Support for Professional Collaboration in Middle School Mathematics: A Complex Web

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Introduction

How does teacher change get conceptualized, supported, and realized? We address this far-reaching question by exploring how teacher collaboration, centered on examining student learning data, can result in changes in instructional perspectives and practices. Our case study consists of a middle school mathematics teacher group working with administrators and professional developers. A grounded theory approach is used to discuss their five-year journey, which includes two years prior to their formal beginning, and the various factors that impacted individual and group teacher change. We specifically address the following research question: What influences the long-term trajectory of a collaborative teacher inquiry team, and what is the nature of the changes that define this trajectory?

Teacher collaboration in the existing professional development (PD) landscape is increasingly common, but it is also being represented and supported in a variety of ways (Borko, 1994; McLaughlin & Talbert, 2006; Slavit, Nelson, & Kennedy, 2009). For example, although varying in form and purpose from site to site, the use of professional learning communities and lesson study are common PD structures currently found in U.S. schools, as well as many other nations. While a convincing body of research on teacher professional development has emerged to support the use of collaborative structures (Garet, Porter, Desimone, Birman, & Yoon, 2001; Wilson & Berne, 1999), we are also becoming keenly aware of the potential limitations of PD of this kind. For example, teachers who lack student learning data to enrich and guide their conversations are limited in their opportunity to truly reconceptualize their practice (Slavit & Nelson, 2010; Watson & Sullivan, 2008). A lack of collegiality or an inability to coalesce around a common goal can also be a limiting force (Achinstein, 2002; Grossman, Wineburg, & Woolworth, 2001; Horn & Little, 2010). Acknowledging the increase in collaborative PD contexts, Horn and Little (2010) state:

> We posit that such formally constructed workplace groups are more likely to prove generative for learning if they develop a capacity for talk that centers on dilemmas and problems of practice. (p. 183)

Teacher collaboration might occur across an entire school or, as is the case in this study, all teachers in a particular content area. Whatever the structure, teachers who have the ability to truly engage in a collaborative effort to improve student learning and who receive the necessary support to do this are in a position to transform not only their individual practice, but to transform the culture and practice of a group of teachers (Nelson, Kennedy, Deuel, & Slavit, 2009; Nickerson, 2008), and perhaps even a school (Gamoran et al., 2003; McLaughlin & Talbert, 2006). Kazemi and Franke (2004) describe the shifts in participation that can occur when teachers, through engagement in work with others, redefine their role and activity as professional educators. They state:

> The shifts in participation do not merely mark changes in activity or behavior. Shifts in participation involve a transformation of roles and the crafting of new identities, identities that are linked to new knowledge and skill. (p. 205)

Shifts in participation are more than slight changes to practice or teaching perspective, but a significant change in the way teaching and learning goals are framed and instructional actions are conceived and enacted. To study such change requires long-term analyses of teachers' conversations and reflections around issues of classroom practice. Shifts in participation are not sudden and usually coalesce to form an important structure for change. True shifts in participation are relatively stable products.

In this study, we examined the shifts in practice that were enacted systemically by all mathematics teachers in a middle school and explore both the overall complexity and the specific characteristics that defined the group and their developmental trajectory. We focus on the role of student learning data and the supported, collaborative nature of the teachers' professional growth environment. The shifts in participation that framed the teachers' development involved (1) learning to talk to each other, (2) individually using student data to inform practice, (3) collaboratively using a variety of student learning data to inform practice, and (4) taking seriously the notion of reaching all learners.

Methods

Context: The Silver Valley Professional Collaboration

Silver Valley (SV) is a small, rural school district with one mathematics teacher for each of Grades 5 through 8. Ongoing school improvement efforts in K-8 mathematics over the past 15 years have resulted in adoption of research-based mathematics instructional materials, targeted professional development, and dedicated collaboration time for staff. While the nearest major population center is over two hours away, district resources have allowed teachers and administrators to access several professional growth opportunities.

In Years 1 to 3 of this case study, a professional development initiative (PRiSSM; described below) supported a voluntary group of nine SV middle and high school mathematics and science teachers (Figure 1) in forming a collaborative teacher inquiry group (CTIG). The project focused on developing collaborative inquiry skills, including the analysis and use of student data to reflect on instructional change. The cross-content, cross-grade composition of the CTIG opened up new collaborative avenues in the district. While a renewed focus on supporting student learning emerged, the teachers tended to focus on general learning processes (e.g., communication) rather than on specific mathematical or scientific content.

