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PROFESSIONAL COMMUNITIES IN THE CONTEXT OF TEACHERS' PROFESSIONAL LIVES: A CASE OF MATHEMATICS SPECIALISTS

ABSTRACT. We describe an urban school initiative aimed at teachers' professional development with the goal of increasing their mathematics content knowledge and helping them improve their practice. In the lowest performing schools, mathematics specialists were employed to teach only mathematics in upper-elementary grades (ages 9–12). One aspect of this initiative was a provision of time and space for the formation of site-based professional communities that were intended to support teachers in trying to implement changes in their practice. Teachers' professional communities developed at some sites and not at others. In this analysis, we explore the conditions that afforded or constrained the development of teachers' professional communities. Using two contrasting school sites as examples, we describe five aspects of the teachers' individual and collective professional lives that influenced the emergence of teachers' professional communities.

KEY WORDS: context of teaching, elementary mathematics teaching, inservice teacher education, mathematics specialists, professional development, teachers' professional communities

Teachers' professional communities are advocated as an effective means of supporting teachers into continuing inquiry into practice (e.g., Cochran-Smith & Lytle, 1999; Little, 1993; National Research Council, 2001; Nelson, 1997; Smylie, 1994). Yet, as Smylie (1994) noted, "...it is not clear how such communities have come to be or how they may be created and sustained through programs and policies" (p. 165). The focus of the research we report on here was on the emergence of site-based professional communities formed by upper-elementary mathematics teachers who were participating in a professional development initiative that was intended to support their continued professional growth.

The elementary mathematics teachers are part of a reform of mathematics instruction in the eight lowest-performing schools in a large urban school district in the western United States. The teachers are *mathematics specialists* who teach only mathematics to other elementary teachers' students. The preparation of mathematics specialists included extensive professional development in the form of mathematics

and pedagogy courses taken at a local university and six professional development days arranged by the school district. Two master elementary school teachers on loan from the school district provided additional on-site support. Furthermore, the mathematics specialists were provided with substantial time for professional development in a shared office space. The coursework, site-based support and daily, shared professional development time were intended to facilitate teachers' sustained growth in content knowledge and practice. The designers of this reform initiative expected that these conditions would promote continued growth by the mathematics teachers in this initiative – growth supported by the formation of a "professional community". Teachers' professional communities developed at some sites and not at others. What aspects of these teachers' professional lives afforded or constrained the development of professional communities at their schools?

THEORETICAL PERSPECTIVE

Our theoretical perspective and choice of frameworks emerge from our goals as mathematics educators collaborating with the mathematics leadership in a large, urban school district to support teachers' development. One of our research goals is to understand the instructional practices of the teachers so that we can support their continuing development. Part of our research involved investigating the relationship of professional development to teachers' knowledge and practice, with professional development seen as encompassing formal and informal sources of support. This work can be characterized as intervention research because it was generated through interaction and communication with practice (Krainer, 2003). Results of our research informed our work with teachers in the subsequent year. Though the participants were unaware of research constructs and connections to the larger body of research literature, the gathering of data from teachers and university instructors was an intervention into their learning processes. Research potentially influenced practice when, for example, university instructors and teachers were asked formally to reflect on aspects of their practice.

Studies suggest that learning the mathematics of the elementary school curriculum deeply, increasing attention to student thought and examination of student work, changing beliefs about the nature of mathematics and what students can do, and participating in a supportive community are elements that support changes in instructional

practice (Hiebert, 1999; Nelson, 1997). We sought a theoretical perspective that accounts for individual development while acknowledging that teachers' instructional practices are influenced by perceived organizational constraints and both formal and informal assistance (Cobb & McClain, 2001; Stein & Brown, 1997).

For our work, this means we see the learning processes of teachers as encompassing more than explicit teaching events, such as coursework at the university or professional development days arranged by the school district. In our approach, we adopt a situative perspective where individual actions are viewed as aspects of an encompassing system of social practices (Cobb & Bowers, 1999). We view the practices of the teachers as situated within their professional communities and in the schools and school district in which they work. We focus on the reflexive nature of the settings of teacher learning and teachers' different kinds of knowing (Cobb & McClain, 2001; Putnam & Borko, 2000). Our working hypothesis is that teachers' practices develop within a community and that local contexts can play a crucial role in teachers' beliefs, knowledge, and conceptions of effective pedagogy (cf., Franke & Kazemi, 2001; McLaughlin & Talbert, 2001).

The communities of importance to us are communities of people who have organized themselves for action around a shared sense of purpose (Secada & Adajian, 1997). Members of the community are accountable to each other in achieving goals associated with this shared sense of purpose. Wenger (1998) defines "communities of practice" in describing a group engaged in a joint enterprise to share significant learning. Bellah, Madsen, Sullivan, Swidler, and Tipton (1985) suggest the added constraint that this socially inter-dependent group also share practices that define the group. Likewise, Wenger suggests that in this shared endeavor the community develops a shared repertoire and tools that define the community. A mutual accountability develops that includes what the community values paying attention to, what the community considers important, and what artifacts and actions are considered acceptable by the members of the community.

Professional communities have some particular features. Members of the same profession "...share a common sense of identity and common values; they share the same role definitions, in relations to members and nonmembers alike; they share a common language; and they control the reproduction of the group through selection procedures and socialization processes." (Goode quoted in Grossman, Wineburg, & Woolworth, 2001, p. 964). The self-selecting nature of communities around shared enterprise distinguishes them from teams brought together by formal predetermined goals or networks that have no joint

enterprise (Krainer, 2003). Furthermore, for instructional purposes, the practice of the profession's newest members is open to review in what is known as deprivatization of practice (Secada & Adajian, 1997).

In particular, in the profession of *mathematics education*, one may view the National Council of Teachers of Mathematics (NCTM) Principles and Standards (2000) and Professional Standards for Teaching (NCTM, 1991) as attempts by a national professional community to develop a collective vision for mathematics teaching and learning. These documents describe common values, roles, and goals for the teaching of mathematics. In this profession, teachers are asked to develop practices that embody certain values and principles rather than implement particular skills. At a local level, small communities of mathematics teachers are engaged in on-going collaboration with the purpose of interpreting values and principles, achieving shared goals and forging shared norms and practices.

