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COMMUNITIES OF PRACTICE:
PARTICIPATION PATTERNS AND PROFESSIONAL IMPACT FOR
HIGH SCHOOL MATHEMATICS AND SCIENCE TEACHERS

DISSERTATION
Presented in Partial Fulfillment of the Requirements for
The Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

Susan M. Printy, M. Ed.

The Ohio State University
2002

Dissertation Committee:
Professor Helen M. Marks, Adviser
Professor Wayne K. Hoy
Professor Cynthia Uline

Approved by

Adviser
College of Education
ABSTRACT

Improving the quality of teachers in schools is a keystone to educational improvement. New and veteran teachers alike need to enhance their content knowledge and pedagogical skills, but they must also examine, and often change, their underlying attitudes, beliefs, and values about the nature of knowledge and the abilities of students. Best accomplished collectively rather than individually, the interactions between teachers as they undertake the process of collaborative inquiry create “communities of practice.”

This dissertation investigates the importance of science and mathematics teachers’ participation in communities of practice to their professional capabilities. The study tests the hypothesis that the social learning inherent in community of practice participation encourages teachers to learn from others with expertise, enhances teachers’ sense of competence, and increases the likelihood that teachers’ will use student-centered, problem-based instructional techniques aligned with national disciplinary standards.

The researcher conceptualizes communities of practice along two dimensions that affect social learning: legitimate participation in activities and span of engagement with school members. Differences in teachers’ subject area and the curricular track of their teaching assignment contribute to variation in teachers’ participation in communities of practice along those dimensions. Using data from the National Educational Longitudinal Study, first and second follow-up, the study has two stages of multi-level analysis. The first stage examines factors that contribute to teachers’ participation in communities of practice.
practice, including teachers' social and professional characteristics and school demographic and organizational characteristics. The second stage investigates the professional impact of such participation on the three outcome variables: teacher learning, teacher competence, and use of standards-based pedagogy.

Hierarchical linear models provide evidence that teachers' participation in communities of practice significantly increases teacher learning, competence, and use of student-centered techniques. For two dependent variables, communities of practice and standards-based pedagogy, the analyses include significant interactions for subject and curricular track. Findings from the study suggest that communities of practice serve both an adaptability and a stability function. Even as the social learning inherent in communities of practice enables teachers to gain knowledge, modify beliefs, and change instructional practice, it also results in normative pressure to maintain institutionalized approaches to instruction.
DEDICATION

To my father, Dr. James Printy
ACKNOWLEDGMENTS

My practical interest in communities of practice comes from many years of teaching in a public high school where norms of autonomy held sway. Reading educational research in my graduate studies, I knew that my rather solitary experiences regarding instructional matters were not unusual, but I also knew that they were not optimal for my development as a teacher or for my students' learning.

My academic interest in communities of practice developed over the years of my doctoral program, as I studied how organizations and the people within them learn to do things more effectively. My interest in organizational learning was piqued as a result of a review prepared for an organization theory class with Professor Wayne Hoy, now a member of my dissertation committee. That interest was sharpened in work for a book chapter with my advisor, Professor Helen Marks. Interest in organizational inquiry deepened in a doctoral seminar with Professor Cynthia Uline, also a member of my committee.

Specific focus on communities of practice came in the second year of my program, as a result of a writing project and a seminar with Dr. Robert Backoff and Dr. Suzanne Catana. Set within the larger framework of organizational learning, the social learning theory associated with communities of practice gave me needed insight into my own experiences as a teacher and also offered ways to think about improving teachers' professional skills and the quality of their worklives.
For the preparation to do the multilevel analysis required for this dissertation, I thank Professor Valerie Lee, with whom I studied hierarchical linear modeling at the University of Michigan. I survived that HLM summer with a wealth of knowledge about analyzing data. More than that, I also experienced what it is to learn and develop skills in a community of practice, in this case, one comprised of other struggling HLM students.

From their influence in the beginning of my doctoral program until now, the members of my committee have offered their continuing support of my work and have contributed in untold ways to my professional development. Dr. Hoy gave me insight into organizations, not only academically in terms of teaching and research, but also practically in terms of a professional career. Dr. Uline modeled what it means to be a dedicated teacher, one who extends herself to her students in a uniquely responsive way.

Dr. Marks, as my advisor, provided me with support as a research assistant and with other experiences that few graduate students have. I have benefited from our ongoing research collaboration, and I am grateful for additional opportunities she facilitated for independent research and teaching. As my committee chair, Dr. Marks provided guidance through the long dissertation process and reviewed and commented on multiple drafts of each chapter. I agree with her that half of one’s doctoral education is in the dissertation itself. Our association has reinforced for me the value of commitment, the benefit of clarity, and the excitement that comes with discovery.