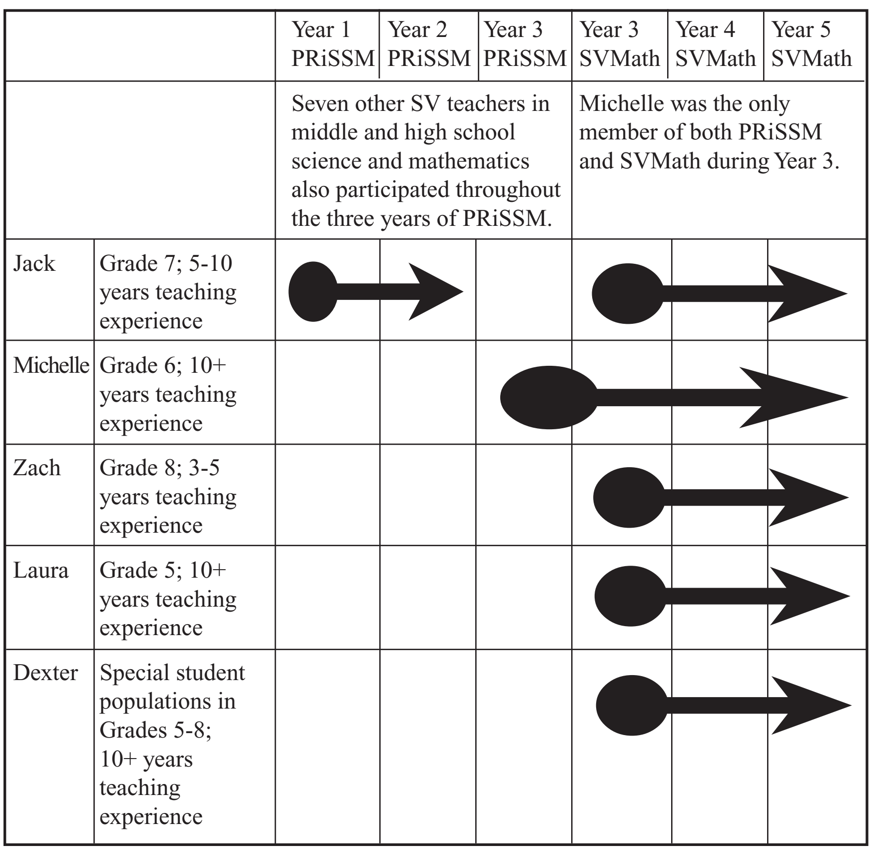
At the end of Year 3, the original collaborative teacher group ended when the associated PD (PRiSSM) concluded. However, during Year 3, a second set of collaborative inquiry groups emerged at SV Middle School that were content-focused and driven by a district-wide curriculum mapping initiative. This initiative grouped all five middle school mathematics teachers (Zach, Jack, Michelle, Laura, and Dexter; except for Zach, pseudonyms are used throughout) and represents the origin of the target case—the SV Middle School mathematics teacher inquiry team (SVMath). Michelle was a member of both the PRiSSM team and SVMath during Year 3. In Years 4 and 5, after the conclusion of PRiSSM, a variety of other supports emanated from within the SV district that renewed the support for the collaborative work. Some of these supports were identified and initiated by the SVMath teachers. Therefore, while the original impetus and source of support for the collaborative work came from an external source (i.e., PRiSSM), the SVMath collaborative team developed into a stable, sustainable collaboration.

The specific developmental trajectory of SVMath, including the teachers' individual and collective shifts in participation, represents the focus of this article. After a discussion of methods, we discuss four specific forces of change that influenced the developmental trajectory of SVMath. We then focus explicitly on the four shifts in participation that define this trajectory.

Data Collection

The data corpus from this 5-year case study is broad and diverse and were jointly collected and analyzed by a six-person research team. The primary data sources were collected during the meetings of the various Silver Valley CTIGs. With the exception of Year 4, over 90% of the meetings were video- or audiotaped and transcribed; approximately 25% of the meetings were attended by a member

Figure 1
Silver Valley Collaborative Inquiry Group 5-Year Membership



		Year 1 PRiSSM	Year 2 PRiSSM	Year 3 PRiSSM	Year 3 SVMath	Year 4 SVMath	Year 5 SVMath
		Seven other SV teachers in middle and high school science and mathematics also participated throughout the three years of PRiSSM.			Michelle was the only member of both PRiSSM and SVMath during Year 3.		
Jack	Grade 7; 5-10 years teaching experience						
Michelle	Grade 6; 10+ years teaching experience						
Zach	Grade 8; 3-5 years teaching experience						
Laura	Grade 5; 10+ years teaching experience						
Dexter	Special student populations in Grades 5-8; 10+ years teaching experience						

of the research team. No meetings in Year 4 were recorded, but descriptive notes and artifacts were collected. Artifacts from CTIG meetings included student work, agendas, and other documents created by the teachers in relation to their collaborative inquiry. Interview recordings and transcripts from two interviews per year with several of the teachers were collected, as well as one interview per year with school principals. The PRiSSM facilitator was also interviewed in Years 1-3. Numerous email exchanges and informal conversations with all of the above participants provided additional insights into group activity and were used prominently in the data analysis.

