixotto & Fager, 1998; Rényi, 1996; American Federation of Teachers, 1995).

While there is general agreement on what constitutes effective professional development, methods for determining their effectiveness have had more variation. For example, in one recent study based on a national evaluation of the Eisenhower Professional Development Program, researchers focused on professional development's "structural features" (i.e., the form of the activity, the duration, and the degree of collective participation), and "core features" (the content focus, opportunities for active learning, and coherence with teachers' goals and alignment with state standards and assessments) (Garet, Porter, Desimone, Birman, & Yoon, 2001). The findings of this study indicated that teachers reported greater impact from sustained and intensive professional development. Also, they suggest that professional development that is closely related to the actual work of teachers is more likely to result in enhanced knowledge and skills. In addition, their data provided empirical evidence that collaboration and alignment of activities with teachers', schools', and districts' goals resulted in change in teaching practice (Garet, Porter, Desimone, Birman, & Yoon, 2001).

In another study, Cwikla (2002) analyzed four "mechanisms" of professional development that facilitated teacher learning. She found: (1) a focus on student thinking and learning facilitates teacher thinking and learning; (2) teacher collaboration influences instructional improvement; (3) small, steady changes create improved instruction; and (4) teachers' experimentation and inquiry serve to bring about instructional improvement. The impact of these four mechanisms should result in transformative and generative learning. In summary, programs which emphasize content and how students learn that content, rather than on what teachers should do in their classrooms, are the most effective in producing transformative and generative learning among teachers.

Ultimately, however, the effectiveness of professional development must consider the relationship between teacher activities and student learning (Guskey & Sparks, 1996). It is not enough to just measure content characteristics (the "what" of staff development), process features (the "how" of staff development), and context characteristics (the "who," "when," "where" and "why" of staff development). The impact of changes in practice on student learning must also be examined. Using formative and summative assessments, Guskey (2002) suggests evaluating professional development at five levels of increasing complexity. These levels serve as benchmarks as well as a framework for designing effective professional development.

At level 1, participants' reactions are examined while Level 2 evaluates participants' learning of specific knowledge or skills. Level 3 examines organizational support and change by determining the alignment of the activity to district goals and the sufficiency of resources to support the professional development goals. Level 4 evaluation seeks to determine participants' use of new knowledge and skills and whether or not those skills affect their practice. Finally, Level 5 evaluation is based on student learning outcomes. Since improved student outcomes is the ultimate goal of professional development, it should be a major factor in determining the effectiveness of a professional development activity.

Remarkably, a meta-analysis of 93 studies of professional development found only ten studies that indicated evidence of benefit to students (Kennedy, 1999). By grouping the various professional development programs into four categories, the study suggests that the most effective programs are those that provide a greater understanding of how students learn and provide opportunities for teachers to develop and refine their own practices. This meta-analysis points out Cognitively Guided Instruction (CGI) as one particular professional development activity that creates the greatest change in teacher beliefs and practices.

The key feature of this CGI is that it provides the environment that focuses on student learning. As teachers engage in inquiry of their students' understanding of mathematics, they build upon that knowledge to adapt their instructional practices. In other words, the teachers engage in a systematic examination of (1) general knowledge about student thinking, and (2) practical knowledge of their classroom practice (Franke, Carpenter, Fennema, Ansell, & Behrend, 1998). Thus, the hallmark of CGI is that it shifts the role of the teacher from being a dispenser of knowledge to being action researchers in their own classrooms (Rhine, 1998). As teachers notice their students responding to difficult problems, they begin to alter their expectations for themselves and for their students. This brings about an iterative change in the teachers' knowledge, beliefs, and practices. The more they see their students performing, the more challenging they make the tasks, which then allows the students to demonstrate even more ability, and so on (Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996). While some teachers changed their beliefs before their practice, others changed their beliefs as a result of changing practice first. Further, the shifts were widespread and enduring.

Models of professional development such as CGI create the social environment conducive to collaborative inquiry (Swafford, Jones, Thornton, Stump, & Miller, 1999; Cranton, 1994). As professional development shifts its emphasis from implementation of programs to generation of new knowledge, schools and districts need to create opportunities for teachers to learn and experiment (Ball, 1996; Little, 1993). Most important, professional development must provide time—the "intellectual space"— to think and reflect on classroom experiences (Wilson, Miller, & Yerkes, 1993, p. 92). Such models of "practitioner-based collaborative action inquiry" (Yorks, 2005, p. 1217 or 1218) represent a relatively new area of discussion in professional development.

The SITTE Model of Professional Development

Even though substantial research exists to suggest that generative change in teacher beliefs and practices requires a social environment that allows teachers to think,

discuss, experiment, and reflect (Swafford, Jones, Thornton, Stump, & Miller, 1999; Chapin, 1994; Little, 1993), the current structure of most American schools do not afford teachers the time that they need in order to engage in such learning experiences (Ball, 2002, Darling-Hammond, 1999). Further, the tendency of American schools to emphasize action often inhibits the creation of space for reflection (Yorks, 2005). As a result, the existing structure and culture of schools can actually thwart the professional growth of teachers (Elmore, 2002; Stigler & Hiebert, 1999; Lieberman, 1995).

Based on this current problem in American schools and a conceptual framework organized around research on student learning and extensive literature on how teachers learn and grow (Little, 1993; Sparks, 1994; Knowles, 1990), the Student Empowerment Through Teacher Empowerment (SITTE) model was designed specifically to provide teachers the social space in which they are afforded the opportunity to experience transformative and generative learning. One setting which can provide teachers the time they need in order to engage in reflection and inquiry *while they are actually teaching* is the traditional summer school or inter-session (Denton, 2002). During this time, teachers and students are not bound to the routines and constraints of the traditional semester. Typically, teachers have only one or two classes per day, similar to the regular schedule of teachers in Japan (Stigler & Hiebert, 1999; Darling-Hammond, 1996). With fewer classes to teach (and a smaller student load), teachers have more time to analyze their students' work. Stevenson and Stigler (1992) suggest that freeing teachers from the time demands of the traditional school day would give teachers the time to plan activities and reflect on their teaching. Thus, SITTE is structured around the teachers' own summer school (or inter-session) classes as the learning environment in which they could conduct "practical inquiry" (Franke, Carpenter, Fennema, Ansell, & Behrend, 1998) as well as apply their own professional knowledge (see Figure 1).

While this model may bear some resemblance to a Japanese lesson study (Lewis, Perry, & Murata, 2006; Stigler & Hiebert, 1999), it differs significantly in that the SITTE process focuses on *daily* collaborative lesson planning around immediate analyses of *student thinking* rather than on polishing a particular lesson over some extended time (Curcio, 2002; Stigler & Stevenson, 1991). Further, SITTE provides a practical way to help teachers *develop a new identity* of being innovative problem solvers as they address the learning needs of their students. This distinction from lesson study was based on the belief that transformative learning is fundamentally an "experience of identity" (Wenger, 1998, p. 215) in that "identity drives perception, choice, and behavior" (Costa & Garmston, 2002a, p. 70).

Further, the literature suggests that job-embedded professional development is one of the most effective methods of changing teacher practice and improving student learning (Franke, Carpenter, Levi, & Fennema, 2001; Kennedy, 1999; Rényi, 1998, 1996). Thus, the SITTE model utilized the teaching of a summer school/inter-session class as the context in which teachers could reflect on their own teaching. At daily meetings, an instructional coach facilitated a discussion to engage teachers in a "Plan-Do-Check-Act" cycle of inquiry (Wilms, 2003) around their evolving knowledge of student thinking (see Figure 2). Together, they examined student learning and student misconceptions and then explored possible ways to teach the next day. They also rehearsed and experimented with new ideas for teaching, first in the meeting and later in their classes. Finally, they revised their lessons, refined them, and established their

repertoire of strategies. In this manner, the teachers were afforded the opportunity to develop their mathematical knowledge for teaching, within the context of an actual classroom.

Figure 1. List of features for the SITTE model of professional development

Overview of the SITTE model for professional development:

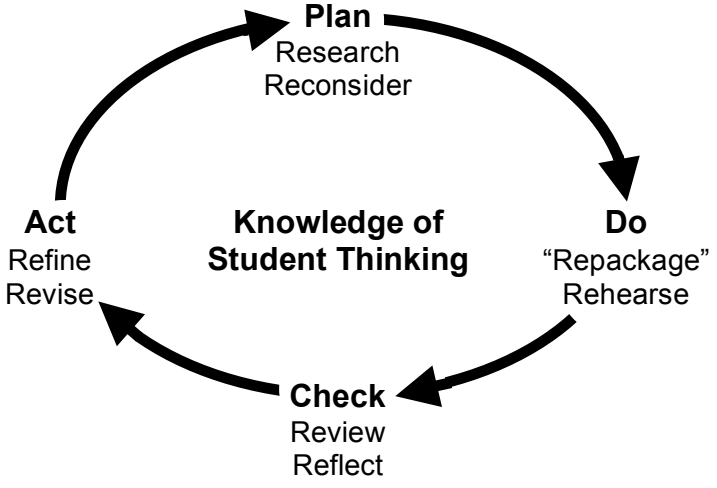
Key principles:
- Professional learning situated in the context of teaching during summer school (or inter-session)
- Teachers collaborate to find ways to help *their* own students succeed in a clearly defined time frame with clearly defined goals
- Leverages teachers' knowledge as the starting point for creating solutions to *their* own problems
- Provides tools and resources without mandating strategies or curricula

Key processes:
- Plan-Do-Act-Check cycle of inquiry around an increasing awareness of student thinking
- Teachers explore, experiment, examine, and establish new strategies to "get through to students, rather than get through a book"

Key practices:
- Professional growth in four areas of teaching: *Planning*, *Implementing*, *Communicating*, and *Assessing*
- Teachers help students make sense of mathematics by organizing information to bring out patterns, using multiple representations, contextualizing abstract concepts, and connecting new concepts to students' previous knowledge

Other features:
- Aligned to district instructional guidance systems
- Teachers compensated for planning and teaching
- Collaboration facilitated by instructional coaches

Figure 2. Plan-Do-Check-Act cycle of inquiry



One additional feature of the SITTE process is that it incorporated the key principles of the Cognitively Guided Instruction (CGI) model, in which teachers rehearse new strategies and reflect on their own practices based on careful examinations of student thinking (Franke, Carpenter, Levi, & Fennema, 2001; Carpenter, Fennema, Franke, Levi, & Empson, 2000; Carpenter, Fennema, & Franke, 1996). In applying the principles of CGI, SITTE helped teachers examine the effectiveness of various teaching strategies based on data gathered from their own daily teaching in order to make further decisions about instruction. Research suggests that such an approach is generative, in that it allows teachers to experience ongoing improvement through analysis and reflection of practice (Kilpatrick, Swafford, & Findell, Eds., 2001).

The focus on student thinking meant that everything the teachers did in SITTE—planning lessons, implementing mathematical tasks, communicating during instruction, and assessing student learning—was informed by and informed an increasing understanding of student thinking. As a result, teachers were able to generate powerful guiding principles for their own teaching practice, such as using multiple representations or using patterns to help students make conjectures and generalize key concepts. Further, findings from three pilot studies suggest that SITTE helped teachers develop their skills in asking effective questions, i.e., those that seek more than just the correct answer. This then led them to become attentive, expectant, and responsive to possible trajectories of student thinking. In the process, the teachers developed flexibility and resourcefulness in adapting their lessons or in adjusting their teaching approaches.

The SITTE approach suggests a distinctly different, yet replicable model for effective professional development. With SITTE, learning comes from improvised practice rather than from a mandated agenda (Lave & Wenger, 1991). Because teachers see themselves as partners in the learning process, they become more willing to consider trying new strategies. As a result, SITTE empowers teachers to *get through to their students rather than just getting through a curriculum.* This, in turn, leads the teachers experience success with students and gives them the confidence to take additional risks in trying new teaching methods (Loucks-Horsley et al., 2003).