We see the strength and nature of local mathematics teachers' professional community as significant because (1) professional communities can mediate interpretations of reform efforts, and (2) professional communities can support the sort of inquiry necessary for developing shared practices that embody shared values and principles. Empirical and theoretical evidence suggests that the strength, nature and focus of teachers' professional community can mediate a school's effect on student learning. A school community can filter broad principles and affect interpretation of a reform's goals (cf., Knight, 2002; Perry, 1996; Talbert & Perry, 1994).

Mathematics teachers' professional communities can support inquiry into instructional practice. Franke, Carpenter, Fennema, Ansell, and Behrend (1998) distinguish between teachers who search for successful practices and teachers who examine their practices in relation to their own thinking. When teachers examine what the broad principles look like in practice, they are engaged in generative change (Franke et al., 1998). This kind of examination fuels the teachers' ongoing learning and enables them continually to improve their practice. The existence of a professional community may be critical in supporting experienced teachers learning to teach in new ways (Franke & Kazemi, 2001; Stein, Silver, & Smith, 1998).

Teachers' professional communities provide not only a space, but can also provide an environment for learning about teaching practice. Mathematics teachers in communities engaged in the joint enterprise of inquiry into practice can experience the kind of learning that we, as mathematics educators, advocate for students. Current reform

initiatives call for teachers to establish in their classrooms "communities of learners" where students explore subject matter in depth (Thomas, Wineburg, Grossman, Myhre & Woolworth, 1998). Rogoff (1994) explains that the basic premise of a "communities of learners" mode of learning is that learning occurs as people participate in shared endeavors with others. In a community of learners, both mature and less mature members share responsibility for knowing, directing and structuring shared endeavors. In the vision of mathematics teaching described by the mathematics reform, teachers manage children's mathematical learning, but serve as facilitators, not dispensers of knowledge. Mathematics classrooms are seen as places for students to engage actively in personal meaning-making with an emphasis on the process of learning mathematics (Stein et al., 1998).

Changes in practice require engagement that helps teachers construct new meanings rather than acquire information (Knight, 2002). If we assume that different models of learning place the learner in a different relationship with what has been learned, the implication is that teachers' participation in collective meaning-making endeavors, cited as important for children's learning, places them in a different relationship with what they learn than traditional models. In other words, one argument for teachers' professional community is that teachers, too, learn differently when engaged jointly to learn about teaching. Furthermore, teachers who have come through a different model of learning, that is an adult-directed model of teaching and learning, often find it difficult to align themselves with the community of learners model (Rogoff, 1994). As teacher educators, we ask teachers to teach in ways that they have rarely experienced themselves. In order to lead their students in such activity, teachers themselves need to share significant learning in a community.

In sum, we see the practices of teachers as situated within the professional communities, schools and school districts in which they work. The strength and nature of teachers' professional community is significant in teachers' interpretations of mathematics reform goals and values, support for teachers' working out principles in practice, and engagement in the kind of learning we advocate for students. This is not to suggest that all teachers' professional communities support the adoption of reform goals and values, but that professional community can be significant in local interpretation of collective professional values and goals (cf., Perry, 1996; Talbert & Perry, 1994). The research discussed here explores the organizational and individual factors that afforded and constrained the development of teachers' professional

communities at the school sites. We begin by situating teachers' professional lives in local context.

Teachers' Professional Lives

Our work is embedded in a large, urban school district. The superintendent of the district had developed a broad-based system-wide plan to increase student learning in literacy and mathematics. The plan oriented the organizational system around instruction. The leadership in the central office designed an initiative that invested in improving teachers' practice. It emphasized professional development and focused attention initially on low-performing students and schools. Instructional leaders were given the task of leading "learning communities" of principals. The initial focus of the system-wide plan was on implementing a Literacy Framework. Literacy peer coaches were hired to work in schools to support teachers and to work with principals to design and implement professional development. At the start of our work with the district, literacy had been the focus of the reform efforts for two years. The instructional plan called for elementary school teachers to teach three hours of literacy a day, in mornings only. Principals encouraged or "required" adoption of specific literacy strategies (Hightower, 2002). At the time of this research, mathematics had received little emphasis in the district-wide implementation of the plan.

In other ways, the plan to increase students' mathematics achievement had unprecedented support. It involved a partnership of private industry, university mathematics educators and the school district. Local businesses, particularly private industry in the technology sector, expressed a desire to assist in efforts better to prepare students for the workforce. A private foundation was formed to assist the school district's reform efforts in mathematics and science education. In addition, the mathematics leadership of the school district well understood reform efforts in mathematics and they supported the vision of the improvement of mathematics instruction as described by NCTM documents (1991, 2000). All the members of the core mathematics leadership team at the school district had been involved in leadership roles in mathematics education on a state and national level.

Within this district-wide effort, the lowest performing schools (as determined primarily by scores on a standardized test) received additional support. This included an extended school year, an additional staff developer, allocation of additional 1st grade classroom materials for literacy, and enhanced efforts at communication with parents. One

component of the plan to increase student achievement in mathematics was to assure that all students in grades four through six were taught mathematics by teachers with special preparation in mathematics. To begin this work, the eight lowest performing schools in the district hired 32 additional teachers to their staffs, with the understanding that these teachers would teach only mathematics (three classes each 90 minutes long), that they would have 60–90 minutes each day together for professional development time, and that, while teaching the first year, they would take university coursework developed to help them obtain a deeper understanding and ability to teach mathematics. Through the partnership with private industry, new curricular materials, specifically *Everyday Mathematics* (UCSMP, 2001), were purchased for these schools. The teachers applied for the mathematics specialist positions directly to particular schools. The school principal made the hiring decisions. At a few schools, teachers that were already at the site were encouraged to apply. Other sites hired all their staff from outside. For the most part, teachers who sought out these positions reported doing so because they enjoyed teaching mathematics, but a few cited a desire to teach something other than literacy.