A grounded theory methodology (Strauss & Corbin, 1998) guided the data collection and analysis of our research. It has been widely documented that effective, impacting professional development involves ongoing collaboration and evidence derived from teachers' own instructional contexts (Garet et al., 2001; Wilson & Berne, 1999). However, more recent research has begun to explore these issues more specifically. For example, Kazemi and Franke (2004) studied a group of mathematics teachers and provided evidence of the benefits of facilitated support on teacher interactions and the analysis of student learning data. Grossman et al. (2001) documented the need for teachers to establish productive norms and collaborative group processes in order to fully engage in productive conversations. Others have focused on the need for teacher groups to take an inquiry stance toward their work (Cochran-Smith & Lytle, 2009; Jaworski, 2006; Nelson & Slavit, 2010). However, very little evidence exists on the long-term development of collaborative inquiry teams over multiple years; this void prompted our grounded theory approach. Preliminary analysis from the first two years produced tentative hypotheses and directed future data collection. Beginning in Year 3, the research team used existing data to construct case reports twice each year that discussed the developmental trajectory of the target group, and the specific contexts, forces, and activities that influenced this growth. Specific attention was paid to collaborative inquiry processes with a focus on the nature of the teacher interactions and uses of data, connections to classroom practice, group leadership and facilitation, and administrative and community support. Themes emergent in the case reports were then used to frame further data analysis and findings, which were then renegotiated by the research team.

Three of the five authors played significant roles in the development and implementation of some of the PD discussed in this study. These roles included PD design, facilitation, and project oversight. These experiences added additional researcher insight into participant activity, but also increased the possibility of bias in data interpretation (Denzin, 1978). To minimize bias, the authors iteratively analyzed data sets to construct multiple interpretations via the case reports described above, and met regularly to critically analyze each others' interpretations of the data corpus. Zach, one of the members of SVMath, significantly participated in the final stages of data analysis and helped generate final themes and overarching results.

Results

Essential Characteristics of Effective Professional Collaboration

The SVMath teachers identified six specific characteristics of their effective collaboration:

- Creation and use of team roles and productive collaborative norms
- Open, honest team interactions focused on students
- Affective, structural, informational, and instructional support from the school principal
- Collaborative analysis and discussion of various student learning data
- Use of data to determine a precise, mutually-agreed upon content focus
- Translation of collaborative work into real changes in classroom practice

SVMath did not achieve these characteristics easily, nor quickly. We first describe the forces of change that provided catalysts for their development, and then discuss four shifts in participation that illustrate the precise nature and development of these six characteristics of effective professional collaboration. Although Jack was the only SVMath teacher participating in the first two years of formal collaboration, it is important to include these formative years in our discussion of the ongoing CTIG development in the district.

Forces of Change

For teacher and/or school change to occur, a complex network of people and material resources is likely to be present. While some resources support change efforts, others may have a negligible effect, and still others can limit or inhibit the change process. Resources become supports when they are accessible, usable, and beneficial to teachers (Slavit, Laurence, Kennedy, & Nelson, 2009). When professional collaborations play a role in the teacher change process, it seems inevitable that a resource network would contain multiple perspectives and points of origin (Mclaughlin & Talbert, 2006). The four forces that collectively comprised the bulk of the resource network supportive of teacher change in SVMath were needs-focused PD, administrative support, program-focused PD, and student learning assessments. Because the use of student assessments is thoroughly grounded in the shifts in participation described later, we focus here only on the first three supports.

Needs-focused Professional Development. Silver Valley participated in two PD initiatives that built resources to address areas of need identified by participants. The Partnership for Reform in Secondary Science and Mathematics (PRiSSM) was a three-year PD project involving middle and high school mathematics and science teachers; the authors (except Zach and Angie) played lead roles in the development and delivery. Each year began with a summer academy focused on building community, negotiating instructional beliefs and perspectives, developing inquiry perspectives and skills, and supporting lead teachers' abilities to organize and facilitate collaborative inquiry processes. PRiSSM provided monthly meeting time and a facilitator to assist groups through collaborative inquiry cycles. These progressed at various speeds and degrees of success. The SV teacher group's general progress is discussed in more detail later; additional discussions of PRiSSM are found in the literature (e.g., Slavit, Nelson, & Kennedy, 2009).

Immediately after PRiSSM, Silver Valley participated in a second needs-focused PD initiative called Guidance Plus Support (GPS), also developed and delivered by the authors. Principals in all three SV schools developed their own collaborative inquiry team for the purpose of examining how to better support teacher-research groups. Activities that supported the principal group's inquiry consisted of a summer academy, facilitated work sessions for both teachers and principals throughout the year, classroom observations, and consultation with mathematics facilitators and higher education faculty.

Zach and his principal, Brandon, participated fully in all GPS activities. Reflecting on his own status as learner, Brandon talked about the results of his GPS experience:

> We (administrators) probably had the steepest learning curve because half of us were new and, for the others, our involvement in an actual [collaborative inquiry team] had been limited. Our wrestling with the tough questions and issues gave us new insights into the difficulties of the process as it faces teachers, and helped us as building principals to be able to better assist our teacher [groups] in their quest to help students.