Designing SITTE

In its three implementations, SITTE occurred as part of an intensive, six-week long action research project where teachers engaged in reflective inquiry around their students' thinking. It began with two days of initial planning, followed by daily two-hour meetings during the entire six-week inter-session. Before the professional development activities were actually designed, I first met with district coordinators responsible for mathematics professional development to establish some goals and intended outcomes of the professional development activity. At this time, the roles and responsibilities of the participants and the roles that the district math coaches as well as their level of participation were clarified. For the first two implementations of SITTE, the math coaches from the host school participated informally in many of the daily discussions. In the third implementation of SITTE, two different district coaches joined the teachers each week as observer participants.

Next, district math coaches, district and school site administrators, and I coordinated operational matters such as incentives for teacher participation (e.g., overtime pay) and the necessary arrangements for the scheduling and staffing of inter-

session classes. With that in place, teachers were recruited to participate during math department meetings at each of the participating schools. At these meetings, it was emphasized that the school's high failure rate in algebra was a problem with student understanding rather than with teachers teaching poorly. Thus, the message communicated was that SITTE was *not* an effort to "develop" the teachers or of "fix" their teaching. Rather, it was a means to leverage their knowledge and experience to create solutions for raising student achievement. As a result, teachers perceived the summer school program as one in which their assistance was sought, rather than an effort to improve them. This approach was vital in gaining the trust and support of the teachers.

For the first implementation of SITTE, I met with the school's math coaches to consider the content of the professional development. Various types of activities were discussed, and exemplary curricula and other off-the-shelf materials were considered for supplemental resources for the teachers. For the actual professional development, agendas were then developed for the first two days of teacher planning along with specific activities that would be used to help focus the discussions on principles of effective inquiry based teaching. In particular, teachers were challenged to consider three things: (1) the benefits of organizing content so that students recognize and use patterns and themes; (2) the advantages of using collaborative inquiry in solving problems; and (3) the depth of mathematics that could be addressed through the examination of alternative methods and the connections between those methods. Finally, summaries of research were provided to teachers as tools for guiding further discussions during SITTE.

One final detail that proved to be essential was providing stationary supplies as well as refreshments each day. This included everything from white board markers to coffee and bottled water. Having all of these items sent a strong message to the teachers that they were valued as professionals. At the same time, the snacks provided much needed energy to process all the "food for thought" that they had to digest.

Implementing SITTE

Initial planning. Before actually teaching summer school school/inter-session the teachers met for a two-day planning meeting that began with a discussion about the teachers' concerns and expectations. Immediately, they began complaining about the academic quality of the students in the classes they were about to teach. Specifically, they identified students' lack of basic skills, students' lack of confidence and motivation, students' weakness in retaining learning, students' poor attendance and work habits, students' inability to monitor their own learning, and the need to provide a fun experience for students in order to motivate them. The teachers felt it was important to generate this list of concerns as the starting point for their discussions in finding ways to help their students become successful in algebra.

The next task was to plan out the scope and sequence of the course they were about to teach. Even though some teachers brought their old semester plans, they were encouraged to carefully reexamine the district's pacing plan and state standards. The discussions around what students really needed to learn soon brought to the teachers two important realizations: (1) the traditional approach of teaching section by section through a textbook was simply not feasible, given the time constraints of inter-session, and (2) the large number of discrete topics and skills found in a traditional textbook could be organized into thematic units that would allow teachers to teach conceptually rather than

simply cover content as a collection of discrete topics. This then required the teachers to begin thinking differently about how they would go about teaching algebra during SITTE.

To help them think differently about their approach to teaching their inter-session class, the teachers were provided three activities that allowed them to *experience* some of the teaching approaches that the were consistent with the principles of teaching for understanding. Together, these activities served to illustrate the power of using patterns to develop generalizations, and the importance of organizing concepts in order to make sense of the big ideas. More important, the activities helped the teachers recognize that working as a team provided them additional insights and solution paths. In short, the teachers were able to experience what they were being asked to provide for their students.

Following these activities, the teachers then began the task of designing actual lessons for their algebra classes. At this point the teachers had only identified some of the non-cognitive factors that affected student learning. This was evident in their initial lesson designs. For example, the teachers considered spending a significant amount of time reviewing basic skills as a prerequisite for doing algebra. They all agreed that this was necessary because the students lacked basic skills. However, the reality of time constraints once again forced the teachers to reconsider. As a result, they agreed to embed basic skills into daily warm ups rather than spend two weeks focusing on them. At the same time, the teachers began to take a new look at how they could teach algebra to students who did not have basic skills. This ultimately proved to be a significant step in moving toward designing mathematical tasks based on student thinking.

Daily meetings. Following the two initial half-day planning meetings, the professional development consisted of daily two-hour meetings that took place after the teachers taught their inter-session classes. Since the primary focus of the professional development activities was on building the teachers' knowledge of their students' thinking, as well as knowledge of content and pedagogy, they were provided summaries of research findings to help them identify patterns of misconceptions in their own students' work, as well as frameworks analyzing the types of tasks they implemented and frameworks of problem types. The process of the professional development that followed was essentially a "Plan-Do-Act-Check" cycle (see Figure 2) that revolved around the teachers' increasing knowledge of student thinking, content, and pedagogy. Each day the teachers gathered after teaching their morning class to review what had just happened in their classes. Then they researched and explored possible ways to teach the next day. Next, they rehearsed and experimented with new ideas for lessons, first in the meeting and later in their classes. Following that, the teachers again examined and reflected on what had taken place in their classes. Finally, they revised the lesson they taught, refined it for the subsequent lessons, and established their expanding repertoire of strategies and activities. .

Researching/exploring. One of the most important activities that the teachers engaged in was to research and explore ways to bridge the students' existing knowledge of arithmetic with the abstract concepts of algebra. They were assisted in this process with a variety of publications and instructional resources that served as "eye openers" and idea generators. Further, the teachers were encouraged to bring and share their own teaching materials and strategies. With this collection of resources, the teachers were able to design mathematical tasks that promoted conceptual understanding of algebra.

The emphasis of SITTE, however, was developing teaching strategies around how student thought about mathematics, rather than providing handouts and add-on activities (Franke, Carpenter, Fennema, Ansell, & Behrend, 1998). Thus, the resources provided served primarily as "eye-openers" to help the teachers think differently about how a concept might be represented or taught.

Rehearsing/experimenting. While the resources helped to "spark" the teachers' creativity in designing their own lessons, a second key element of the teachers' daily work was to experiment with new teaching practices, both by rehearsing them in planning meetings as well as in their inter-session classes. In this way, the they were able to learn how to generate their own solutions. Thus, the curriculum for the professional development actually *evolved* as the teachers gradually began to formulate guiding principles by which they designed their inquiry based lessons. Research on CGI indicates that its effectiveness was due, in part, to the fact that no instructional materials or specific instructional techniques were specified (Franke, Carpenter, Levi, & Fennema, 2001; Kennedy, 1999; Rhine, 1998). And in fact, this strategy was also one of the most essential features of the SITTE professional development approach.

Reflecting/examining. As a logical extension of the daily discussions around student thinking and understanding, the teachers also examined their practices and explored what worked and what did not work in their classes. In particular, the teachers were pushed to recognize *why* something worked or did not work through the use of reflective conversations and analysis of student work samples (Costa & Garmston, 2002a, 2002b). This daily activity allowed student thinking to inform the design of subsequent lessons. Further, these periods of reflection allowed the teaches to gain new understandings about their students' capabilities, which then impacted the teachers' attitudes and approaches.

For example, after the first day, the teachers were surprised by how engaged the students were during the lesson. They were also surprised by how much more work the students in SITTE produced than what they were used to seeing in their regular classes. This led to a discussion about why the students seemed more engaged. While the comments were subjective, it was significant that the teachers were beginning to pay attention to what their students were doing and to make inferences about how their lesson design affected the behavior of the students.

In using their understanding of student thinking to inform their decision making, the teachers began to discuss and consider various alternative approaches, rather than just do what they had always done in the past. They discussed how they improvised on the spot to make the concept more comprehensible. Improvising lessons was nothing new to teachers. However, what was new for the them was that they were now analyzing their improvisations and considering the benefits and impact of their decisions.

Refining/establishing. As the teachers engaged in the daily cycle of inquiry, they began to display confidence in their own abilities to design and implement new lessons. Further, they demonstrated a willingness to try teaching strategies that were new to them. As a result, they began to establish a pattern of instruction which emphasized student collaboration and inquiry-based lessons, rather than the typical focus on classroom management and basic skills. The emerging pattern of instruction included (1) planning the lessons based on the students' learning needs; (2) developing and implementing worthwhile tasks; (3) engaging students in learning through collaboration; and (4)

assessing students for understanding beyond just getting the correct answer. These four elements then served as a framework for analyzing the teaching practices of the teachers.

In refining the teachers' practices, one major emphasis of SITTE was to help teachers utilize assessments that would unveil student understanding (Manouchehri & Lapp, 2003). Initially, the assessments consisted of the typical checking for correct answers to computation problems. However, the coaching conversations pressed the teachers to gather information about what their students knew or did not know. This forced them to begin paying attention to what their students were saying, which then led them to make changes in their assessment strategies. As the teachers began to think more deeply about their assessment strategies, both formal and informal, they began to gain insights into their students' conceptions and misconceptions of algebra, which then helped them prepare for possible learning trajectories. Thus, one important activity of SITTE was for teachers to work together in developing the actual questions that would help them assess for understanding. As a result, the teachers began to establish the practice of (1) using their students' existing knowledge to make the content make sense; (2) organizing information to bring out patterns that could help students generalize; (3) contextualizing abstract concepts using familiar situations; and (4) connecting concepts through multiple representations.

Pilot Studies of the SITTE Model

Little empirical research currently exists on the use of summer school/inter-session classes as the setting for teacher professional development. Nor is much known about how such a setting affects the beliefs and practices of secondary mathematics teachers, and how those beliefs and practices might affect student learning. The SITTE model of professional development offers an ideal opportunity for gathering and examining empirical data for practitioner-based collaborative action research. Specifically, I focused on the knowledge development of teachers because "ultimately, how a teacher behaves and the potential effectiveness of a teacher rests on the knowledge that a teacher possesses" (Fennema & Franke, 1992, p. 156). Thus, three key research questions were considered:

1. How does SITTE affect the knowledge of teachers who participate in SITTE (particularly in their design of instruction)?
2. How does SITTE affect participating teachers' perceptions, plans, and practices?
3. How does SITTE affect the performance of students in the classes of participating teachers?

Study Design

The data for this study were collected from three separate implementations of the SITTE professional development at two high schools (pop. 4,616 and 2,603, respectively) in Los Angeles Unified School District (LAUSD). The number of teachers participating in each implementation was small (N = 4, N = 3, N = 3). The ten teachers who volunteered ranged in experience from less than two years to over 30 years. Four had master's degrees and another four had just recently earned their preliminary teaching credentials. Even though they varied in their teaching experience, all had a history of using lecture as a primary method of instruction, with the two oldest teachers using lecture exclusively. At the same time, only three had ever used student groups at all. All

ten teachers expressed frustration with their students' lack of motivation and success, citing the lack of basic skills as the primary cause of student failure. However, these teachers all volunteered to participate because they all expressed an interest in finding new ways to help their students succeed.

Because the sample size of the teachers was small, it is important to note that the this study represents a "local proof" approach (Lewis, Perry, & Murata, 2006), rather than a randomized controlled experiment. This study primarily sought descriptive knowledge of how SITTE affects teacher practice and student achievement, as well as how it affords opportunities for collaborative inquiry. While the findings could not be generalized beyond the sample that was studied, the effects on the participants themselves cannot be diminished. Thus, there are some important lessons that can be learned as empirical data is added to the knowledge base of how such a model of professional development affects teachers and students.

Qualitative and quantitative data were collected during each professional development, as well as during four weeks of classroom observations in the regular classes of the participants following the first implementation of SITTE. The data that was collected were essentially descriptive in nature. At the same time, I recognized that the data was not readily quantifiable and the analyses would be highly interpretive. Even so, the risk of drawing invalid conclusions was less serious than trivializing the study into quantifiable research questions (Maxwell, 1996). Thus, this study was addressed primarily from a qualitative perspective.