During the day, these *mathematics specialists* taught mathematics to three classes; thus each taught about 100 students every day. The teachers had 4–28 years teaching experience, with an average of 10.9 years. Fourteen of the 32 teachers reported no prior mathematics professional development. About half of the mathematics specialists were bilingual in Spanish and had a credential for teaching bilingual children. 57–91% of the students in these schools were English Language Learners (ELL) and were predominantly Spanish speaking.

The university-based mathematics specialist professional development program for the teachers consisted of 12 semester hours of coursework designed specifically for a certificate program. Two experienced instructors taught the 6 semester hours of mathematics. Both had master's degrees in mathematics and experience teaching elementary school mathematics to preservice teachers. The 6 semester hours of mathematical pedagogy courses were taught by two teachers-in-residence (TnRs) who were master teachers on loan from the school district, who had prior experience in high-poverty, culturally diverse schools and as providers of professional development.

The focus of the mathematics courses was on learning the mathematics of elementary school in a deep, connected way and changing beliefs about the nature of mathematics. The focus of the pedagogy courses was on children's thinking about mathematics with increasing

attention to student work, pedagogical issues concerning teaching second language students, and curriculum implementation. Many elements identified by Nelson (1997) as supporting changing practice (learning mathematics conceptually, attending to student work, changing beliefs about mathematics and teaching, and participation in a supportive community) were goals of this reform effort.

In addition to teaching courses, the two teachers-in-residence provided extensive on-site assistance in pedagogy. Each teacher-in-residence worked with four schools, visiting them each week to plan with teachers, to observe, and to discuss what had been observed. These meetings were often focused on a need that had been identified by the teacher. The teachers-in-residence frequently visited teachers in their classrooms and assisted them with the many problems inherent in teaching from new textbook materials to poorly prepared students, many of whom had little understanding of English. The teachers-in-residence occasionally co-taught a class. The period of time designated each day for professional development provided an opportunity for reflection with the teacher-in-residence. Even though the teachers-in-residence were the instructors of the education courses, their relationship with the teachers would be described as similar to a peer coach and not evaluative. In addition, the university mathematics instructors met with the teachers to support their work in the mathematics courses. The university mathematics instructors also observed classes in a coaching capacity.

In sum, our initiative was embedded in a school district-wide reform organized around increasing student achievement by improving teachers' practice. Experienced teachers were hired as mathematics specialists. They began work in the lowest performing elementary schools, while completing coursework designed to help teachers obtain deeper understanding of elementary mathematics. The school district provided the opportunity for shared, daily professional development time for the mathematics teachers in addition to on-site coaches and a new curriculum.

METHODOLOGY

Defining Teachers' Professional Communities

In our analysis of the site-based communities that emerged at these schools, we use the construct of *teachers' professional community* as defined by Adajian (1995) and Secada and Adajian (1997). Secada and

Adajian operationalize this construct along four dimensions: (1) shared sense of purpose, (2) co-ordinated effort to improve students' *mathematics* learning, (3) collaborative professional learning and (4) collective control over important decisions affecting the mathematics program. A shared sense of purpose refers to teachers' shared values and goals as related to mathematics. Their co-ordinated effort to improve students' mathematics learning reflects their working together toward shared goals. How closely teachers work together to improve teaching practice reflects collaborative professional learning. Finally, the last dimension of teachers' professional communities reflects whether the teachers as a group exercised collective control over important decisions.

It is important to note that a situated analysis focuses not on the structural analysis of an institution but on teachers' activity and experience as situated within the institution (Cobb & McClain, 2001). In many ways one would describe the structure of these eight elementary schools as the same. However, the teachers' professional lives varied from school to school. Teachers' professional communities formed at some of these sites and not at others. In this paper, we focus on teachers' experience at two of the eight schools participating in the first year of the mathematics reform initiative because they illuminate aspects of teachers' professional lives that affect the formation of teachers' professional communities. In what follows, we will first discuss the two schools in terms of degree of alignment along the four dimensions of teachers' professional community. We then discuss aspects of teachers' professional lives as they relate to the development of teachers' professional communities.

Data Corpus

Our data corpus for this aspect of our research included field notes of observations and visits to schools, semi-structured interviews with teachers and mathematics administrators, teachers' written reflections in surveys, teachers' coursework, and observers' answers to a survey about curriculum implementation. The weekly field notes were compiled from the two teachers-in-residence who were providing regular on-site support, mathematics instructors as they visited the schools to work with teachers, and the first author who visited less frequently to observe classes or discuss student achievement results with the teachers. As mentioned earlier, the two teachers-in-residence and two mathematics teachers observed classes and met with teachers individually and collectively during their professional development time. The

weekly field notes included (1) how they spent their time with teachers during professional development time, (2) difficulties and strengths of instructional practice noted in their observations, (3) site factors that seemed to have impacted on teachers' practice and (4) summaries of conversations with administrators and others at the site.

Also, the data corpus included the notes of the first author's interviews with teachers. Mid-year and end-of-year interviews included questions that asked teachers to reflect on ways in which they felt their instructional practice or mathematics knowledge had changed and what had provided support for this change. The data corpus included the written reflections of the teachers as they responded to questions posed by the instructor, papers for class, and a survey given at the end of the year. For example, at the beginning, middle and end of the year, teachers were asked to write about what constitutes effective mathematics teaching. We documented changes in teachers' pedagogical content knowledge as measured by a pre- and post-intervention survey. The items from this survey were primarily taken from a survey developed for an earlier research project (Sowder, Philipp, Armstrong, & Shappelle, 1998). Figure 1 provides an example of a survey item with both content and pedagogical components. In this item, teachers were asked to order decimal numbers and also to comment on misconceptions that students might bring to the task. The teachers' coursework was considered in concert with the content instrument in an assessment of changes in teachers' pedagogical content knowledge.