Figure 2
Silver Valley Focus and Vision for Students of Mathematics

Student Communication of Mathematical Understanding
As they communicate their mathematical understanding, students:
(1) Show appropriate mathematical thinking, justified with evidence and checking for accuracy, using words, pictures with labels, numbers, diagrams and/or graphs;
(2) Use mathematical language that builds conceptual understanding to explain their thinking, reasoning and solution process;
(3) Utilize effective problem solving strategies;
(4) Agree/disagree, clarify ideas, ask tough questions, engage in discourse, and are free to make mistakes;
(5) Apply mathematical concepts across the curriculum to solve relevant and real-world problems.

The initial, facilitated GPS session was devoted to constructing a district vision for mathematics around the question: "What do we want our math classrooms to look like in 5 years?" A set of student learning priorities regarding mathematical communication emerged (Figure 2). Specific ways GPS impacted the presence and nature of administrator support for SVMath are now provided.

Administrator Support. Silver Valley has a tradition of progressive leadership. In the mid-1990s, 60 minutes of weekly job-embedded PD was successfully negotiated and supported by the school board. Community support has remained constant, primarily due to effective communication and student learning gains. Brandon and other SV leaders sought to create a culture of professional learning, even as funds disappeared. For instance, when a middle school teacher voiced a need to learn more about student engagement, Brandon consulted with colleagues (including district, regional, and university experts) to identify possible options, eventually providing needed support.

Brandon's ability to garner resources and active desire to support teacher-initiated ideas engendered high levels of trust and cooperation from his teachers. Brandon spent approximately 10 hours per week in classrooms talking with students and supporting teacher requests to observe for evidence of learning. He was a frequent attendee at SVMath sessions, and maintained these interactions outside of these meetings on a regular basis to monitor and support the group's progress.

Program-focused Professional Development. During Years 4 and 5 (after PRiSSM's conclusion), individuals in SVmath participated in program-focused PD involving solutions to perceived student and teacher needs. For example, a focus on productive classroom discourse led to the school-wide enactment of Accountable Talk, similar to the Socratic questioning method for student inquiry. A series of workshops and coaching resources were also enacted that were inspired by the First Steps PD program, which is based on a diagnostic approach to surfacing student misconceptions. These experiences enabled the teachers to enhance their use of mental calculations and discussions of strategies, manipulative-based (e.g., fraction dice) number tasks, and other assorted instructional activities. This was a clear departure from more traditional methods of instruction by some of the SVMath team.

Further, two SVMath teachers, along with Brandon and others, participated in a Response To Intervention (RTI) program focused on number sense that SV Middle School would later adopt and align seamlessly with SVMath's inquiry objectives. RTI is designed to support teachers in identifying students as needing various degrees of instructional support and provides various ongoing assessments to monitor student progress. These PD experiences proved to be significant catalysts in the group's adoption of a true equity stance toward their instruction.

Shifts in Participation

We now discuss how these forces of change led to four shifts in the individual and group instructional practices of SV teachers, with a focus on members of SVMath. Collectively, these shifts represent a powerful impact of a professional collaboration that utilized a variety of supports and student learning data to truly transform their instructional perspective and practice.

Shift in Participation 1: Learning to Talk to Each Other. In Year 1, teacher interactions amongst the SV group consisted of serial sharing of instruction and assessment practices, with student learning measures usually described in terms of passing rates and grades. In addition, comments inside the teacher group that addressed student achievement were based largely on anecdotal data, with phrases such as "most of my kids are having trouble" and "my Period 2 class seems to get that" heard frequently. However, the teachers also began to reveal their beliefs about teaching and learning, building trust amongst individuals working together for the first time. The SV group, at this time, consisted of both mathematics and science teachers, and the inquiry focus of the group during the first two years was on the general topic of vocabulary development. Conversations in Year 1 tended not to probe deeply into specific issues of mathematics or science content for these reasons. Instead, despite the presence of a facilitator for most meetings, generalizations of students and student learning were couched in broad discussions of student learning goals and instructional practice. Analyses of group dialogue and facilitator's notes indicated that there was never a clear consensus on what students' "proper use of vocabulary" meant or what vocabulary knowledge looked or sounded like. An early meeting in Year 1 illustrates these different and emergent views (Rick and Maggie were high school teachers in the SV district):

> *Jack*: Do you introduce vocab at the beginning of the unit or do you introduce it at the end of the unit? This research [holding up a manuscript], according to the people at this research you do it right in the middle. Because to do it up front is pointless. At the end of the unit everyone has already learned the concepts anyway, so that's pointless, but if you do it halfway in between the kids can start making those connections.
>
> *Rick*: Trouble is I have thirty [potential vocabulary words]. Unless I've kind of settled on ten words, maybe I need to increase these [words to be assessed] to fifteen or twenty words.
>
> *Maggie*: I give them twenty-five.
>
> *Jack*: Well, what I do is I look at the [state standards] that we have. It lists all the math vocab, right? And then I marry it with what CMP [the mathematics curriculum used at SV Middle School] says about concepts we're going to cover with that unit. Make sure that I get all those concepts for sure. And then if there's one or two [words] that I want to re-support, like factors or factorization, so that they [all] have it.
>
> *Rick*: Maybe I could do more words.