However, some quantitative data was also used to confirm the teachers' observations and comments, particularly in the way they evaluated their students. In doing so, the study became a mixed methods approach using a "concurrent nested strategy" (Creswell, 2003, p. 218). In such a nested approach, the qualitative method served as the primary strategy in gathering data. However, even though the qualitative approach was predominant, some of the quantitative data served to support the qualitative data. For example, pre- and post-test scores were used to determine changes in student achievement. The main advantage of using this nested approach was that it allowed me to address two related questions, namely, how the professional development affected teacher beliefs and practices and how those changes in beliefs and practices impacted the way that teachers looked at their students' achievement.

Credibility and validity. This study was limited by the constraints and influences of the context in which the teachers worked. As a result, my findings were particularly sensitive to specific environmental factors such as the learning culture of the school and the "chemistry" of each team of teachers. Further, the six week timeframe of the professional development might be considered by some as too short to effect any real change. However, longer study durations may actually mask the real effects of the professional development because of changes in staff, class populations, and other unforeseen factors (Kennedy, 1999). In fact, a limited study that examined practices immediately after the inter-session professional development yielded valuable information that might have become obscured over longer periods of time. Feelings and attitudes, in particular, were especially susceptible to contamination over time. A short, but intensive study period, then, helped to minimize such contamination.

The greatest threat to validity would have most likely come from the human factor rather than from the research design methods. As the principal researcher of

SITTE, I was also a former teacher and math coach at one of the schools used in the study. Thus, I had an established working relationship with most of the teachers who volunteered to participate in the study. While such an established trusting relationship is one of the keys to success in a professional development process such as CGI (Lockwood, 1998), it may also subconsciously cause the participants to help get "good results." At the same time, they may have been uncomfortable expressing thoughts that they feared may be what I did not want to hear. However, this issue of reactivity was overcome by using anonymous surveys of teachers; and their established trust with me likely promoted openness and honesty in the responses.

Another human factor that might have posed a threat to validity was my own personal biases. Because I occupied simultaneously the role of a participant as well as that of a researcher, findings based on my observations alone were triangulated with the teachers' own words to guide the conclusions. However, to avoid possible false conclusions based on isolated comments, *all* of the tapes from the first implementation of SITTE were transcribed to get a fuller picture, *over time*, of how the teachers really felt, why they might have felt that way, how those feelings translated into actual practice.

Data Collection and Analysis

During the implementation stage of the professional development data was collected through surveys, observations, taped discussions, and interviews. Thus, one important task in this project was developing the tools with which the teachers' beliefs and practices could be analyzed. To do this, I prepared assessments to gain insight into the teachers' knowledge and frameworks for analyzing the nature of classroom practices. Further, a template for recording observations as well as a schedule for observing the teachers were developed.

Data collection occurred during each summer school/inter-session and for four weeks in the semester following the first inter-session. The data collected were drawn from (1) *surveys of teacher attitudes and knowledge*, (2) *observation notes* of teachers in their classes as well as in the daily discussions during SITTE, (3) *taped recordings of daily discussions* during SITTE, (4) *written reflections from the teachers* during inter-session, (5) *observation notes* from the teachers' classes after SITTE, (6) *interviews* with the teachers about their attitudes and instructional choices after SITTE, and (7) *aggregate student performance data* in the form of pre- and post-tests as well as comparisons with grades of students from previous semesters or inter-sessions. These data sources were analyzed and filtered in six stages, each with increasing depth and insight. First, I listened to the taped conversations and made notes on the nature of those comments. Then I reviewed my notes and analyzed the survey results for thematic patterns. Next, I transcribed all the taped conversations, and created initial broad categories for possible patterns and themes. Fourth, I studied the transcripts and established the specific categories used for coding. After coding, I grouped the data into thematic categories. Finally, I compared the different data sources to confirm our analysis.

(1) <u>Surveys of teacher attitudes and knowledge</u>. A researcher designed *Teacher Attitude Questionnaire* was used before and after the professional development to survey the teachers' attitudes about various pedagogical practices (Cheng, 2005). At the same time, thirteen dimensions of teaching expertise from a National Board study (Teachers With National Board Certification Outperform Others in 11 of 13 Areas, 2000;

Blair, 2000) was modified into a *Teaching Expertise Questionnaire* to determine the teachers' perception of their own expertise. Changes in the Likert scale responses from the *Teacher Attitude Questionnaire* and the *Teaching Expertise Questionnaire* were observed and noted, particularly for patterns across the three implementations.

Further, items adapted from Mathematics Achievement Partnership (2002) and from Biagetti (1999) were used to assess teachers' knowledge of students' understanding of mathematics. This *Survey of Content Knowledge* (Cheng, 2005) was also administered at the beginning and at the end of each implementation of the SITTE professional development. Results were then compared to determine how the teachers' knowledge was affected. In particular, I wanted to see if the teachers were able to provide additional solutions and additional reasons why students might make an error. Thus, I chose to use items that allowed multiple solution paths and offered the potential for revealing some of the common student errors identified in the literature. For example, the first five items allowed me to see if, in fact, teachers were able to generate new ways of solving the problem beyond the traditional algorithm. This provided insight into how well the teachers could anticipate how their students might solve such problems. The remaining ten items specifically asked the teachers to provide possible reasons why a student may have answered incorrectly. Such an analysis of error allowed me to determine the depth of the teachers' knowledge of common errors made by students.

(2) <u>Observations of teachers during SITTE</u>. During the SITTE professional development, I noted my observations of the participants in their inter-session classes as well as during the professional development meetings. I used a framework of teaching practices to examine four specific aspects of instructional practice: (1) the basis for instructional decisions during lesson planning; (2) the nature of the mathematical tasks implemented; (3) the means of communication during instruction; and (4) the focus of questions and assessments. This framework allowed me to examine changes in their teaching patterns as well as potential changes in their attitudes about non-traditional teaching strategies. For example, did the teachers design tasks that focused on procedures or on inquiry and connections? Did they promote collaborative teamwork or rely on lecture alone? Did they assess for right answers or for student reasoning?

(3) <u>Taped recordings of daily discussions</u>. Each day I recorded the conversations from the professional development meetings. The conversations included discussions on the implementation of a lesson as well as the typical concerns of a classroom teacher, such as taking attendance and dealing with classroom management. Further, the conversations involved the planning of lessons and the analysis of student work. These tapes were later transcribed and analyzed. In particular, I used these transcripts to understand their thoughts, feelings, intentions, and reasons for their instructional decisions, as well as their awareness of student errors and the cognitive demands of tasks (Smith & Stein, 1998; Stein & Smith, 1998; Stein, Smith, Henningsen, & Silver, 2000). The tapes, over time, also allowed me to detect changes in tone and attitude, both in terms of their comments about students and remarks about mathematics. Thus, the conversations revealed the evolution of the teachers' beliefs about their students, themselves, and the nature of the mathematics that they were teaching.

(4) <u>Written reflections from teachers</u>. Throughout the inter-session, the teachers also recorded their thoughts in a journal. This activity served to focus the discussions by having the teachers reflect individually before sharing. They also allowed

the teachers to formulate their own opinions before hearing—and possibly being influenced by—the thoughts of others. Thus, the journal entries provided an accurate gauge of the teachers' true thoughts and intentions, as well as a means for verifying their recorded comments.

(5) Observations of teachers after SITTE. During the second phase of the first implementation of SITTE, I also observed the teachers in their regular classes to explore *how* the teachers were actually changing in their practice. Guided by my framework based on four key aspects of teaching (i.e., planning, implementing, communicating, assessing), I recorded my observations using a researcher-developed observation template. The observation notes allowed me to identify the nature of their classroom interactions and of the mathematical tasks they implemented. I observed each teacher once a week in their regular classroom for four consecutive weeks in the semester following SITTE. In particular, I looked to see whether the teachers employed the inquiry based teaching strategies that they practiced during SITTE and how they were determining what their students were thinking.

(6) Interviews with teachers after SITTE. Following the first implementation of SITTE, I also conducted weekly interviews to help the teachers reflect on their lessons in order to understand their instructional choices. These semi-structured interviews were conducted in a manner similar to cognitive coaching conversations, in which the respondents analyzed their own actions (Costa & Garmston, 2002a, 2002b). For example, I probed teachers on their decision making processes in how they designed their lessons and in their choices of instructional strategies. This helped me capture the elements of the professional development that were most influential in effecting changes in the teachers' practices. Further, these reflective conversations helped the teachers continue the generative process initiated during the SITTE.

(7) Student performance data. To confirm the teachers' perceptions of how their students performed, I also collected data in the form of student grades and test scores. First, I compared the SITTE students' aggregated grades with grades from classes in previous semesters and inter-sessions where the students had also failed their first semester of algebra. I recognized that, even though grades lacked a certain degree of objectivity and validity, they were still useful in determining how the teachers' changing perceptions might have impacted their students' achievement. In other words, grades provided some insight on how SITTE might have affected the teachers' beliefs and practices as well as an opportunity for them to examine their own effectiveness.

The district's own periodic assessments were also used to compare the achievement of the students before and after inter-session. I chose this assessment because it was specific to the content that was being taught during the inter-session. This assessment consisted of multiple choice items and one constructed response item. Historically, students rarely even attempted the constructed response item. Thus, it was also important for me to analyze *how* students treated this item, which would provide a finer grained analysis than simply comparing the total scores. Additionally, for the first implementation of SITTE, the CSU/UC Mathematics Diagnostic Testing Project (MDTP) was used as a pre- and post-test to provide additional data on how inter-session might have affected students' general algebraic skills. This instrument was selected because it was already part of the school's existing diagnostic practice.

Findings

According to Costa and Garmston (2002a), there are five states of mind which describe teachers' attitudes and actions: *consciousness*, *craftsmanship*, *flexibility*, *efficacy*, and *interdependence*. Taken together, these five states can be considered as "diagnostic constructs" (p. 143) which are useful in analyzing teachers' decision making and their teaching practices. I used these states of mind as a framework for analyzing the data, and for discussing the impact of SITTE on teachers.

The Impact of SITTE on Teacher Knowledge

The impact of SITTE on teachers' knowledge could be discussed in terms of two important states of mind: *consciousness* and *craftsmanship*. Surveys, transcripts, observations, and interviews provided evidence that the teachers exhibited increased levels of consciousness and craftsmanship in their teaching. For example, all ten teachers indicated in the surveys that they either had a high level or an increased level of using their own knowledge to help students connect to prior learning, as well as a high or increased level using their knowledge to plan instruction. The teachers also indicated that they increased in their understanding and use of students' verbal and nonverbal responses to prioritize instruction as well as an increase in the practice of generating hypotheses and reassessing instructional options. Finally, the teachers indicated an increased use of student discussions to and stronger agreement with the statement, "I learn a lot from listening to students." More specifically, the impact of SITTE on teacher knowledge was evidenced by an increasing awareness of students' mathematical understanding as well as an increasing application of that knowledge in designing lessons and in evaluating their own practice.

<u>*Consciousness*: Awareness of Student Thinking</u>

The teachers' increased awareness of student thinking could be organized into five specific categories: (1) *acquaintance* with solutions methods beyond the standard algorithm; (2) *watchfulness* of student misconceptions; (3) *attentiveness* to student attitudes; (4) *responsiveness* to student reasoning, and (5) *expectation* of trajectories in student thinking and problem solving.

(1) <u>Acquaintance with solutions</u>. One place where the teachers demonstrated their knowledge of solutions was in the *Survey of Content Knowledge* which I adapted from Mathematics Achievement Partnership (2002) and from Biagetti (1999). In comparing the results from their initial responses with those from the conclusion of SITTE, all ten teachers were able to provide additional solution methods for some problems. For example, there was an increased use of graphical approaches in solving the problems. In fact, some teachers were even able to provide novel solutions in their final inventory that were not typically found in standard textbooks or college courses. Though not all teachers generated new solutions for all problems in the inventory, one particular exception stood out.