The four observers (two teachers-in-residence and two mathematics instructors) answered a series of questions for each teacher regarding how closely each of the teachers followed the curriculum. The responses of the four observers were summarized and the observers reconciled any differences. The data also included an interview with a member of mathematics leadership team at the school district most familiar with the professional lives of the teachers at these schools. Table I shows a summary of the data collected as well as the people

a. Place the following three numbers in order from smallest to largest.
   0.5, 0.42, 0.423
b. Margaret, Sammy, and Maria placed them in order as follows. What might each of the students be thinking? How could you find out?
   Margaret: 0.5, 0.42, 0.423
   Sammy: 0.423, 0.42, 0.5
   Maria: 0.42, 0.423, 0.5

Figure 1. Example of item testing teachers' mathematics and pedagogical understanding.

TABLE I
Summary of data collection

Data	Who collected data
Compilation of field notes of observations of classroom practice, visits to schools during professional development time and district professional development	Four instructors (two teachers-in-residence and two mathematics instructors); researcher (first author)
Interviews with teachers and mathematics administrators	Researcher (first author)
Teachers' written coursework and reflections (as part of classes)	Two teachers in residence
Teachers' major mathematics exams (as part of classes)	Two mathematics instructors
Survey regarding curriculum implementation completed by the four instructors	Additional researcher
Interview with member of the school district mathematics leadership team	Researcher (first author)

responsible for collecting the data. The first author, a mathematics education researcher, structured the research study, co-ordinated the data collection and conducted the interviews. The second author, one of the teachers-in-residence, became involved in the post-hoc coding analysis of fieldnotes and interviews.

Method of Data Analysis

There were two phases of our analysis. In the first phase, we began by examining field notes of visits to the eight low-performing schools on a case-by-case basis. We also examined the written class work of the teachers and their response to journal prompts, the notes and transcripts from informal interviews, and response to the survey by the teachers. From this body of data, we determined the degree of alignment for each school along the four dimensions described by the Secada and Adajian (1997) framework. At one of the eight elementary schools, we determined that a subset of the teachers at the site comprised teachers' professional community.

Teachers' voices were a critical element in determining alignment with the constructs of a professional community. For example, we examined whether the teachers reported that they had made collective decisions affecting the mathematics program. Our determination of a shared

sense of purpose arose from a survey of teachers' words, written and oral, not in response to a specific question put to teachers. For example, the teachers in the coursework wrote papers and reflections. The question of shared sense of purpose was never directed to teachers but was arrived at through coding of teachers' written work. Where we identified teachers' professional community, a focused theme had emerged when teachers wrote about their goals and vision of effective teaching. In all these cases, all or nearly all of the teachers at a school site chose to write about the same themes. Our focus was on teachers' interpretations situated with respect to the settings in which they worked.

In a second phase of analysis, we hypothesized aspects of teachers' professional lives that might account for the development of and the nature of these professional communities. We began by looking for patterns in the case analysis of the first phase. From this we generated a list of hypothesized relationships of individual and organizational aspects of teachers' professional lives. We examined closely the cases of two schools that seemed to represent the extremes. We returned to the data of these two schools to test these conjectured factors and modified our conjectures accordingly. Finally, we returned to interview, observation and survey data from all eight schools to discern whether our conjectures were indeed true for all eight schools. Therefore, credibility of this analysis rests in part on an approach that relies on Glaser and Strauss's (1967) constant comparative method. In our analysis, provisional conjectures were open to constant refutation.

After our analysis of the first phase was complete, we interviewed a member of the mathematics leadership team in order to ensure our data came from multiple sources and found that our assessment of the presence of professional communities aligned with the assessment of the member of the district leadership team. In the process of examining the aspects of teachers' professional lives more closely, we returned to the results of a pedagogical content survey. The results of the pre- and post-test of pedagogical and mathematical knowledge were compared with their mathematics coursework and we found that performance on this test did not show a severe departure from the teachers' work during the school year.

Creswell (1998) has identified eight verification procedures for qualitative studies and recommends that qualitative researchers engage in at least two in any given study. Four of these verification procedures were present in this study: prolonged engagement, triangulation, negative case analysis, and member checks. Our relationship with teachers has spanned more than two years in the contexts of teaching and coursework. Our data came from a variety of sources: researchers,

teachers and university instructors as well as observations, teachers' written work and interviews. We refined our hypothesis with regards to disconfirming evidence until we eliminated any exceptions among the eight schools. Finally, we asked participants (a member of the district mathematics leadership team, instructors, and some mathematics specialists) their view regarding the credibility of our findings. All of them agreed with our determination of alignment with the dimensions of teachers' professional community and all of them found the five aspects of teachers' professional lives credible factors in influencing the nature of teachers' professional community.

RESULTS

Two Schools in Contrast

The eight sites in the initiative varied in the extent to which the teachers formed professional communities among the mathematics specialists. In this paper, we discuss the cases of two contrasting schools. The two schools represent, to some extent, the extremes along the continuum of developing community. We will call the two schools Harbor View and Palm. The students who attended Harbor View were Kindergarten through grade 6. At Palm, they were kindergarten through grade 5 students. Harbor View had five mathematics teachers in this program; Palm had four teachers teaching mathematics. The student populations at both schools included a high percentage of second language students. At Harbor View 63.3% were classified English Language Learners (ELL) and at Palm 73.3% were classified English Language Learners. However, Harbor View students were Spanish-speaking (62.5%) whereas the Palm students were more multi-lingual (only 44.5% were Spanish-speaking). Palm's student body included new immigrants from Africa and Southeast Asia. Three of five mathematics teachers at Harbor View and two of the four Palm mathematics teachers had teaching credentials for teaching bilingual students. Mathematics teachers at Harbor View averaged 14.9 years of teaching experience; Palm teachers averaged 9.75 years of teaching experience. Four of the five teachers at Harbor View and two of the four teachers at Palm had participated in prior formal professional development activities in mathematics.