The comments from Jack, Rick, and Maggie reflect a type of interaction that permeated the first-year dialogue. Embedded in their discussion, but never explicitly examined, are multiple perspectives about what is important regarding students' understandings of scientific and mathematical vocabulary. On the one hand, throughout the year, the teachers repeatedly referenced vocabulary games and flashcards as a means of supporting students' recognition of vocabulary when encountered on tests. Hence, there was a clear but inexplicit goal articulated within the teacher group of students learning specifically-worded phrases that would match with given vocabulary terms. Alternately, and to a lesser degree, the teachers (especially Jack) sought ways of supporting students' abilities to use vocabulary meaningfully when discussing mathematical or scientific concepts. Hence, while teacher interactions attempted to address meaningful instructional issues, a lack of student learning data, inconsistencies between instructional perspectives, and a non-specific content focus thwarted these attempts.

Conversations in Year 2 were less productive. Because of the presence of overly dominant voices as well as a limited data set with which to understand learners and challenge current practices, teacher interactions in Year 2 can be characterized as congenial (Grossman et al., 2001). Such conversations avoid cognitive conflict to maintain pleasant relationships and teachers "behave as if we all agree" (p. 955) and pretend to share values and beliefs, but in fact fail to delve deeply or critically into meaningful issues. The only student learning data collected in Year 2 was a single pre/posttest which provided little insight into the specific learning approaches or understandings of students, and did little to frame critical explorations of current instructional practice. This left the teachers to rely on anecdotal information; Year 2 conversation is flush with teacher stories, many of which were unrelated to each other and the inquiry focus of the group.

Year 3 was a unique year in that two different sets of collaborative teacher teams were in place at SV Middle School. The PRiSSM team was concluding while the content-based SVMath teacher team emerged. SVMath embraced the opportunity to work in content-based teams and quickly developed a set of collaborative norms and a positive working environment, despite the lack of a formal facilitator. Distributed leadership truly emerged, as different members took on different roles and responsibilities within the group. These included agenda setting, data organization, and task oversight, with curricular coherence across Grades 5 to 8 comprising one of the main goals of the year.

In the two years after PRiSSM (Years 4 and 5), SVMath held weekly, hour-long meetings. Written/electronic agendas and maturing group norms and roles provided structure. The teachers in SVMath characterized Year 5 as "effective" and "powerful" professional collaboration. Comfortable with group norms, roles, and interpersonal communication styles, and supported by past PD experiences and ongoing initiatives at the school, SVMath enacted three significant changes to their individual and collective practice. First, the teachers switched to a focus on number sense with subsequent instructional change supported by targeted PD events (First Steps and RTI) that occurred early in the school year. Second, a firm commitment to principles of equity and a desire to improve the mathematical development of all students emerged in Year 5. Third, the group's maturing data collection and analysis process, described below, enhanced the decision making of the group. This shift in inquiry focus and teaching perspective produced significant changes in the nature of the conversation inside the group. Questions and uncertainty became more prominent, and a sense of inquiry about instruction emerged. For example, SVMath devoted an entire session in the middle of Year 5 to a collaborative analysis of student work on tasks from AIMSweb, one of several mathematical learning assessments used by the group. Details of student thinking were revealed and discussed by the teachers, which prompted Laura to make the following reflection:

> I'm finding kids I thought might be pretty low aren't actually as low as I thought. I've got a kid here in Host (remedial instructional group) who is just below 75. I don't know if she needs to be [in Host]. But I'm also going to look at their MAPS scores and their [state achievement test] results. Because if you look at it, I have another kid in here, he will show really low on [AIMSweb]. He's as slow as they come. But he passes the [state achievement test] with flying colors. He scored a 232 on his MAPS, so he'll do fine. And he may score in less than 50 percentile [on AIMSweb], but there's no way I would put him in [Host]. He's just a slow worker.

Shift in Participation 2: Individually Using Student Data to Inform Practice. The SV teachers devoted significant time in Year 1 to exploring data collection and analysis methods. Among other things, the teachers attempted to record and share classroom conversations and conduct peer observations. However, they found some of their data, such as recordings of their classroom discussions, to be unusable given the time and equipment available. They also encountered significant challenges in sharing and co-analyzing student work due to the differing grade levels and courses taught. Several months into the process, one member described their inquiry status as "spinning its wheels," and the group continued to wrestle with how to collect and use data the following year. As stated, a single pre/posttest constituted the entire data collection on student learning in Year 2. While this provided little information on student development, the teachers' own understandings of the relationships between clear learning goals and appropriate assessments began to emerge.