In the initial survey where the teachers were asked to provide as many solution methods as possible (e.g., solve the equation $4x + 9 = 6x + 1$), all ten teachers provided the standard algorithm initially. For example, for the equation $4x + 9 = 6x + 1$ (1)

they would first subtract $2x$ from both sides of the equation→ $9 = 2x + 1$ (2)

and then subtract 1 from both sides of the equation→ $8 = 2x$ (3)

and then divide both sides of the equation by 2→ $4 = x$ (4)

One teacher, a 30 year veteran, provided only this one method for solving the equation. Other teachers provided "alternative" methods simply by simply interchanging some steps such as subtracting 1 from both sides of the equation (1) before subtracting $2x$ from both sides. Three teachers provided alternate methods by expressing the equations using non-standard symbols, such as using rectangles for x or tally marks for the constants. In all of these cases, the teachers regarded these superficial differences as alternate solution methods.

Six weeks later, after intensive daily discussions around student thinking, the teachers were able to provide a genuine alternative method for solving the same equation. In fact, several teachers also provided a solution for the equation by using their own invented method called "double cover up." This method was actually developed by one participant, a new teacher, based on the notion that the variable can be considered an unknown number (Kieran & Chalouh, 1993). Thus, for the same equation as above,

$$4x + 9 = 6x + 1 \quad (1)$$

they "covered up" the variable terms to create an *inequality*→ $\square + 9 \neq \square + 1$ (2)

and found a *number* that would turn (2) into an equation→ $\square + 9 = \square + 1 + \underline{\mathbf{8}}$ (3)

Next, they covered up the constant terms in the original equation to create an *inequality*.

So, they covered up the 9 and the 1 in the original equation→ $4x \;\square \neq 6x \;\square$ (4)

and found a term that would make (3) into an equation→ $4x + \underline{\mathbf{2x}} = 6x$ (5)

They set the two *added* terms from (2) and (4) equal to each other→ $\underline{\mathbf{2x}} = \underline{\mathbf{8}}$ (6)

and then they solved (6) instead of the original equation→ $x = 4$ (7)

While this "double cover up" approach may appear algorithmic, it was actually created as part of the teachers' conscious effort to help their students use an intuitive understanding of number sentences. By employing this approach as a bridge between arithmetic and algebra, the teachers empowered their students to be successful in solving complex equations. Not surprisingly, teachers reported that this was an effective way of teaching equation solving. According to one teacher, one of his students even proclaimed, "This is his first time learning was easy." In his reflection one teacher noted that "we have been trying to teach them so many years using traditional ways; with the computational skills that they have, I have also seen that we cannot teach them using traditional ways of teaching."

(2) <u>Attentiveness to student attitudes</u>. During the implementations of SITTE, the teachers began paying close attention to their students' thoughts and feelings. The teachers all demonstrated a high level or increasing level of recognition of students' verbal and non-verbal responses in guiding instructional . For example, after just a few days teachers began to notice on how engaged their students were and how well they were working together. Their positive comments suggest that the teachers were engaged in reflective conversations about their teaching practice as well as making insightful analyses about the impact they were having on their own students' behavior.

(3) <u>Watchfulness for misconceptions</u>. A further example of the teachers' awareness of their students' thinking comes from a section in the *Survey of Content Knowledge* where they had to interpret the possible mistakes that their students might make on a true/false assessment (Cheng, 2005). In this survey, most of the teachers showed little difference between their initial and final interpretations of likely student errors. For most of the items, they initially attributed likely student errors simply to "lack of basic skills." However, in the final survey, teachers provided more thoughtful

analyses of likely student errors. Further, transcripts of taped discussions suggest that teachers were, in fact, paying greater attention to reasons why students got wrong answers. This represents a significant shift from their typical practice of assessing students simply on the correctness of answers.

(4) <u>Responsiveness to student reasoning</u>. Conversations during the daily meetings also reflected the teachers' attention and responsiveness to student reasoning. For example, survey results indicated that teachers felt that they increased in their practice of continually reassessing their instructional options as a result of an increased use of student discussions and from listening to students. In the first week, one teacher remarked, "When I did this $3 + 4 \times 5$, I wish you could've been there, you would've loved to have seen that debate that was raging because what happened was half the class said 35, half the class said 23 and they kept arguing for their case and somebody came up with PEMDAS." For some, such comments represented a departure from a previous habit of simply complaining about students' weaknesses in basic arithmetic skills.

As the inter-session progressed, the teachers also continued to examine their own knowledge of their students' thinking. For example, Jim explained how he deliberately assigned three equations to expose a common student misconception and to guide student thinking in solving them:

$$5x + 3 = 13$$
$$(3x + 2x) + 3 = 13$$
$$3x + 3 + 2x = 13$$

> Jim: I start my warm ups because I took three of these like this. First one $5x + 3$, second one I use the parenthesis $(3x + 2x) + 3 = 13$. Then third one I had $3x + 3 + 2x = 13$, which is all same problem... Then those kids come up and start doing this, distribute... Because those kids, whether there was multiplication or addition, as soon as they see parenthesis and number, they, they have some idea about distribute property so they start using it.

Not only was he conscious of what the possible errors his students were likely to make, he was also aware of his own reasons for choosing the three problems.

(5) <u>Expectation of student trajectories</u>. Throughout SITTE, the teachers also demonstrated their thoughtfulness in designing mathematical tasks for their lessons. One particularly significant development occurred in the fourth week of the first implementation of SITTE as the teachers struggled to find a better way to teach inequalities. After much reflection one teacher came up with a novel method for solving inequalities. His ideas sparked a lively discussion about student thinking and how the teachers could help students overcome their discomfort with solving inequalities.

> Jim: This morning I put equation here, and inequalities on that side. I asked them, what's the difference? Can you see a difference? A few of them come up with, the equation you only have one solution, but the inequality, and then, most of the kids saying ah, different sign, or different what, a few get it. The equation has one solution, and inequality has more than one solution, a lot of solutions.
>
> Sam: Well, I think that would be what I would want to start with, with the table. And then, then show them how to do it, be it that way, or cover up with the Jimster test... Well what I would add to what

we're doing is just a table. I mean, I love the table, I love the kids finding particular values, and seeing when it shifts from less than to greater than. That's, that's cool.

Tim: And then you can use this as a lead in to two equations, two unknowns... When you're doing these inequalities with variables on both sides, what you are doing, and you can use this as a lead in to two equations, two unknowns, is you're really plotting graphs and where the lines cross is your solution.

Craftsmanship: Application of Student Thinking

With their awareness of student thinking came a new focus on applying that knowledge. Over the course of the SITTE professional development, the teachers used their growing understanding of student thinking to develop additional ways to help their students experience success. Survey results indicated that the teachers increased in their agreement of the statement, "I identify problems related to curriculum and instruction, and formulate a range of solutions that connect students, content, and context." For some of these teachers, this was the first time they had ever done so in their practice.

And as the teachers considered how they can help their students learn, they focused on improving their craftsmanship in teaching. In fact, they indicated on the surveys that they had increased in the practice of adapting and improvising instruction to better meet their students' needs. One key findings drawn from the transcripts and observation notes is that the teachers consciously used their knowledge to help students overcome a condition of chronic discomfort with mathematics. As one teacher observed, "I would say half of my kids have, have an allergic reaction when they see this. Yeah, yeah, I need some, some salve, balm to help the allergic reaction so that they're not frightened away when they see this." Another teacher noted in his final reflection, "I have seen myself that students can learn much better if we can motivate them by doing something that they can do at the beginning of the semester." In other words, the teachers were beginning to recognize how they could use their knowledge of student thinking to provide opportunities for their students to succeed.

One of the best examples of how the teachers demonstrated their craftsmanship in practice was the way they developed a new approach for teaching inequalities. For days they had failed to find a way to teach this topic in a manner that was consistent with the seven principles they had adopted. So it appeared that they might have to teach the concept in the traditional way (i.e., give students the rule of reversing direction of the inequality when multiplying or dividing by a negative number). Then Jim, a new teacher, came up with a creative process for solving inequalities such as $2x + 1 > 3x - 2$.

Jim: Friday night, I really could not get to sleep because last few weeks, we tell our kids to use cover up, it works best. Now, how can we tell them, don't use it, it's not going to work? So, you know, I think there must be some way to teach them another way to come up with the answer, OK?

Sam: So, essentially, you're telling them, if I heard you right Jim, you're telling them to like test with the zero, just like when we teach them, when eventually we're going to teach them, how to graph systems of inequalities.

Jim: So, the kids really understand the meaning of the answer. And those kids, those kids that solve using traditional way, after they solve the equation, I tell them what is it mean? They just solve it. But by asking them to test it, they really understood what that answer meant, was.

Sam: It's so obvious.

In the discussion that followed, the teachers refined the solution process and developed it into an activity for the students. First, they wanted the students to recognize a pattern of relationships between two expressions, $2x + 1$ and $3x - 2$. By using a table, the students would be led to recognize that with consecutive values of x, say, 0, 1, or 2, the first expression was greater than the second expression. But when $x = 4, 5, 6$, the second expression would be greater than the first. The key, then, was to have students determine the value of x that would make the two expressions equal. Solving inequalities, then, simply became a matter of finding the critical value of x that would make the two expressions equal and then "testing" an arbitrary value of x to determine the nature of the inequality relationship. If the value of x, say, 0 made the inequality true, and since $0 < 3$, then all values of $x < 3$ would make the inequality true.

As the teachers reflected on the lesson, they realized how this approach helped the students develop a relational understanding (Skemp, 2006; Orton & Frobisher, 1996) of inequalities.

Matt: And I think that helped to get the actual answer, 'cause before they would just get the answer but not know what it means. And now they're reading the graph, before to get the answer. So I'm all, so what does this mean? They're all, x has to be greater than two, or whatever. So then, so they were picking that up. And I think that made a big difference just 'cause before, we show 'em how to solve it, and then they can do the graph, but they don't know what the graph means. But in this case, they're actually using the graph to get the actual answer.

Jim: I just found out one interesting thing. After they use cover up, they start to think. When I teach equation, OK, they used to write down something. But now they think. And after we, by the cover up, get the critical point. But now they know it's either this side or that side. If this was last three semesters, no, no way. But now they think it's either this side or that side, which one do I have to pick? But I do think they actually know what they mean. When the solve with the pencil, they just follow the rule. But now they think what they should do.

The teachers were now using their knowledge of student thinking to inform their lesson planning. In recognizing that students often confused rules and procedures, they sought to make the algebra make sense and connected to what the students already knew.

Jim: One thing I noticed is, that they knew a lot of things. They knew a lot of things but they cannot fit them together.

Tim: It's like little isolated bits of information and they don't see connections.

Jim: We have to figure out some ways to put together those connections for them. And then by using those little, little things, they create their own rules.

Further, the teachers often departed from the traditional lecture approach to using patterns and discovery to help their students understand mathematical relationships. They also "repackaged" traditional topics by using multiple representations to promote retention. Thus, the important point to note here is that the teachers demonstrated that they were not satisfied with just giving rules to students. Instead, they now had the confidence to depart from the traditional and the familiar to try new approaches. In fact, over the course of the inter-session, the teachers came to develop the following seven principles that they used to guide their lesson design:

(1) "unscrambling" and organizing content to make the subject "make sense";
(2) encouraging student engagement through successful experiences;
(3) "packaging" concepts creatively to promote retention;
(4) using patterns to promote exploration, discovery, and generalization;
(5) pushing for conceptual understanding through multiple representations;
(6) connecting concepts to get a "payoff" in subsequent lessons; and
(7) connecting new approaches with traditional contexts.

As a result, the teachers began to (1) use students' existing knowledge to make the content make sense; (2) organize information to bring out patterns that could help students generalize; (3) contextualize abstract concepts by using familiar situations; and (4) connect concepts through multiple representations.

The Impact of SITTE on Teachers' Perceptions and Practices

Analyses of the teachers' practices during SITTE focused on four specific aspects of teaching: (1) planning; (2) implementation; (3) communication; and (4) assessing. Continuing the use the five states of mind as "diagnostic constructs," I will now discuss the impact of SITTE on teachers' perceptions and practices in terms of the remaining three states of mind: *flexibility*, *efficacy*, and *interdependence*.

Flexibility: Resourcefulness in making instructional decisions

The ability to consider options and to choose strategically from among them is commonly referred to as flexibility. Research has shown that flexibility is one of the distinguishing characteristics of expertise (Bransford, Brown, & Cocking, 2000; Borko & Livingston, 1989). During the SITTE professional development, and in the semester following, the teachers demonstrated increased flexibility in several ways. First, they departed from reliance on the textbook as the basis for sequencing, pacing, and lesson design. They also altered teaching approaches in response to the needs of their students. Further, they developed and applied guiding principles for their own teaching.