At both sites, the professional development time was left for the teachers to structure, except when they were visited by university or school staff and even then the teachers usually were the ones that set the agenda.

Phase 1: Identifying Teachers' Professional Communities

We found that, according to Secada and Adajian's (1997) description, the teachers at Harbor View aligned well along the four dimensions of a teachers' professional community whereas the teachers at Palm did not. We discuss the two schools with regard to each of the four dimensions.

First Dimension: Shared Sense of Purpose

An analysis of the writings of the Harbor View teachers in courses and reflections reveals that they developed a shared sense of purpose. Their reflections expressed a collective desire for their students to be prepared for later life. They discussed instilling children with the desire to learn and giving Latino children an opportunity in later-life situations. An analysis of field notes and teachers' responses to questions about their professional development time indicates that Harbor View teachers' discussions revolved around what they could do as teachers to provide students with the opportunity to learn mathematics.

This theme of preparing children, particularly Latino children, for later life situations appears in much of their writing for their coursework and emerged as a theme in interviews. Harbor View teachers cite explicitly discussing this with their students. For example, the following is a quote from a Harbor View teacher's response when asked at the end of the year to describe an effective mathematics teacher:

> It is well known that Latino students are not faring well in our educational system, let alone in mathematics. They are left behind. They are shut out of opportunities because of the minimal understandings they have developed. One of the most important jobs that I have is to instill a desire to want to know and learn. This is challenging. I am very honest with my students. Most are unaware of how little they know.

In a paper written midyear for the coursework, another Harbor View teacher wrote, "I have been communicating to my students that gender and ethnicity cannot be excuses for under achievement, but do [sic] to injustices outside their control they were going to have to try that much harder." The teachers at this school in an end of year interview discussed the "dead end" jobs that are available to unskilled Hispanic workers and how their work focused on "lifting them out".

Although teachers at Palm also taught ELL, high-poverty, low-achieving children, Palm teachers did not craft a similar purpose. At Palm, teachers espoused general, more diverse goals, such as having the students understand mathematics. The stated goals were different for each teacher. One teacher frequently discussed his goal of getting

the students to work independently. He described the role of an effective mathematics teacher:

> A teacher's role is to know where to start and to establish norms and procedures, then get out of the way. If a teacher has set a strong foundation in the classroom, the students could hypothetically teach themselves ... I feel a good teacher can just observe while the students teach themselves.

Another teacher discussed the goal of enabling students to solve problems in novel situations. This focus on general goals for student behavior resonates with the teacher-in-residence's observations that the teachers' focus during professional development time was on the students' lack of ability to work independently and successfully on a task rather than discussing what they could do pedagogically to scaffold students' learning. Palm teachers' goals differed one from another and they did not discuss how their individual goals, such as enabling students to work independently, were to be met. Palm teachers, without shared goals, functioned more as a team, formally connected around perceived organization goals (Krainer, 2003). Harbor View teachers negotiated their own shared enterprise.

Second Dimension: Co-ordinated Effort to Improve Students' Mathematical Learning

A co-ordinated effort refers to teachers' working together in favor of shared goals. Do they set aside personal goals to act beyond their classrooms and grade level to adopt a co-ordinated perspective? Teachers that demonstrated a co-ordinated effort to improve students' mathematical learning worked outside their individual classroom settings to adopt informal supportive roles within the group. Teachers working with co-ordinated effort examined curriculum across grade levels, organized after-school programs, worked together on parent nights, or wrote a grant to address the needs of all their students. In short, they invested in work that was for the benefit of all students.

Harbor View and Palm teachers differed in how much time they spent together and how they used this time. The teacher-in-residence and the Harbor View teachers reported using much of their professional development time planning together prior to teaching. During professional development time, they reported sharing the successes and failures of their previous classes and discussing what modifications could be made for revisiting the topic. The university mathematics instructor visiting the site reported that the teachers needed less assistance with mathematics content and spent their time discussing the teaching of mathematics. As the year progressed, they spent some of

their professional development time looking ahead to prioritize topics in preparation for standardized tests and to examine mathematics across grade levels. They submitted and received a technology grant. They maintained an on-site shared library of professional materials. Like teachers at a few other schools, they organized discussions of professional articles or NCTM Yearbook chapters focused on teaching particular content.

The teachers at Palm also reported using their professional development time to report on instructional successes and failures, and to learn mathematics from each other or from the university mathematics instructors. However, Palm teachers emphasized learning mathematics from each other and "sharing" instructional successes and failures. The teacher-in-residence and the teachers at Palm did not report any long term planning across grade levels. They rarely discussed pedagogical solutions to failed lessons. The teacher-in-residence made several references in her field notes to her efforts to move the professional development time discussions during her visits beyond a discussion of what the students cannot or were not willing to do to what they, as teachers, could change in their practice. A literacy peer coach who shared the office space with the mathematics specialists expressed concern to the teacher-in-residence that discussions among the mathematics specialists when the teacher-in-residence was not present tended to focus on the limitations of the students rather than on what the teachers could do better.

Third Dimension: Collaborative Professional Learning

Collaborative professional learning describes how well and closely the teachers work together to learn about and improve their instructional practices *as related to mathematics*. The arrangement of physical space was noted by the researcher and by the district mathematics leader as one indicator of whether or not there was a conscious effort by the mathematics specialists at the beginning of the school year to work together. Some arrangements of physical space at the eight schools facilitated reflective dialogue and collaboration, whereas other arrangements inhibited dialogue. Harbor View teachers arranged their physical office space to facilitate working together by arranging their desks to face one another in a large circle. The Palm teachers displayed no conscious effort to work together, and arranged their desks so that two of them faced a wall and two faced each other, even though the site would have afforded many other arrangements.

Hargreaves (1994) distinguished between a collaborative culture and contrived congeniality. Collaborative culture is spontaneous,

voluntary, development oriented, pervasive across space and time, and unpredictable. At Harbor View, teachers initiated discussions informally in smaller groups, and sought opportunities to work together outside of the space of their professional development time to improve their instructional practice. Deprivatization of practice is a strong indicator of collaborative professional learning. The teachers at Harbor View observed one another's practice, both by visiting each other's classrooms and in viewing videotapes with the videotaped teacher, with the goal of helping one another improve on teaching practices.