The following year, as teachers' understanding of data continued to grow, the nature of the collaboration inside the PRiSSM teacher team changed. Each teacher collected a variety of student assessments specific to their own content focus. Meetings during Year 3 were similar to case stories (Hughes, Smith, Boston, & Hogel, 2008), as teachers reported their focus, data collection, and analysis to the group, receiving both feedback and support. While this prevented an analysis of common assessments around a shared learning goal, the teachers began to delve more deeply into their own students' thinking. While the PRiSSM teacher group made significant, albeit individualistic, uses of student learning data, the SVMath group focused on curricular and instructional alignment that made minimal use of data. Collaboration around student learning data for SVMath did not significantly occur until the following year.

Shift in Participation 3: Collaboratively Using a Variety of Student Data to Inform Practice. In Years 4 and 5, a collaborative focus on SVMath's student-learning data collection and analysis emerged that was quite expansive and thorough. Early in Year 4, the teachers used state achievement data to identify problem solving as a collective area of student need, leading to the inquiry question: "How can we help students improve their problem-solving skills?" The teachers then administered and collectively scored a series of open-ended mathematics problems. Michelle summarized their findings:

> Students don't know what to do, or how to start attacking the problem . . . Is it that the students can't communicate their understanding because they don't understand the mathematics, or because they don't know how to explain their thinking?

Teachers agreed to modify their instruction to include multiple solution methods and to better monitor students' problem-solving ability, including verbal and written explanations.

Year 4 informally started before the actual school year began. With support from the GPS Project, a dozen teachers from the SV school district, including one from SVMath, attended a two-day professional development workshop on the STAR Protocol, a student-centered classroom observation tool (BERC, 2009). This coincided with the district's main educational focus on peer classroom observations. Additional GPS workshops impacted the direction of the team by supporting administrators and SVMath in aligning mathematics instruction and assessment practices. As discussed, analysis of state achievement test data led the group to focus on problem solving and number sense, leading to the implementation of additional problem-solving activities and assessments. Despite this, SVMath encountered stumbling blocks and inconsistencies as the year progressed. For instance, while insights into student learning were gleaned from reading, scoring, and discussing problem-solving assessments, many felt ineffectual in responding to the team's inquiry question for two reasons. First, most team members felt their insights into student thinking didn't help them know how to change their instructional practice. Second, the team felt a quantitative data approach might better provide evidence of student learning gains. As Zach reflected,

> We simply scored and discussed the assessments and moved on to the next grade level's problem-solving assessments. Data were not fully analyzed or measured to depict student growth or directly used to respond to holes in students' mathematical comprehension. Unfortunately, the full potential of the data was not capitalized upon; it was simply collected and discussed without it truly being analyzed or applied back to the classroom.

An inability to adequately process and analyze data is an unfortunate commonality in teacher work of this kind (Slavit & Nelson, 2010). Further, we have found teachers often take a "proving stance" toward collaborative inquiry, exhibited by the desire to show quantifiable student learning gains (perhaps to an external audience, such as the principal), rather than an "improving stance," embodied by a desire to collect and use data to better understand the teaching and learning environment in order to make appropriate changes to instructional practice (Nelson & Slavit, 2010). Here we clearly see SVMath challenged by these perspectives.

In Year 5, Jack and Zach enhanced the team's inquiry by sharing a variety of quantitative learning measures they had collected over time (e.g., state achievement test, Measurement of Academic Progress (MAPs), AIMSweb, and Brigance Assessments). This triangulation of data increased teacher's understanding of students' number sense development and further informed their efforts to investigate student learning. The teachers' ability to routinely access these resources and to use them productively is significant. Their commitment to understanding learning at both the individual and program level allowed them to gain a deep and nuanced understanding of the impact of their current practices. A powerful example of this shift in practice is evidenced in a conversation regarding the teachers' use of mental math strategies at three different grade levels:

> *Laura* (Grade 5): You know we were talking about doing the mental math, and I had one of those practice sheets on the distributive property. I said, "You can't write anything down, but you can think about the problem broken down. 93 plus 9 is 90 x 9 plus 3 x 9." They couldn't do this, but by the end of the period they're going, "This is so easy, this is so easy." All of a sudden they can do this mental math so much better than they could before, and they love it. And the distributive property is helping them do that mental math so much more easily because they're figuring out 93 is 90 plus 3 … I didn't show them boxes yet, we're going to get into that.
>
> *Alex* (Grade 8): The area model?
>
> *Laura*: I just had them do the 400 times 9, the 60 times 9, and the 3 times 9, then just add those up. Most of them can do it in their heads. But I don't think, the kids are so unused to having us say do it in your head. It's like, "Wait, I have to write this down?" No you don't, do this in your head.
>
> *Alex*: Normally I have entry tasks. Today I said, "This is not an entry task, do this mentally." … The first one was 18x6, and these kids want to do the algorithm. 6x8, 6x1. Bit is it really a 1 or a 10? I said if you're going to do that method, please throw it out the window. 6x10 is 60, then add 48 …
>
> *Jack* (Grade 7): Did anybody say, "But half of 18 is 9, so 6x9 is 54, 54 plus 54" –
>
> *Alex*: That's what I did. Nobody realized that. They liked that, so I showed the factors of 18. What about 3 and 6, 6x6 is 36, 36x3, that might work for you. Another one

we looked at was 14x15 to see where kids go, and a lot of them did 10x14, then 5x14 … Then I said I know 15 squared is 225. Then we talked about groups.