Adapting and designing lessons. Designing lessons based on student needs is generally considered difficult, if not impossible, by teachers in LAUSD. Typically, math teachers must follow a district pacing plan, which commonly translates into teaching a section of the book every one or two days. Thus, lesson planning is essentially reduced to determining which section to present on any given day. During the inter-session, however, the teachers had little choice but to depart from the textbook because they simply did not have enough days to cover the book section by section. Survey results

verified this as teachers indicated that they felt less responsible for covering material from a textbook (*Teacher Attitude Questionnaire*, Item 9) and a decreased sense of need to cover one section a day (*Teacher Attitude Questionnaire*, Item 10). As a result, the teachers felt "free" to explore other options. And this freedom brought about the single most distinguishing feature in their teaching practice—the creation of original and creative curriculum materials based on content standards.

This emphasis on developing original curriculum was motivated, in part, by the teachers' recognition that students were unable to generalize and transfer the skills they learned to unfamiliar problem situations. They felt that perhaps the books were largely responsible for presenting concepts as discrete topics without connections. Thus, they sought ways to create mathematical tasks that emphasized connections through multiple representations and contextual problems.

> Tim: This is one the things I'm thinking about because... so far we're not using books, we're more focusing on the standards themselves and that they will be assessed on and I think that's helping.
>
> Sam: I would like to give the kids some word problems that they have to translate into a linear situation, so they have some context for that... One of the things I like about what we've been doing is almost every new concept we've tried to, uh, give them a foundation of, some, some context that they're relatively familiar with.
>
> Tim: One of the things I like about these problem worksheets, and I've had a couple of students comment on 'em, is that they can sort of personally relate, uh, to the problem. That pimple one was pretty good. But the thing is, is that it's not the cut and dry problems you typically find in the book. And I think that's made a big difference.

Altering teaching approaches. Survey results indicated that teachers decreased in their desire to break down problems into easy steps (*Teacher Attitude Questionnaire*, Item 6) and decreased in their emphasis for solving problems using the most efficient methods (*Teacher Attitude Questionnaire*, Item 13). At the same time, they indicated that they had become more comfortable with students using trial and error (*Teacher Attitude Questionnaire*, Item 28) and had greater confidence in their students for coming up with ideas for solving problems (*Teacher Attitude Questionnaire*, Item 31).

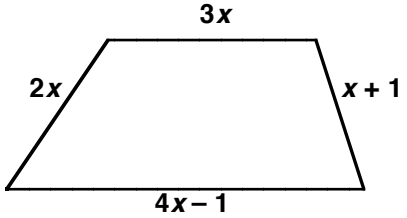
Further, the discussions during SITTE also afforded the teachers the opportunity to attend to their students' learning difficulties. This led them to design and implement mathematical tasks that focused more on inquiry and connections rather than on procedures and algorithms. In particular, the teachers came to recognize the fact that their students struggled with algebra because it often appears to be a collection of rules and formulas. Thus, the teachers made an effort to show students patterns and generalizations as part of a system that "made sense." In other words, the teachers' response to their students' struggles was to provide ways for students to see the connections between concepts, representations, and procedures. In the process of doing this, they developed seven guiding principles for lesson design over the course of the professional development. With these principles in mind, the teachers designed a number of creative learning activities. For example, they often emphasized discovery through

patterns and they continuously pointed out connections between topics. As a result, the teachers developed a number of successful lessons that were engaging and empowering for the students.

Application of guiding principles. One of the first successes based on the teachers' own guiding principles was in teaching equation solving by using the "cover up" method (Kieran & Chalouh, 1993). This strategy allowed the students to apply their existing understanding of arithmetic to gain mastery in solving symbolic equations in algebra. More importantly, the success of this approach encouraged the teachers to continue seeking methods that made sense for students. It was this breakthrough that eventually led to the "double cover up" method and a new approach in solving inequalities.

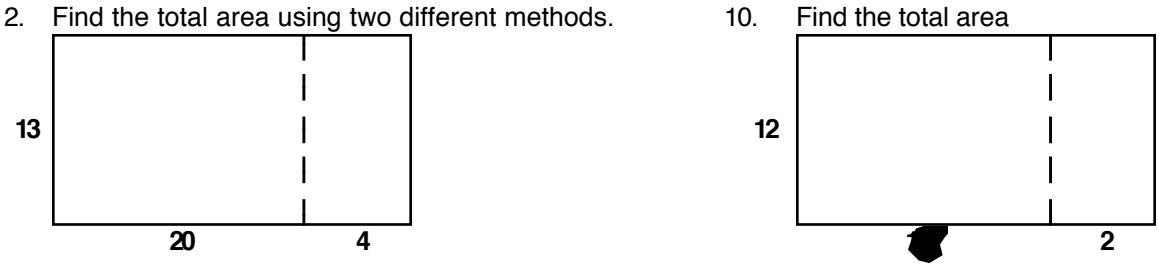
Another strategy that the teachers used often was to contextualize concepts in ways that were familiar to the students. For example, instead of teaching "combining like terms" as a stand alone unit, the teachers embedded this concept in problems that necessitated combining like terms. Where typical textbooks might ask students to perform a number of exercises in simplifying expression such as $2x + 3x + (x + 1) + (4x - 1)$, the teachers gave students problems such as finding the value of x that would make the perimeter of a figure equal to 50 (see Figure 3). Such problems made it necessary for students to combine like terms as a part of solving the problem.

Figure 3. Sample perimeter problem used to teach combining like terms



In a similar fashion, the teachers guided the students in understanding the distributive property using the area of rectangles. Through a series of guided discovery activities, the students were asked to find the area of the rectangles using two methods, e.g., 13 × 24 and (13 × 20) + (13 × 4). This then led to problems where the students had to generalize the arithmetic to represent unknown values, i.e., the "ink spot."

Figure 4. Problems using area to teach the distributive property



Further, the teachers made use of problem categories, such as "start unknown" or "change unknown" (Carpenter, Fennema, Franke, Levi, & Empson, 1999) as guides for informing their own design of problems. In the process they created "word problems"

that helped students see equations as symbolic abbreviations for "real life" situations. The "cookie" problem, for example, was one of the favorites with students.

> ***Cookie Problem***. Igor was so excited because his rich Uncle Fester doubled the number of cookies he had in his lunch box as he left for school. As he walked along O'Melveny, he jacked another six cookies from his homie Favian. Five minutes later, however, Jennifer and Daisy came up to him and insisted that he share his cookies fairly (so everybody gets the same number) with them. While doing this, he accidentally dropped two cookies in the gutter. When he got to school he had two cookies left in his lunch box. How many did he have to start with?

The teachers wrote such problems specifically to capture interest by including students' names and in telling a "story" that was humorous. At the same time, the teachers found that they were able to engage students in a learning process that involved higher level tasks beyond the rote exercises found in many textbooks. Thus, the implementation of mathematical tasks began to shift from procedures to inquiry and connection building.

> Tim: I haven't seen here at Santa Felicia for years. Um, OK, first of all these problems we're doing, the uh cover up part two and the life in high school, um, I've heard kids get into vicious arguments about which way to go with the problem, and I've never seen, uh, I'd say rarely seen that in a uh regular classroom.

Buoyed by their success, the teachers again used contextual situations later to capture student interest while emphasizing the nature of inequality relationships. To do this, they designed an activity that asked the students to paraphrase problems in their own words, draw number line to illustrate the conditions described in the problem, and then write the symbolic representation. The following problem illustrates this:

> ***Basketball Problem***. Kim's goal is to score at least 20 points in a basketball game. If she already scored 7 points, how many possible points can she score and make her goal?

The nature of this problem allowed the teachers to engage the students in a discussion regarding multiple possibilities for solutions. As a result, the students were able to see that 13 could be a valid answer while 12 would not. Thus, the solution would be $x \geq 13$, where x represents the number of points that must be scored in order for Kim to make her goal (note that for the purposes of this activity, it was assumed that $x \geq 0$).

While many problems were designed to "make sense," others were designed to "pay off" in subsequent lessons. One good example was the use of tables for evaluating expressions. The students were able to use what they learned in evaluating expressions such as $2x + 1$ and $3x + 6$ to solving inequalities such as $2x + 1 < 3x + 6$ and systems of equations such as $y = 2x + 1$ and $y = 3x + 6$.

> Tim: Well, looking at your, uh, worksheet, it's um, the traditional versus the connected approach. It has the same elements in it. I think the difference is between what's done in the textbook and what we're doing is that we're bring the connections, uh, to the attention of the kids.

One of the areas that has traditionally been difficult for algebra students is the subject of linear equations in two variables. Students must grapple with a number of new ideas such as slope and intercepts, as well as different representations of these ideas.

Typically, these ideas are presented as separate topics in separate sections of a book. As a result, teachers often teach each idea as a discrete topic. During SITTE, however, the teachers came to recognize how the various ideas were connected. So they explicitly connected symbolic, graphical, and tabular representations, as well as contextual word problems to represent the concept of slope.

Resourcefulness in developing lessons based on students' learning needs also became evident in the communications that occurred during instruction. In particular, I found that the teachers became more willing to allow student conversation in small groups rather than just lecture and demonstrate procedures. For some, this was the first time that they experienced teaching through small groups.

> Matt: Well, it's not, my, my, my lessons aren't as teacher directed as it used to be. Mine used to be more like lecture kind of styled lessons.
>
> Jim: One thing I noticed today was, they learn better from their friends if I let them teach... So, so, actually I was watching them working together. But they understood much better when they, they learning from their friends.

The use of formal and informal assessments represents yet another aspect of my framework for analyzing teacher practice. Research suggests that students learn more effectively when teachers seek to understand their thinking and use this knowledge to guide instruction (Bransford, Brown, & Cocking, 2000). Thus, the teachers were encouraged to go beyond asking for the correct answer and, instead, ask questions such as "what do you notice?", "what can you conclude?", "why?", and "how do you know?".

Over time, the types of questions asked by SITTE teachers slowly began to resemble those typically found in classrooms using reform curricula (Boaler & Brodie, 2004). The ongoing practice of questioning for understanding also allowed the teachers to rehearse and refine their informal assessment skills. One teacher observed, "This program has helped me improve my wait time. Now I know how to wait after I ask a question." Even though survey results indicated that the teachers felt that they increased in their practice of listening to and learning from students, their practice in their regular classrooms sometimes did not reflect what they did during SITTE. When asked about how he determined what connections the students were making between various topics in quadratic equations, one teacher admitted, "That's the problem, I'd have to ask 'em questions." In other words, this teacher recognized that he was not asking questions as much as he had done during the inter-session. Nonetheless, the teachers still engaged in more inquiry based teaching than they had prior to the professional development.

Along with question asking, the teachers also designed formal assessments to check for conceptual understanding and student reasoning. To that end, the teachers began to develop questions that required explanations. For example, on the first test, the teachers included the following question:

> Fester and Broomhilda were simplifying (–749) + (–847). Fester's answer was –1596 while Broomhilda's was 1596. Who was correct and what mistake did the other person make?

The discussion after the test revealed how the teachers saw that they could use the students' responses as a starting point for helping them correct their errors.

Further, the analyses of students' work seemed to encourage the teachers. One experienced teacher remarked, "I have never had a chance to evaluate student mistakes like this. Great!" Another commented that this affected his testing practice.

> Tim: I am now emphasizing showing work. In fact, I am designing tests for next semester that require the students to show their work.

Lastly, the teachers recognized how much more response they were able to get from the students when they designed tests that assessed for understanding.

> Jim: Uh, one thing I noticed about the word problems... usually I never get any response on that. But this time, they write something. All of them.

However, the ability of the teachers to insightfully design assessments to get at specific student understandings was only at an emerging stage. These teachers were generally not accustomed to exploring their students' thinking. More common than not, they only looked for the correctness of students' answers from a procedural standpoint.