Contrived congeniality, as defined by Hargreaves (1994), makes working together a matter of compulsion such as in mandatory peer coaching and when teachers are "persuaded to work together to implement the mandates of others". At Palm, teachers spent little time together except when mandated by the presence of on-site assistance. The discussions at Palm tended not to focus on planning but on sharing and reporting of experiences and on students' shortcomings. They did, however, report having helped each other learn mathematics content. Furthermore, the Palm teachers expressed a view that they were implementing district mandates and reported feeling that their "hands were tied".

Fourth Dimension: Collective Control over Important Decisions Affecting the Mathematics Program

The fourth dimension reflects whether teachers as a group made decisions about the direction of the mathematics program. Harbor View teachers were willing to deviate from the adopted curriculum as needed in order to meet their shared goal of preparing underachieving students for their later life experiences including students' success in school in subsequent years. They began mid-year to make decisions about the sequencing and emphasis of curricular topics. The analysis of the data from the survey on individual teachers' curriculum implementation and teachers' reports indicated that Palm teachers predominantly adhered to the curriculum as given.

Palm teachers felt a lack of control over decisions affecting the mathematics program. The teacher-in-residence and the teachers at Palm reported that Palm teachers' decisions were questioned by an administrator, classroom teachers and parents. The vice-principal sought out the teacher-in-residence on two separate occasions in order to express concerns about the mathematics instruction being given to students, and particularly about students' need for more direct instruction. The teacher-in-residence was told that parents and classroom

teachers had requested that more homework be assigned. At Palm, other classroom teachers tried to assert control over the mathematics program. Some classroom teachers assigned mathematics worksheets, though they were not teaching mathematics. At Palm, the teachers expressed a desire to follow the curriculum materials closely and to adhere to what they believed were the directives of the district mathematics leadership. The worksheets assigned by the classroom teachers were not part of the curriculum and were not seen as consistent with the values of the district mathematics leadership. Two teachers at Palm expressed that they were being opposed because they were seen as ''add-on staff''.

Manipulatives were being used for the first time in mathematics classes. *Everyday Mathematics* incorporates games for skill practice. The goals of this curriculum were not communicated to parents and other classroom teachers. In a meeting with the teacher-in-residence, the mathematics specialists at Palm discussed these pressures and expressed a desire to give more homework but frustration that they were limited by the ''no adaptations, no supplementing'' rule communicated by the district mathematics leadership team.

One mathematics teacher at Palm faced the problem of working in the classroom of a teacher who had classroom rules and procedures that were not aligned with hers. In October, the teacher-in-residence and the mathematics specialist met with the classroom teacher and the principal to talk about ways to make the rules and procedures ones that both teachers would find suitable. They had some common ground but continued to disagree about many classroom management issues.

In sum, Harbor View teachers articulated a shared sense of purpose, demonstrated a co-ordinated effort to improve students' mathematical learning, collaborated to improve their practices, and exercised collective control in decision making. We could not determine that Palm teachers had a shared sense of purpose. They did not exhibit a co-ordinated effort to improve instruction. Palm teachers' efforts were focused on their individual classrooms with the exception of sharing teaching experiences or assisting each other in learning content. They exhibited a lack of collective control in decision making.

Phase 2: Identifying Factors in the Formation of Teachers' Professional Communities

One of the goals of the mathematics initiative was to provide teachers with substantial professional development and then support their continued professional growth with daily shared professional development

time. Hargreaves (1994) described a three-year initiative intended to develop co-operative planning among school staff by providing additional preparation time. Yet, among the findings cited were that "...increased preparation time did not necessarily enhance the association, community, and collegiality among teachers. Time itself was not a sufficient condition for collegiality and community." (p. 131). So, why, under what could be identified as ideal conditions for the formation of communities that support teacher growth, did some groups of teachers form professional communities at their site and others not?

In the second phase of analysis, five aspects of teachers' professional lives that related to the development and strength of teachers' professional communities at the school sites emerged. We discuss how each of these aspects is related to the dimensions that distinguish teachers' professional community. These aspects are the:

(1) relationship the mathematics teachers had with the school administration and other classroom teachers,
(2) respect for and access to the knowledge of other mathematics teachers,
(3) presence or absence of a teacher leader,
(4) shared base of mathematical and pedagogical knowledge of the teachers, and
(5) teachers' expectation that every child can learn.

One important aspect of teachers' professional lives was the nature of the relationship with the school administration and other classroom teachers within a school. At Palm and Harbor View, none of the teachers was already working at the site. However, the Harbor View principal hired first, and so was able to choose and select the best combination of teachers applying for the positions, whereas Palm teachers were selected last by their principal. Additionally, the shared professional development time was scheduled for the beginning of the day at Harbor View, whereas the professional development time at Palm was scheduled for the end of their day. The time allotted was shorter at Palm because of other responsibilities given to these teachers. The Palm school administrator's questioning of the mathematics teachers' teaching and the classroom teachers' assigning mathematics homework contributed to the lack of collective control Palm mathematics teachers had over important decisions affecting the mathematics program.

A second important aspect of teachers' professional lives was the respect for and access to the knowledge of other mathematics specialists both at their sites and beyond. "Knowing what others know, what

they can do, and how they contribute to an enterprise'' is one of Wenger's (1998) indicators of a community of practice. At sites with teachers not characterized as aligned with the four dimensions of teachers' professional community, there were often teachers with complementary expertise. At these sites, teachers failed to have respect for and access to each others' expertise. Instructional practice was privatized which indicates a lack of collaborative professional learning.