Jack: I used that problem for my entry task…

Alex: There's some brilliant strategies. And somebody said, "I wouldn't do that for this problem." I said, "You're right. I'm not going to use the same strategy for each problem." That was great.

Jack: What might work for one person might not be easy for another.

The collaborative analysis of student data, and subsequent discussion, enabled SVMath to make significant changes to their classroom practice. As importantly, these data collection efforts spurred a shift the following year towards principles of equity and attention to all learners. Evidence of this shift is provided in the following section.

Shift in Participation 4: Taking Seriously the Notion of Reaching All Learners. A genuine commitment and attention to equity within SVMath occurred in the final year. An advanced use of student learning data was key, as was a renewed purpose to rethinking both individual and collective instructional practices. The variety of resources, described above, that engaged the work of SVMath were fundamental to the formation and success of this work.

In Year 5, the teachers collaboratively analyzed their continuously updated database to make decisions on supporting the number sense development of each individual student. Three learning levels identified by RTI framed the group's analysis, and a timed, four-minute number sense assessment placed students into one of three categories: Benchmark, Strategic, or Intensive. These classifications were a genuine commitment to equity and not intended to "pigeon-hole" a student, but rather to identify their mathematical needs, and students were tested at least twice a month to monitor change. Comments from SVMath teachers consistently expressed a desire to "move kids up," and the teachers identified specific instructional approaches to accomplish this. Students classified "Intensive" were placed into a highly-structured program focused on developing number sense skills utilized in the Benchmark/Strategic classrooms. Students categorized "Strategic" received an additional twenty-five minutes of daily number sense instruction. All students received a renewed number sense curriculum that included additional problem solving and student-centered instructional tasks, many of which were inspired by the previously-discussed PD projects or developed by the teachers themselves. Teachers discuss student progress at a meeting in early January:

Laura: Guess what (student) got? What did he get last time?

Theresa: I'm trying to remember, like 23?

Laura: 54.

> *Theresa*: I can't remember what he got last time but it wasn't that good.
>
> *Laura*: No, it was very low.
>
> *Theresa*: I was thinking it was less than 10%.
>
> *Laura*: He's plus 75. She's given it to a few kids we picked out, so this was his second time. Greater than 75% right now, and he's only been working with Iris for two weeks.
>
> *Theresa*: So he can do it.
>
> *Laura*: Yes, he needs a smaller group too to be successful. He's very competitive. It was funny, today she said, "I've noticed he's gotten a little cocky, but it's not a bad thing because maybe he feels good about something for once."

While SVMath acknowledged each individual student assessment as inadequate for characterizing learners, they had confidence in the broad set of information from which they were making decisions, and their team analysis of student work added promise to their efforts. Follow-up data in Year 6 showed that teachers were continuing to monitor student number sense development, and were frequently moving students up and down the RTI levels; this initiative was not tracking (as it possibly could be), but a genuine, data-based commitment to the mathematical success of each of their learners.

Transcript analysis, particularly from Year 5, reveals numerous examples of the characteristics present in SVMath's effective professional collaboration, including the emergent focus on equity. To provide illustration, we focus on a team session two months into the school year that illustrates the ways in which SVMath used student data to pursue inquiry and discuss changes to classroom practice. Discussion initially focuses on if and how the teachers can reach all learners:

> *Michelle*: We still aren't sure what to do about those kids, what do we do when they don't get it? I don't feel like I can keep practicing adding and subtracting. I feel like I need to move on. My goal is fractions, decimals, and percents . . . Some of them aren't very comfortable with place value. Although it seems like you gear off those kids that are right there giving you the answers, you've got to remember there's a bunch sitting out there that are —
>
> *Laura*: I'm actually thinking about changing the way I'm doing math. I found a team that can't subtract . . . I'm going to put another team in CMP, so one of my teams is going to be doing prime time, another team is going to be . . .

This discussion illustrates the ways in which equity became a centerpiece of group discussion around number sense development. Explicit attention was given to the "bunch sitting out there" throughout the year, and the teachers were now able to provide multiple forms of instruction to address the learning needs of their wide variety of learners.