Efficacy: Confidence in making instructional decisions

An important theme that emerged from the conversations and activities during the inter-session was a sense of efficacy among the teachers. Costa and Garmston (2002a, 2002b) refer to efficacy as the knowledge that one has the capacity to make a difference through his efforts. The importance of efficacy is that it significantly affects student achievement (Ashton & Webb, 1986). The teachers demonstrated their confidence and sense of efficacy in three ways. First, they expressed how much they appreciated the new strategies they learned in SITTE. Second, they expressed new perceptions about themselves as teachers. Third, they displayed more positive attitudes about the capabilities of their students.

Appreciation of SITTE. One of the most common remarks that the teachers made was how useful the knowledge they acquired would be in their regular classes in the following semesters.

> Tim: OK, now, in the regular semester, when we do Algebra 1A again, I'm planning on doing a lot of what we did in here, Algebra 1A inter-session. What I'm beginning to think about now, is how I'm going to take the techniques I've learned here and apply it to Algebra 1B.

In fact, this teacher made similar remarks no less than 40 separate times—more than one per day—during the six weeks of SITTE.

However, the teachers also expressed both confidence and a lack of personal efficacy simultaneously. For example, when asked about how SITTE affected him, one teacher replied, "Uh, teaching wise, uh, just renewed confidence, and as, as, uh, teachers, we can make a big difference. And at the same time, at the very same time, awareness that the hurdles are really, really high and we can't make a difference. But both at the same time."

Attitudes of self. The teachers also indicated a new confidence in their own teaching skills. In contrast to teachers who typically loathe being observed by colleagues or administrators, the teachers in SITTE were eager to show off their work at a department meeting.

Tim: And I also think the PDD day, uh, meeting yesterday went very, very well. And I was hoping to see [the principal] today. And I was going to ask him, um, uh, you weren't at the, uh, math department PDD as I've seen you there many times before. And now I was going to tell him, you missed the best of, um, you missed the best PDD of the math department all year. That's how good I think the, uh, meeting went yesterday.

As the teachers experimented with new ways of teaching, they began to see themselves differently. One teacher became so used to teaching with alternative approaches that he became frustrated at himself at times when he resorted to traditional algorithms.

Matt: I just noticed that when I, when I was doing the traditional method, I just felt like I was going back into that, that old way of teaching. And that felt weird. I didn't want to go back into that. I was like, no.

Over the inter-session, comments from another teacher illustrated the change in the perception that he had of himself. Early in the professional development, he described his own experience as traditional.

Tim: I think uh looking at my own experience coming up um most of the teachers I had, did just give us rules and say, "Play the game by the rules and if you don't play the game by the rules you're not going to be successful." So, I sort of accepted that.

However, by the end of the inter-session, he spoke quite differently about traditional methods as he criticized the way that typical textbooks presented mathematics.

Tim: Well, first of all, um, I think textbooks are written by people who learned math the traditional way the first time, never had any difficulty learning math. I'm beginning to come to that conclusion.

On a similar note, he criticized what he perceived to be the beliefs of district officials.

Tim: The people who are in a position to make these kind of decisions are the people that learned it the traditional way: if I could learn it this way, everybody else can. Well, we know what happened to that theory.

Attitudes of students. In the surveys, the teachers consistently indicated increased agreement with statements such as, "I articulate high expectations and formulate lessons and activities that are more demanding and challenging for everyone" and "I promote academic achievement in ways that emphasize both personal accomplishment and intellectual engagement." Another example of how teachers' shifted their thinking could be found in their comments on students' level of engagement and the quality of students' work. Again and again, the teachers expressed their surprise at how well the students performed.

Jim: This program changed my mind 360. The one thing that let me trust this inter-session is that, like, like, before I teach in this inter-session I thought this would be really ugly inter-session because I have to teach all the, all the kids they are repeating. But after like first two, like last couple of days, I could not notice whether I'm teaching in inter-session or regular semester, because those kids,

nothing to it... The kids right now? They just look like normal kids I'm teaching in regular semester. So, sometimes, I say, wow, these are kids that all failed from last semester?

Throughout the inter-session, this teacher frequently expressed his amazement that the students he had in inter-session were previously unsuccessful in algebra.

Jim: While I was grading papers, I was wondering why those kids are here. I mean, this graph, making tables, draw graph? Perfect. I don't know why those kids are here.

One additional significant finding is that, based on the transcriptions of daily discussions, there was a noticeable decline in the percentage of negative remarks that teachers made. In other words, comments which suggest a negative outlook towards students or the effectiveness of teaching efforts decreased noticeably from over 20% (23.3%) of all the comments made in the first week of SITTE to less than 10% (8.0%) of the comments in the last week of SITTE. On the other hand, the teachers also made efficacious remarks (i.e., comments which indicate a positive disposition toward students or teaching) during the inter-session. In fact, the percentage of efficacious remarks rose from 15% in the first week of inter-session to over 40% (42.8%) in the last week of SITTE. So, as the teachers experienced increasing success with their students, they began to convey a sense of efficacy. One teacher noted, "My last three semesters here I was vaguely looking for something that I could use to help my students so they can go out of my classroom with something. But I just could not see how. Now I feel like I can make the difference."

But old attitudes and beliefs are resilient and difficult to change. Despite the positive focus on new ways to help students succeed during SITTE, some teachers went back to complaining about the students' lack of arithmetic skills. In their daily discussions, the teachers from the first implementation of SITTE made no less than 78 such remarks in six weeks. Again and again, one teacher continued to express his concern about students' lack of computational skills. "Improper fractions just kind of wrinkle me, um, because when you get out there in the real world and you see a number displayed, you're never going to see an improper fraction," he complained, "The whole issue with computational skills I've been bringing up, uh, a lot, because... I'm concerned about the computational skills hanging up, uh, the, uh, kids."

Not unexpectedly, after the SITTE ended, some teachers also reverted back to the traditional method of teaching by lecture. Lecturing and demonstrating are deeply ingrained teaching methods that are not easy to change (Ball, 1996; Smith, 1996; Lampert, 1990). And it was no different with these teachers. In the semester following the professional development, only one teacher actually continued to develop lessons that were consistent with the seven guiding principles adopted by the participants during SITTE. Two teachers claimed that they had carried over the SITTE way of teaching into their regular classes, even though their actual practice was much more traditional than they realized. These teachers employed teacher directed demonstrations with only minor improvisations.

Nonetheless, the teachers did notice changes in themselves *during* the inter-session and they did seem to embrace new teaching practices. In fact, one teacher was extremely adamant that the SITTE changed him, "If you tell me I didn't change because of that Algebra 1A inter-session, Ivan, I'm gonna hang you out to dry." Another teacher

reflected, "This inter-session program made me a totally different teacher. Last 30 days in my classroom ... I have learned so many things that I could not learn elsewhere." So, perhaps one of the most noticeable change in the teachers' sense of efficacy was in their recognition that they now possessed the means to continue their own improvement.

Along with the changes in teachers' attitudes about themselves, they came to see that they could make a positive difference in their students. They also felt that they had gained some new skills that can help them with the students in their regular classes. In fact, one teacher felt so confident in his abilities that he even requested to teach the lowest achieving students for the following semester! It was clear that the teachers felt energized and gained a renewed enthusiasm for teaching.

> Matt: I mean, kind of like, we got re-energized, you know, kind of like more something, I mean, something more to teach every now, it's like before, I mean, it's not that I wasn't teaching, but I got, I kind of got into a little slump where I was just like, just going through the motions, 'cause I didn't see the kids were producing anything, you know? But now with this, it's getting me more energized to where now I think that they'll be, I think they'll be able to see the difference next semester, where they'll see me more, more enthusiastic about teaching them.
>
> Tim: Uh, one of the things that's, as far as me personally, is concerned, a little bit of a renewed enthusiasm, because I've seen, I've got, I've now got my hands on some stuff that works. And that I think is useful.

In short, it was apparent that the teachers had come to identify themselves as teachers who *were* capable of helping their students succeed.

<u>*Interdependence*: Teamwork in making instructional decisions</u>

One other key place where the teachers revealed their beliefs and practices was in their interdependence, or level of collaboration. Because isolationism is one of the "pathologies of the existing institutional structure" (Elmore, 2000, p. 35), the teamwork and interdependence that the teachers displayed represents one of the most significant acts that could occur in teaching practice. In working together, the teachers built on each other's strengths and co-constructed their knowledge of teaching through reflective conversations. In other words, they helped bring about individual improvement collectively. Specifically, this interdependence affected teachers in four ways.

First, the daily extended collaboration allowed the teachers to create and rehearse lessons before actually teaching them. Again and again, the teachers practiced in front of each other how they would explain such topics as "what's in the bag," "cover up," or "Jim's method" for solving inequalities.

> Matt: OK, I'm starting to feel more comfortable with it, with the, with Jim's method.
>
> Ivan: OK, then, here, you need to take the lead here. I'll tell you why, because you have to be comfortable; if you're not comfortable with it then we can all be comfortable with it. So, so, take us through. How do you envision tomorrow's lesson to go?

A week later, when the teachers discussed the area model for fraction operations, one teacher was particularly uncomfortable with this new approach. However, after he practiced explaining it to the group, he proclaimed, "This is the best thing I've seen, since just plain memorizing the algorithms, for teaching fractions that make sense.

Second, the teachers were also able to help each other by sharing teaching tips from their own experience. One example was their discussion about ways to get more homework from students and how to decrease tardies. Furthermore, they were able to support each other in dealing with the common struggles that they faced.

> Matt: What I was going to say was, I just think that, um, I think that it worked out real good, like we were, we were all able to disagree with each other, and still come up with, you know, similar ideas. And I think that helped me a lot was when I realized I'm not the only one that has the same problem. That was, that I'm not the only one that has that one problem, you know? Which gave me more, oh, OK, you know, so I mean, I'm not alone.

A third place where the teamwork became transformative was in the experience of authentic collaboration. Because the teachers knew that they had to come up with actual lessons that they had to teach the next day, they were motivated to come up with real solutions and to push themselves farther than they would in any simulated group activity found in typical professional development workshops.

> Sam: If you have a team, if you have like, like us four, there were several days where we got started, we didn't want to finish. We wanted to make sure we had things settled and, and in something we can use before we moved on, even though the clock was ticking.

Furthermore, research suggests that teachers sometimes must experience a change in practice before they will change their beliefs (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003; Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996). Because the teachers experienced true collaboration, they were able to see the value of collaboration. And because they experienced the power of constructivism, they became open to letting their students construct their own learning. The following conversation illustrates this.

> Matt: No, but what I think happened was that inter-session thing, that I tried something new, you know, that, that I gave the kids the opportunity to show me that they're able to discover it on their own. 'Cause before I didn't think they were capable of it… I didn't think that they'd be able to come up with it on their own. 'Cause I kinda just looked at it as, well, if they don't want to even do their work, I mean, what makes you think they're even going to try and think, and try to do their work, you know, try to discover what, and why not?

The mutual support and collegiality during SITTE was a powerful new experience for the teachers. One of them observed, "Most of the time we plan our lessons during the year, um, we don't talk to anybody else about it." In fact, it was the first time these teachers had ever experienced this type of teamwork.

Tim: Well, first of all, there's different ways of doing things. And the collaboration it involved, it's, that collaborative group that we were in was the first time I've ever done anything like that in my entire career.

Ivan: The first time?

Tim: The first time I had that kind of collaborative association with other teachers.

Even though the collaboration was new to some, the transformative effect of the professional development touched all the teachers. For example, some teachers continued to design their own activities rather than teach out of the textbook. Also, some teachers designed mathematical tasks that called for students to work in groups. But it appeared that teacher collaboration had the greatest lasting impact. How that affected the teachers, however, differed dramatically among the various participants.

After SITTE ended, the teachers committed themselves to continuing the collaborative process and agreed to meet together twice a week. Because of conflicting schedules and differences in the textbooks (two taught a computer based curriculum, while the other two used a traditional textbook), the teachers met in pairs instead of working as a group. Two of the teachers continued working together to design inquiry based lessons. They brainstormed ways to teach the required content and through mathematical tasks.

Matt: Kind of, I mean, it lightens the load, as far as, you know, work wise. 'Cause, you know, we're working together like, you know, like he's real good at making these sheets and stuff like that. So, he'll, you know, we'll both discuss about, you know, what we should have in there.