A Harbor View teacher said, ''I feel the strongest support [for change in my instructional practice] came from the daily staff development we have at Harbor View... We have a level of trust to be able to discuss what went wrong and what could be done to correct a lesson.'' At Harbor View, each mathematics teacher had an area of expertise and others knew and respected and took advantage of the expertise of others. For example, one teacher had developed considerable expertise in mathematics in preparation for his previous professional work. The least experienced teacher at Harbor View (in terms of the number of years teaching and professional development time) was relied upon for help with technology.

Technology was also a factor in the quality of communication with those outside of school site. Harbor View teachers regularly used e-mail and the electronic bulletin board for the mathematics and pedagogy class. Due to both hardware problems and a lack of technical expertise, Palm teachers often did not have access to e-mail and the World Wide Web. These constraints affected the degree of collaborative professional learning possible with teachers at other school sites.

Third, at sites where we identified a strong alignment with the four dimensions of teachers' professional communities, we could identify a teacher leader. The teacher leader appeared to play a fundamental role in shaping the shared sense of purpose and was cited as the individual who encouraged organizing the physical space to facilitate working together. Other roles of the teacher leader included inviting university instructors to share expertise and maintaining a professional library. At Harbor View, a teacher who had experience with a state mathematics project led the co-ordinated effort to improve students' mathematical knowledge. She wrote a successful technology grant. At Palm, even though one could identify teachers with particular strengths (such as strong knowledge of mathematics), none of them took the lead in organizing physical space, coordinating professional development time, or in shaping a shared sense of purpose.

The fourth factor we identified was the teachers' content knowledge. We used a pre- and post-survey to measure pedagogical content knowledge corroborated by teachers' work in mathematics classes. We

categorized teachers that answered less than one-third of the items correct as Level 1 teachers. Teachers answering one-third to two-thirds of the items correctly were categorized as Level 2 teachers. Teachers who answered two-thirds of all of the items correctly were considered Level 3 teachers. In order to describe the change in the content knowledge of teachers as they took coursework, we indicated both beginning and ending levels. For example, if a teacher scored Level 1 on the pre-test and Level 2 on the post-test, we described the teacher as Level 1/Level 2.

Our two schools can be contrasted in terms of teachers' mathematical and pedagogical knowledge. Harbor View had two teachers who were characterized Level 2/Level 3, one teacher who was Level 1/Level 3, and two teachers that were Level 3 on the pre and post-test. Palm had one teacher characterized as Level 2/Level 3, one teacher who was Level 1/Level 2, one teacher who was Level 3 on the pre- and post-test, and finally, one teacher who was characterized as Level 1 on the pre- and the post-test. In sum, at the end of the year, all of Harbor View's five teachers are characterized as Level 3 whereas Palm continued to have teachers at all three levels (see Figure 2). There were no schools that we found to align well with the four dimensions of teachers' professional community that still had teachers at Level 1. At schools where we identified a professional community, there was, at most, one teacher at Level 2. However, there were groups of teachers at other schools with strong mathematical knowledge that did not form a community.

Our analysis suggests that teachers' knowledge of mathematics affected their collective control over decisions related to the mathematics program. Harbor View teachers felt empowered to alter the curriculum. Palm teachers did not feel that they could. Though two teachers at Palm were strong in mathematics content knowledge, two were quite weak. In the field notes there were suggestions that teachers with limited mathematical understanding struggled when discussing interpretations of student work and how to scaffold students' mathematics

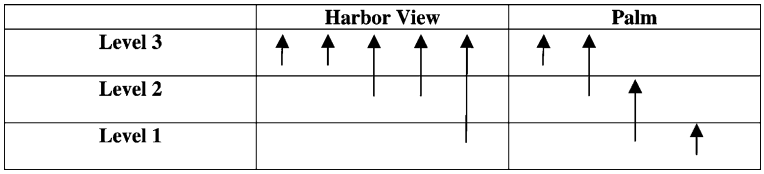

Figure 2. Changes in teachers' pedagogical content knowledge at Harbor View and Palm.

instruction. Lack of support from others at their site and difficulty in discussing mathematics contributed to their feeling a lack of control over decisions affecting the mathematics program.

The fieldnotes included observations of missed opportunities for teaching mathematics and of teachers' using misleading or incorrect language who nevertheless, in the post-conference debriefing, assessed the lesson as having met their instructional objectives. A teacher who does not recognize the opportunities or his/her own misconceptions, and whose practice is privatized, misses the opportunity to "share" them with the community. Conversely, there was evidence that increased mathematical knowledge supported teachers' recognition of the need for assistance.

Finally, the expectation that every child can learn was an important factor. Harbor View teachers shared a vision of empowering Latino children and were able to begin working together toward meeting their goals.[1] It appears that this expectation is facilitated when teachers share the cultural lives of their students as, for example, when Latino teachers teach Latino children. The mathematics specialists at Harbor View believed their students could learn and held high expectations for their students.[2] In Palm's case, a multi-lingual environment and vast cultural differences in the student body affected teachers' shared sense of purpose. Palm teachers struggled with new immigrants unfamiliar with our country's norms and customs, but part of this difficulty may also be attributable to their lack of an expectation that all children can learn. It was possible to have this expectation without having Latino teachers teaching a Latino student population. A teacher at another school site whose group aligned well with the dimensions of teachers' professional community but whose colleagues were not Latino talked about her principal's clear message: "She communicates that you are responsible for teaching all students. You don't pass by a student that is misbehaving without communicating your clear expectations. Respect is key. This is what we do." Thus, we characterized this as an equity issue.

DISCUSSION

There are important reasons for examining emerging teachers' professional communities at a school site. First, it has been argued that teachers' opportunities for growth are affected by the strength of teachers' professional communities. The most notable growth for teachers occurred in knowledge of mathematics and pedagogy. In

contrast to the beginning of the year, by the end of the year very few observations revealed mathematical misconceptions on the part of the teachers. However, substantial changes in practice, for example, becoming skilled at facilitating student-to-student talk about substantial mathematical ideas take a very long time to develop. Another longitudinal research study is analyzing selected case studies of teachers' changing practice over an extended period of time (Nickerson, 2003).