As stated, the complex nature of the existing resource network provided a wealth of opportunity for the team to rethink and change their practice. This was clearly evidenced in numerous discussions during Year 5, such as the following:

> *Laura*: I started doing, you know where [a PD provider] said play these games. I turn the projector on and I roll dice. They have to make columns of 10 . . . Then I do multiply the dice, then I did subtract the smaller from the larger, and we've done it, we do it Fridays for about 20 minutes —
>
> *Jack*: 20 minutes?
>
> *Laura*: Yes, is that okay?
>
> *Jack*: I think it's awesome . . . What we learned at training is the kid that's still at that counting stage, there is no way they can do that in 3 seconds. No way. They have to be able to recognize numbers and analytically process that data that fast or they can't do it, so it's training them to do it quickly.
>
> *Laura*: And the kids who hated it at the beginning, after four times they're going, "Can we do that dice thing again?" Then I found some 12-sided dice . . . I totally make it up as I go, but if there's time I do 4 or 5 columns. What did she call it? Subitizing? Where you put things in groups and you're able to do that mentally. Some kids can't do that, they don't know what 10 looks like, but some kids look at those dice in random patterns and they see 3, 3, 3, 1 —
>
> *Michelle*: So they have to begin to see the groupings.
>
> *Laura*: Yes, and that's what we talk about. There were 14 on this, how did you do this? One of the kids will say there were 5 here, 5 here, then 4 here.
>
> *Jack*: It helps them transition up from that counting stage into a higher-level stage.
>
> *Laura*: Yeah, 'cause they're hearing it. That kid that's trying to count 14 going, "I can't count 14 in 3 seconds," they're going, "Oh, 5, 5, 4." And they begin to hear their peers say it, and it becomes more useful to them.

Conversations that addressed specific instructional change based on knowledge of student learners were not present in prior years. The focused mathematical goal of number sense, the usable student learning database, and the wealth of developmental opportunity arising from a broad resource network supported the teachers in achieving this level of professional sophistication.

Conclusion

SVMath illustrates the power of a dynamic resource network responsive to and partially framed by teachers. No single force would have made such a difference, but collectively the resource network significantly influenced cultural and structural change in the teachers' professional lives. A cultural shift towards equity principles and school-wide attention to all learners' mathematical needs, including the use of more student-centered instructional strategies, is highly significant. The collective wisdom of this professional collaboration increased teacher efficacy and flattened the power structure. The generative, collaborative work was heavily dependent on the teachers' fluency with using data to inform instructional decisions around shared mathematical content.

The importance of powerful teacher talk in collaborative professional development is becoming increasingly clear (Horn & Little, 2010; Nelson & Slavit, 2010). For powerful talk to occur, teachers must be comfortable in sharing questions and uncertainties, challenging the status quo of practice, and reinterpreting views on teaching and learning from other perspectives. As was seen in the early years of the SV PRiSSM group, their talk was characterized by the sharing of stories and individualized practices—i.e., they were congenial but not collegial (Lieberman & Miller, 2008; Little, 2007; Nelson, Deuel, Slavit, & Kennedy, 2010). A number of factors supported their shift to more productive talk, resulting in specific impacts on their classroom practices and their students' learning. Specific attention to this aspect of teacher collaboration can help groups overcome resistance to or fear of opening up their instructional practices, resulting in shifts away from the status quo. In addition, powerful talk can support groups to develop and commit to developing a more common vision of practice. A commitment to this vision requires an expectation that questioning and challenging of ideas, practices, and beliefs is normative and not a personal insult or affront.

SVMath engaged in a collective examination of student learning data for a clearly defined purpose in the fourth year of their collaborative work, identifying number sense as their inquiry focus. This study illustrates considerations for teacher educators when seeking to support such talk through analysis of student work. First, student learning data is an important tool in surfacing problems of practice grounded in ongoing student thinking and achievement. But collecting student data is insufficient in and of itself; teachers must also be afforded the necessary time to collect and fully explore these data, and then possess the ability to adequately analyze, interpret, and apply their findings. Through a variety of resources, the teachers in this study were provided with these important abilities and opportunities. Further, their efforts were grounded in a host of PD initiatives that supported group functioning, student-centered instruction, and nuanced uses of student learning data. These affordances were key in generating an instructional stance toward equity and teaching to the mathematical levels of all students.

Despite a cross-grade composition, SVMath is an example of how structures and supports can positively influence a more equitable view of student learning that leads to instructional change. The long-term, complex development of this group is testimony to the tremendous difficulties inherent in teacher change through collaborative PD processes. The shifts in participation accomplished by SVMath became a part of the math teachers' culture. This is critical, as even when all teachers are required to be involved in collaborative PD, there is a chance that teachers who may be resistant will simply revert to the status quo of previous practice when explicit PD support expires. However, when there is a cultural shift and collaborative inquiry becomes authentically embedded as a normal part of what teachers (and administrators) do, it would be very difficult for an individual teacher to disregard the new norm.

This study makes clear that such long-term change involves a variety of supports and can manifest itself in a variety of shifts that, collectively, produce important and significant changes to the structure and impact of a collaborative inquiry team. As collaborative frameworks continue to expand throughout the PD landscape, it is vital that we remember the necessary role of time and support for teachers engaged in these processes. For collaborative PD to be impacting, supports must consider the important roles of teacher talk and student learning data as potentially transformative forces in professional growth. We encourage additional research of a long-term nature to further explore these issues.

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