For these two teachers, one unexpected outcome was that they were actually able to "get ahead" of the district pacing plan. In other words, they found that they were able to teach the required content in less time than by just going through the book section by section.

Matt: Yeah, I'm very surprised. I mean, I don't think, I think Sam doesn't see it that way yet. 'Cause I'm kind of seeing it as, what am I going to do in quarter four? You know, as far as what needs to be covered? You know, 'cause if I cover all this, I mean?

Furthermore, they found themselves more relaxed about the pace of their teaching.

Matt: No, before it was just kind of like, well, I need to cover this and I have to cover it, you know? And you know, every week, there was one done by week, and I felt pressured to, to cover what was supposed to be covered in that week, you know? And now it's more, it's kind of more, it's more relaxed... What helped was that we did it that way in inter-session... I am, I am more relaxed. I'm not, I'm not as, I'm not pressured to, to cover it, you know, to, it's 'cause, I mean, I'm covering the, the, the standards. You know, it's not, it's not that I'm not covering the standards, you know? It's just, I just feel more relaxed about it, you know? I'm not like looking at the calendar all the time, saying, OK, I need to cover this.

The other two teachers also met together during lunch twice a week. But after six weeks they discontinued the meetings. They expressed frustration that they could not seem to repeat what they had done during inter-session.

> Tim: Um, one of the things that I am frustrated is, is that I can't do the same thing for Algebra 1B, that we did for Algebra 1A inter-session.
>
> Jim: Yeah, but this kind of lunch time is not enough, because I have to go back and prepare for the warm ups like that. So, I mean, we just can't come up with anything in 20 minutes.

Over and over again, they complained that they just did not have enough time to meet. In fact, this was the single most common complaint that the teachers expressed after SITTE ended. Nevertheless, these two teachers were not able to invest additional time beyond the twice weekly lunch meetings, as the other two teachers were doing.

> Tim: Because we don't have, to do what we did in the inter-session, we, Jim and I would have to be here an hour after school every day, at least. Not to mention lunch. And my wife would disown me if I did that.

Thus, the two who eventually discontinued meeting found themselves resigned to the fact that they would not be able to create new lessons apart from what was already developed during SITTE. One teacher summed up the situation by saying, "To be honest with you, we're not really getting as much out of it as we need to. I mean, to do this right, we need to be here an hour a day every day after school, minimum. Neither of us have that kind of time." This, of course, is the very problem that teachers face across the country. Left on their own, teachers must give up significant personal time to engage in the type of collaboration that was so transformative and generative during SITTE.

Still, the rich collaboration that took place during inter-session created an interdependence that increased the teachers' awareness of themselves and of their students. Along with that they indicated that they felt more effective by working together resourcefully to help students. As one district supervisor commented, after observing a meeting, "This is really inspiring to me, to see a group of teachers working collaboratively, trying to resolve the issues instead of just sitting around complaining about it."

Finally, the fourth noticeable effect of working together was the teachers' engagement of reflective conversations around their practice. Research suggests that engaging in reflection is one of the most effective means for teachers to improve (Elmore, 2002; Kilpatrick, Swafford, & Findell, 2001). Over the course of the professional development, the teachers did just that. Each day, they talked about how their lesson went and what worked or didn't work. Further, they spent extensive amounts of time to consider their students' learning needs and possible ways to address those needs. One topic in which they spent a great deal of time reflecting was students' misconceptions and learning trajectories in integers.

> Sam: And the main thing that came out of that, and also what I'll share in just a second, at least in my class, there is a real dominance for adding instead of subtracting. And they, they much prefer to add. If there's any doubt, whatever the numbers are, they add. And then throw in the sign at the end. And the nice thing about it was

after those ten problems I was able to come back to this and say, OK, and we had another discussion about this. And said you guys tell me what, where, where, where is this coming from? Why are we getting this wrong? 'Cause you guys know the answer to this now. But tell me your thinking. So we talked a little more about this.

Another topic that became a prominent focal point for teacher reflections was the concept of slope in linear equations. For many days, the teachers continued an ongoing dialogue about the ways that they could interconnect various representations related to the concept of "slope." These conversations pushed the teachers to consider slope at a greater depth than they had previously experienced. As a result, they came to recognize that, unlike solving equations in one variable, slope can be explained and represented in many ways. For example, slope can mean *m*, i.e., the coefficient of the variable in a linear equation. It can also mean the rise-run ratio in the graph of a linear equation., Or it can also mean the rate of change in a function. And it can be seen as the difference of *y* values over the corresponding difference in *x* values in a table of values generated by a linear relationship. Thus, the discussions constantly came back to what had to be done in order to help the students understand the various aspects of slope.

Ivan: So, do we have a map for tomorrow and for Thursday?

Matt: Tomorrow we're going to talk about the connection between, between the table, general rule, and graph, given the slope and *y*-intercept. And then, and then the second hour we're gonna talk about graphing with slope and *y*-intercept as a shortcut.

As the teachers reflected each day they began to describe how their efforts were paying off.

Sam: I was encouraged that a lot of the kids are getting the connection between the bridges on the table and then drawing the rise over run on lines, and seeing slope in both of those. And one kid, we were talking about slope, and she said, "Can't you just write that as m?"

Perhaps the greatest benefit of ongoing reflection was that it gave teachers the chance to examine why their lesson worked or did not work, as well as how they could do things differently next time.

Matt: And then, um, and then I went over perpendicular, and they were kind of, I think, I, I picked the, I picked the, um, an, uh, um, example that didn't work out too good, 'cause it was the slope of one and negative one. So, so, it kind of, after, after I, after I thought it out, after I thought it out, I was like, damn, I should've used a fraction, you know, just so they could see it, 'cause they couldn't see it.

And rather than wait until the following semester or the following year to make corrections, the reflections allowed the teachers to learn from their victories or mistakes and immediately apply those insights the very next day.

Tim: The fact is we had the time to really do justice to some of these lessons, and really think them out. I think thinking out the lessons, discussing what went, what went well, what went wrong, was really good , because as you focused in to the next lesson, uh,

either consciously or unconsciously, we, we took this information in.

According to the literature, reflection is essential for improving teaching practice (Kilpatrick, Swafford, & Findell, 2001). What the teachers did was to reflect and refine their practice within the context of real teaching experiences as those experiences occurred. As a result, the teachers were able to see rapid improvement in their own effectiveness. "Just by talking with experienced teacher, without knowing it, it made me a better teacher," one teacher said of his experience in SITTE, "I gained 10 years of teaching experience in just 30 days."

The Impact of SITTE on Student Performance

Perhaps one of the most important ways to examine the impact of SITTE is to explore how it affected students as a result of what the teachers did. In other words, I was interested in studying how the teachers' experiences affected how they perceived and evaluated their students. While such evaluations were largely subjective, they were good examples of how student achievement was positively affected.

Teachers' Perceptions of Students. The impact on students could be seen in survey results indicating that the teachers felt increasingly confident in their students' ability to solve problems (*Teacher Attitude Questionnaire*, Item 31). Further, the teachers decreased in the belief that student success depended simply on more practice in basic skills (*Teacher Attitude Questionnaire*, Item 16). The impact on teachers' perception of their students could also be seen in the comments that the they made about their students' performance. In particular, the teachers observed that their students seemed to be doing more work in SITTE, and that they seemed much more capable than even the students in their regular classes.

Jim: But the thing I noticed was, I'm very happy, because most everybody in the class, they got concept of variable. I mean, last semester, *x* don't mean anything to them. But when I go over the problem, if they see the word, "pile," ahh, *x*. If they see... It never happened before.

Furthermore, the teachers found that the students seemed more willing to make an effort. During one discussion Matt commented that his students were able to solve the equations even without integer solutions. In other words, the students seemed to have developed a sense of personal efficacy as well.

Matt: Before they wouldn't even try it. Now they try to do it, even though some of them got it wrong.

Jim: A student thought of using *x*- and *y*-intercepts to graph lines. The students are thinking for themselves.

Sam: They're really trying.

Lastly, the teachers noticed that even the students in their classes following SITTE seemed to be doing better. They noticed that several students who had failed previously were now getting Cs, Bs, and even As.

Tim: I have one, two, three, four, five; five As. One, two, three, four; four Bs. Uh, from this class better than I've ever seen in an algebra 1A in the last five years. 1B.

Jim: I never had this class, see, it's 100 percent. This was a quiz I gave them this morning, my first period, OK? Maybe some of them used this. This, they're creating the formula, a and b. They never did that, I never taught this way.

Ivan: And, and the results are much better now?

Jim: Yeah, yeah, yeah. A, A, A, A.

While not all students improved and not all students became more engaged, there was a common perception among the teachers that, at the very least, the students who participated in SITTE were better prepared than if they had a traditional inter-session. Further, the teachers felt that the students in the following semester seemed to perform better, in part, because the teachers were teaching better.

Teachers' Evaluations of Students. A second area where students were positively affected was in the way their teachers evaluated them. Table 2 shows that students in SITTE classes consistently passed algebra in higher proportions in comparison to students from the same course during the regular school year or from previous inter-sessions. The Fall 2004 SITTE classes were compared with all the Algebra 1A from the same school. The Winter 2006 SITTE classes were compared with the previous inter-session from the same calendar track at the same school. The Summer 2006 comparison was made between the regular classes and SITTE classes of the same teachers. These comparisons suggest that the stronger performance by the students is likely not due to specific teachers or to the use of summer school/inter-session. Rather, the students' success may be due, in some part, to the teachers' new approach of teaching for success, rather than just teaching subject matter.

Table 2. Comparison of pass rates in algebra from the SITTE pilot studies

Algebra 1A Classes (Non-SITTE)	Algebra 1A Classes (SITTE)	Number of students enrolled	Number of students passing	Percentage of students passing
Spring 2004		418	106	25.36%
Inter-session 2004		131	51	38.93%
	SITTE Implementation 1 Fall 2004	**111**	**67**	**60.36%**
Inter-session 2005		95	28	29.47%
	SITTE Implementation 2 Winter 2006	**84**	**44**	**52.38%**
Fall 2005		201	73	36.32%
	SITTE Implementation 3 Summer 2006	**87**	**54**	**62.07%**

In fact, the teachers did attribute the higher pass rate to the different style of instruction that the they used during SITTE, such as teaching for understanding and focusing attention on students' learning difficulties. One teacher observed that his students initially came into the class carrying the "baggage" of expecting failure because they assumed that the class would be boring and difficult like their previous math classes. Teachers in SITTE, however, surprised their students and "broke through some of their defenses" and "lightened some of the baggage by not doing the same ol' thing." Another teacher associated the success of the students with the specific strategies that he and the

others employed during SITTE. For example, he pointed out that they did not use a book, but designed activities based on their anticipation of where students had difficulties. Others also noted that in SITTE, they gained a deeper understanding of students' responses and used this knowledge to modify their lessons. In short, the teachers recognized that in SITTE, they taught differently and that made all the difference in their students' achievement. Then, over the course of the summer school/inter-session, the teachers came to see their students as being more capable and more qualified to "pass" (i.e., receive credit towards graduation) than their students from previous semesters or inter-sessions. This perception of students seems to reflect the teachers' own stated goal of motivating students through successful experiences.

While discrepancies existed between professed beliefs and actual practices, scores and grades can still be strong evidence of possible shifts in beliefs and shifts in practices toward those of reform mathematics. And even though this data may cause some to dismiss the results as simply the teachers *perceiving* their students with higher regard, results from district standardized assessments were, in fact, consistently higher for students whose teachers participated in SITTE. I compared the scores of the students before and after inter-session using the school district's periodic assessment. These assessments were designed to align with the content that was to be covered during the regular semester. At the end of the semester before inter-session, all students in the district took the Quarter 2 Assessment. At the end of inter-session, the students who attended inter-session were given the same assessment once again. The initial mean for the students attending inter-session was 9.65 out of 30 and their final average score was 10.11. Using a paired two-sample *t*-test with $\alpha < 0.05$, I found that there was no significant difference between the scores from before inter-session and those from the end of inter-session.