Likewise, teachers' professional lives are affected by the strength of teachers' professional communities. Harbor View teachers cited the importance of their relationship with each other. At Harbor View, all five teachers remained to teach in the second year. At Palm, two of the four teachers chose not to return for a second year. One left teaching and one left teaching in an inner-city elementary school.

Second, teachers' professional communities are places where teachers can collectively work out the broad principles of reform. Teachers need to do this in the context of their practice. Many researchers have suggested that teachers learn as they interact with students and engage in inquiry with others (e.g., Fullan, 1993; Little, 1993; Wood, Cobb, & Yackel, 1991). Although one might believe that mathematics teachers have a role managing students' mathematical discourse, it is quite another matter to develop in managing student contributions and in judging when to and how to symbolize or record the conversation. In our analysis of eight schools, we characterized a site as not aligning well with the four dimensions of teachers' professional community even though all three mathematics specialists were involved in leadership roles, belonged to national organizations such as NCTM, and took additional mathematics classes. In short, these teachers would seem to share the vision of reform documents such as the Principles and Standards for School Mathematics (NCTM, 2000). Yet, in an end-of-year interview with teachers at this site, two of three teachers complained of a lack of community at their site and a lack of community among the larger group of mathematics specialists. In individual interviews, they discussed having a different vision than their site colleagues of what it means to teach mathematics effectively. While these teachers had the knowledge of the reform goals, sufficient time and collective expertise, other factors interfered with the development of teachers' professional community.

Importantly, the existence of a site-based professional community is reflected in the shared expectations and goals for students across grade levels. Teachers' professional communities are sites for refining the norms and expectations for students' mathematical development. This includes discussions of what students can and should be doing at each

grade level so that as students move from one grade level to the next there is a degree of continuity in their experience. Part of the culture of a place involves working out what students should understand and be able to do (Knight, 2002). Harbor View teachers' shared sense of purpose included a notion of what mathematics can contribute to students' learning, thinking, and later life experience. At Harbor View, an examination of student work across three grade levels reveals mathematics specialists' shared expectation that students give reasons for their answers and not just answers. This expectation appears to have been clearly communicated to students at each grade level. Teachers' shared expectations clearly affected students' mathematical experiences at Harbor View.

CONCLUSION

Many researchers recommend the formation of professional communities of teachers in supporting teachers in trying to implement changes in their practice. With this work, we begin to answer how these communities develop and this leads us to suggest how they may be supported through programs and policies.

What can be changed at a site such as Palm to enable the teachers to work together more like the teachers at Harbor View? We suggest that a start is to attend to the five aspects of teachers' professional lives. Since the year that we report on here, Palm has had a new site administrator who has made a focus on building community a priority. He has scheduled weekly meetings with the mathematics specialists where the focus of the meetings is on measuring the progress of low-achieving students. He asks them how this informs instructional decisions. Their means of measuring progress has evolved over time. The vice-principal said the meetings are "really about the process more than the product." He has asked the mathematics specialists (two of whom were new to the site) to develop a plan collectively on how to use the professional development time. The mathematics specialists meet every other week to discuss an article. They take turns selecting the readings and so far no theme has emerged. There is no clear teacher leader, but one of the new mathematics specialists has taken some initiative to hold the group accountable in the use of professional development time. The teacher-in-residence notes that this same teacher in professional development meetings works hard at valuing the contributions of all the teachers. It remains to be seen whether the group will develop to work in collaboration or continue in contrived congeniality.

We identified five aspects of teachers professional lives related to the strength and development of teachers' professional communities. The relationship that the mathematics specialists had with school administration and other classroom teachers was identified as one critical factor. An administrator committed to supporting the work of the mathematics specialists is a start. Shared vision must evolve through the interactions of the people involved and cannot be produced by external leadership (see Fullan, 1993). Whether the work is focused around a shared vision or the work is seen as an imposition from administrators will be critical to success. Shared sense of purpose was one of the most distinguishing factors among the sites. If a shared sense of purpose is already a part of the larger community, then the mathematics teachers need to define and refine how mathematics contributes to this. Clearly, as in the case of the principal who communicated the necessity of respect and responsibility for all children, the school leadership can contribute to a shared vision. Teachers must then share a vision of what mathematics is and what it can contribute to student learning (Knight, 2002).

It takes time for principals to develop an understanding of effective mathematics instructional practice. Principals should be asked, however, to seek out each teacher's strengths and find a level at which they can ask teachers to exercise collective control over decisions affecting the mathematics program. School administrators can ask and trust teachers to take responsibility at a school site to support other teachers. For example, intermediate grade mathematics specialists can be asked to support primary teachers' professional development.

Developing respect for the knowledge of other mathematics teachers involves teachers seeing themselves as members of a community which have something to offer each other. This was lacking at the site at which teachers seemed to "share the national vision" but did not develop a professional community. During professional development days organized by the district and as part of the university coursework, this respect for expertise should be a part of public practice. One of the ways to encourage respect for one another at a site is for individuals' strengths to be recognized and promoted. We also suggest that the issue of beliefs about what students can do in mathematics should not be neglected in preservice and inservice courses. With the expectation that every child can learn mathematics, teachers like those at Palm can perhaps become the kind of advocates for their children that Harbor View teachers are.

It is also important to note that one of the potential pitfalls of having mathematics specialists can be isolation from the rest of the

teachers at the site. One clear message is that it takes more than a commitment to establishing well-prepared teachers in elementary schools. Administrators, classroom teachers, and parents must understand the goals of the mathematics instruction. A strong culture must develop to support teachers in the difficult work they do.

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NOTES

[1] We concur with Fullan (1993) that shared purpose is not a static have or have not state but instead it is dynamic. We merely note whether we can identify some coalescence of visions.

[2] Another community of mathematics specialists shared a vision of empowering Latino children. As one teacher said in an interview at the end of the year, "We are here to teach 'nuestros hijo que hablan Español.'" This roughly translates to "...our Spanish-speaking children."

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