Second, the students were also given the CSU/UC Mathematics Diagnostic Testing Project (MDTP) assessment for Algebra at the beginning of inter-session and at the conclusion of inter-session. This diagnostic test was designed to assess general knowledge for a first year algebra course and was used regularly as part of the school's pre- and post-test process. For both the pre- and post-tests, the null hypothesis was that the average scores would not change as a result of being in classes taught by teachers who were participating in SITTE. In this case, I found that there was a significant difference in student scores using a paired two-sample *t*-test with $\alpha < 0.05$. More specifically, the initial average score was 18.44 out of 50 with a standard deviation of 6.23 and the final mean was 19.76 with a standard deviation of 6.83. Even so, the relatively small gain cannot provide strong evidence that the SITTE truly affected student achievement. Perhaps the most that can be said is that teaching inter-session using the strategies that the teachers developed during SITTE did not negatively affect student performance.

While my findings suggest that the effectiveness of SITTE can be measured, in part, by student outcomes in addition to analyses of teachers' practices, further research still need to be conducted to determine the nature and extent of SITTE's impact on teachers and students beyond the summer sessions. In particular, teachers who have participated in the SITTE training need to be tracked to assess the pass rate for their algebra classes and the students' success on district assessments.

Discussion

Like many high school math teachers, the SITTE teachers had been accustomed to simply following the textbook chapter by chapter. Traditionally, they demonstrated the procedures for each concept and the students dutifully reproduced them in worksheets and tests. The only problem was that few of their students were successful in learning in this manner. However, during SITTE, the teachers began to shift their focus from content coverage to student comprehension, an approach that few of them had previously tried in their regular classrooms. This shift became noticeable about half way through the inter-session. There appeared a growing sense of confidence for both the students and the teachers. Students indicated that they were experiencing more success than ever before. And they attributed their success to their teachers who "make math easy" for them. Teachers, on their part, were also finding themselves more effective than they had ever been. One teacher said that for the first time in his career he *felt* like a teacher. Another teacher commented that the experience of all the students engaged and focused on the lesson felt strangely foreign. Finally, a third teacher proclaimed, "It was like a hope come true that finally, somehow, I'm going to learn a way to get this stuff across, after 30 years."

During SITTE, a noticeable change also took place in teachers' beliefs about their students. At the beginning of the professional development, they expressed concerns about the concentration of unsuccessful students in their classes. They felt that these students lacked so many basic computational skills that the classes should focus on developing those skills first. However, as the teachers worked on designing lessons that focused on student understanding, they were astonished to find that the students were extremely capable in reasoning and problem solving. In fact, after just a few days of teaching, one teacher who was initially most vocal about the students' lack of basic skills, said, "This program changed my mind 360. The kids right now? They just look like normal kids. So, sometimes, I say, wow, these kids all failed from last semester?"

In the same way that students became empowered to learn, the teachers also found themselves empowered to create their own solutions. Among the guiding principles that the teachers had begun to adopt, one that enhanced their teaching performance the most was to make algebra "make sense" for the students. In other words, rather than present content the way it is typically organized in a textbook, the teachers began with what the students already understood and used that to move them to greater levels of abstraction and generalization. With this sense-making approach, the students were able to gain confidence in their ability to understand what had previously been no more than a set of memorized procedures that made little sense to them. Further, this approach provided students the opportunity to generate their own rules for solving problems. As a result, they became more capable of accessing even more difficult problems later.

If finding solutions through the creation of original curricula was the most visible activity in the teachers' practice, and if reflecting on and revising lessons around student thinking was the greatest strength of SITTE, then the single most powerful *mechanism* for promoting those changes in practice was teacher collaboration. In fact, the learning that occurred with the teachers could be attributed to six particular features of the SITTE professional development project.

First, this project was designed from an understanding of the local school culture and context of individual teachers. Often, professional development consists of outside

"experts" trying to change teachers without really understanding the contexts in which the teachers are working. The design of SITTE, on the other hand, began with the teachers identifying *their* key concerns about *their* students. Thus, SITTE was perceived as a useful tool for helping them solve the problems that they cared about rather than something "forced from above."

A second key feature of SITTE was the use of the teachers' knowledge as the starting point for creating solutions to their own problems. Unlike most professional development approaches that assume teachers are somehow deficient, SITTE was based on the premise that teachers could use their existing knowledge to construct new knowledge by being attentive to their students' understanding of mathematics. This constructivist approach to professional development honored the expertise of the teachers and promoted such practice in the classroom. In this manner, teachers learned how to continue their own ongoing improvement, even after the professional development ended.

Third, SITTE teachers saw themselves as the problem solvers because they had an authentic problem to solve, namely, how to help students succeed in algebra. In other words, SITTE focused on a student goal other than on teacher improvement. Perhaps this was what distinguished SITTE most from other professional development projects. The participants saw that *they* were not the ones being "developed." Instead, they saw how SITTE was designed to meet *their* needs in solving problems that were important for them. In finding solutions to the problem of high failure rates in algebra, the teachers saw themselves as professionals who were charged with the task of developing lesson ideas to help their students at their school. Such a specific project, however, must also have a specific time frame. The six week duration of SITTE was important because it provided a clear finish line for the work and it allowed the teachers to bring closure to their task. This was possibly how SITTE avoided the burn-out and disengagement found in some lengthier professional development projects.

Fourth, teachers had the tools that they needed in order to get the job done. During SITTE, these tools included books, articles, materials from conferences, etc. The key factor here was that the resources were made available, but not mandated. The focus was not to get teachers to adopt a particular curriculum or methodology. Instead, the teachers were empowered to use the tools as they saw fit. In this manner, they became much more willing to consider various options and alternative teaching strategies. As they explored and experimented with the ideas found in the resources, the teachers became more familiar with alternative ways of teaching mathematics. And in the end, they actually did come to adopt many of the same practices promoted in other trainings. The difference here was that the teachers *chose* to implement those practices rather than have those practices forced upon them. This was another key distinction of SITTE from the professional development experiences that the teachers encountered in the past.

A fifth key feature of the SITTE professional development was the constant emphasis on what was working, rather than on what did not work. This positive focus allowed the teachers to build on and improve what they had already done. It allowed them to *start* from where they were at. And it kept the professional development from degenerating into complaint sessions. By focusing on the positive, the teachers could then work on generating solutions rather than on making excuses. At the same time, the teachers experienced a learning environment that was safe and supportive. This allowed them to provide honest feedback to each other and raise tough issues. And this not only

fostered their creativity and problem solving abilities, it also gave them a model for how such an environment can be structured in their own classrooms with students. In this manner, teachers in SITTE learned how to be reflective and insightful about their own teaching.

Sixth, and most important, the conditions for promoting professional collaboration were carefully organized and established. What occurred during SITTE would not have been possible if the environment were not structured to support such work. Just as a park becomes more appealing if it has features that invite visitors, professional development must be designed to invite interaction (Wenger, McDermott, and Snyder, 2002). This meant that teachers had to be given the time and the space, along with the resources and coaching support to engage in the development of solutions. The relaxed atmosphere of inter-session, along with increased flexibility in sequencing lessons, was what gave teachers the "luxury" of re-examining and re-designing the sequence, pace, and content of their lessons. Further, the SITTE teachers were made to *feel* that they were valued in the work that they did. To that end, I provided snacks, drinks, fresh ground coffee, and occasional lunches to foster good will and to create the social conditions necessary for working closely together.

My findings suggest that these six features were instrumental in making SITTE an engaging and enjoyable experience for the teachers. Not only did they experience transformative learning during SITTE, the new practices they learned transferred to their regular classes in the following semester. And as they continued to develop new strategies and lessons apart from an organized activity such as SITTE, these teachers also began to experience generative learning. The key implications is that these teachers were able to experience transformative and generative growth when professional development offered an environment that honored their knowledge in addressing their own concerns.

The lessons learned from the SITTE also suggest that structuring this type of professional activity during summer school/inter-session may have a powerful impact on students. Currently, large numbers of students across the nation struggle with mathematics; and the situation is even worse in large urban schools (Viadero, 2005a; 2005b; Berends, Lucas, Sullivan, & Briggs, 2005). This high failure rate has resulted in numerous costly efforts to improve student achievement, including extensive professional development for teachers. The problem, however, is that the teachers feel that they can only take the proverbial horse to the water, but not make the horse drink the water.

During SITTE many students did "drink" and become successful in a subject that they had previously failed. This suggests that the students were not only capable of succeeding, they were also willing to do so. What they experienced during SITTE was the opportunity to become successful along with learning some of the skills that they needed to continue that success. This occurred because one explicit goal of the teachers was to create successful experiences as a means of motivating students. So, rather than focusing on areas that the students had not mastered, the SITTE approach was to build on what the students already could do. Thus, the students were willing to try. And when they did, they found, to their surprise, that they were able to succeed. This further encouraged them, which then brought more success. In short, the teachers primed the pump for success.

While the SITTE project was well received by the teachers, this study lacked the means to determine the degree of impact that the teachers experienced. If such a

professional development approach is to be implemented in the future, *how much* change teachers and students experience would be an important area to explore. Further, there are three additional areas that need to be considered; and these can be categorized in terms of *resources*, *processes*, and *evaluation* . Together, they help define what would be most useful to know in a professional development such as SITTE.

Resources

First, better tools could be developed to help teachers analyze student work and student thinking. While frameworks were developed to describe the nature of the teachers' work, I did not create frameworks for examining student work. From the teachers' perspective, such a framework would be useful in facilitating their ongoing learning about student understanding. In fact, such an approach is one of the key strengths of CGI professional development because it allows teachers to engage in generative learning.

Beyond frameworks for analysis of student work, the teachers also could have benefited from tools that would help them analyze their own work. For example, the activities they developed could be analyzed specifically for cognitive demand as well as for the instructional approach (e.g., making sense, using patterns, multiple representations, etc.). While lessons and activities were designed with those considerations in mind, the teachers did not get the chance to critically analyze how well those lessons and activities actually satisfied the intended elements of what they designed.

Further, the teachers did not get the chance to analyze other existing mathematical tasks through the lens of their own design principles. Such an exercise would have helped the teachers develop a useful tool for selecting appropriate mathematical tasks for the various learning needs of their students in their regular classes.

Processes

Because my study sought to determine how SITTE would affect teachers after the professional development ended, I was unable to continue supporting the teachers in their collaborative process after inter-session. To create an even greater impact, I would have liked to continue working with the teachers in their lesson development. At the same time, I would have liked to see the project involve more teachers. This would have allowed us to build on the momentum generated during inter-session to affect a greater number of teachers at the school.

Additionally, I would have liked to have the opportunity to engage other teachers as leaders so that they could facilitate the ongoing collaboration of teachers. At present, only the school's math coaches are in a position to do such work. However, the daily demands of the district prevent them from engaging in intensive professional development work such as SITTE.

Last, I would have liked to structure the meetings more tightly. Since this was essentially a trial run, I did not know how much time to allocate for one discussion or another. As a result, I felt that I did not address some important issues while spending too much time on others. In retrospect, I probably should have established a more organized routine to facilitate the flow of activities. For example, time would have been limited for reflection and increased for analysis.

Evaluation

Evaluation of professional development such as SITTE needs to capture the changes that the teacher experienced in their knowledge as well as their practices. Thus, better instruments need to be developed to capture the *ways* that the teachers' knowledge changed as well as the *degree* of change. The survey I used was not field tested prior to the professional development. Thus, I was limited in my ability to draw more conclusions beyond some qualitative observations. Furthermore, the small sample size of ten teachers was not sufficient in generalizing my conclusions. Thus, a larger study is needed to provide more data on the true impact of SITTE.

But before professional development such as SITTE can be implemented widely, several additional questions still remain to be explored. In order to measure growth in teacher knowledge, what instrument might be more effective and valid in determining the teachers' knowledge of their students' understanding of mathematics? In order to determine the change in the teachers' beliefs and practices, it would be important to know how their level of experience might affect the implementation of new practices? Further, how does the level of implementation affect student achievement? And how might the level of implementation be measured? What kinds of supports are necessary to sustain activities such as SITTE? What alternatives in structuring time for collaboration might be more effective? The answers to these questions can potentially alter the very nature of professional development in secondary schools.

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