I have been blessed with the support of many people over the last years. The members of my cohort – Barbara, Kim, Chen, Mark, and Jeff – constituted another community of practice. Jim Arthur always made me laugh and nudged me out of my books and into life.
My family has been an unfailing source of understanding and encouragement. My parents offered steady faith that I would reach my goal. My brother, Mike, his wife, Jan, and their daughter, Katie, opened their home and their hearts to me. Each and every member of my family maintained continuing interest in my progress and cheered each success. Most especially, I want to thank my children, Abby, Andy, and Jim, my daughter-in-law, Jill, and my granddaughter, Emily, for their love, their generous support of my efforts, and their gracious acceptance of the limitations imposed by my studies.
VITA

January 17, 1949 ............................. Born, Toledo, OH

1998 ................................................... M.Ed. Bowling Green State University

1980-1998 ........................................ Teacher
Bellevue High School
Bellevue, OH

1998-2002 .......................................... Graduate Research Assistant
The Ohio State University

2002 ................................................... Researcher and Instructor
The Ohio State University

PUBLICATIONS

Research Publication


FIELDS OF STUDY

Major Field: Education
   Educational Policy and Leadership
   Educational Administration
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5.1 Analytic Model to Investigate the Professional Impact of Communities of Practice ........................................................................................................... 141
The expectation that all children meet high academic standards has been an impetus for change in contemporary education (U. S. Department of Education, Goals 2000, 1993). Most educators agree that, in order to meet such standards, students must be engaged in activities that cause them to exercise higher order thinking skills – to solve problems, to construct knowledge, and to connect to the world beyond the classroom (National Council of Teachers of Mathematics, 1989, 1991, 1995, 2000; National Research Council, 1996; Newmann & Associates, 1996; Perkins, 1991). However, research on classrooms has consistently documented the rarity of these kinds of experiences for students (Cuban, 1984; Goodlad, 1984; Jackson, 1990; Newmann et al., 1996). Many teachers do not have the deep content knowledge and pedagogical skills required to provide students with intellectually rich learning environments.

Inadequate preparation of teachers is a widespread problem, with over 50,000 untrained people entering teaching on emergency or substandard licenses each year. The problem is particularly acute among mathematics and science teachers already in schools. More than half of high school students taking physical science courses, and 27 percent of those in mathematics courses, are taught by teachers who do not have backgrounds in
those fields. In high poverty schools and in lower track classes, the proportion of teachers inadequately prepared is even higher (The National Commission on Teaching and America's Future, 1996).

Based on the prevalence of inadequately prepared teachers, it is not surprising that traditional didactic, text-based instruction still typifies most classrooms rather than the student-centered pedagogy recommended by the mathematics and science disciplinary standards (NCTM, 1989, 1991, 1995, 2000; NRC, 1996). In order for students to succeed, even veteran teachers with adequate certification need to develop a greater ability to analyze their students' current knowledge and find ways to expand that knowledge (Darling-Hammond, Wise, & Klein, 1995). Teachers need to enhance both their content knowledge and pedagogical skills, but they must also examine, and often change, their underlying attitudes, beliefs, and values about the nature of knowledge and the abilities of students.

Recognizing the importance of teacher learning to change in teaching practice, policy documents supporting the professionalization of teaching advocate lifelong learning and encourage "job-embedded" learning tied closely to the classroom. Analyzing how they instruct students in their classrooms encourages teachers to refine new teaching skills and to examine the beliefs, attitudes and assumptions they bring to their work (Interstate New Teacher Assessment and Support Consortium, 1992; Interstate School Leaders Licensure Consortium, 1996; National Board for Professional Teaching Standards, 1994). A process of inquiry is most effective when learning continues beyond the solution to any specific instructional problem and becomes an integral part of teachers' work.

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In order to support teachers' lifelong learning, professional development programs in schools need to be sustained, ongoing, and intensive programs that derive from and are connected to teachers' work with their students. When teaching and learning take place simultaneously, teachers instruct students and, at the same time, observe student development, reflect on the processes of student learning, and assess the effectiveness of their instruction. Professional development programs of this type can connect to other aspects of school change, drawing teachers out of their classrooms into collaboration with other teachers. Professional development that focuses on teachers' communities of practice rather than on individual teachers encourages the collective solving of specific problems of practice and the sharing of knowledge. In groups of colleagues, teachers can struggle with the uncertainties of their profession and receive support, mentoring, and coaching (Darling-Hammond & McLaughlin, 1995).

The interactions between teachers as they deliberately undertake the process of collaborative inquiry create "communities of practice" (Darling-Hammond & McLaughlin, 1995). The term, as used here, refers to a group of teachers engaged in an educational endeavor in which they share common interests and about which they have developed common understandings (cf. Lave & Wenger, 1991). As teachers interact regularly with a group of colleagues, they shape their practice: they determine what the purpose of their joint work is, they come to understand what activities are valued, and they establish social norms for relationships between members (Wenger, 1998).

"Community of practice" – as the term occurs in common educational parlance – can be misleading for several reasons. First, the word "community" would suggest that teachers who work, or practice, together always constitute a tightly-bonded social group.
when, in fact, research on schools has repeatedly shown this not to be the case, particularly in high schools (Huberman, 1993; Firestone & Herriott, 1982; Powell, Farrar & Cohen, 1985; Louis, Marks & Kruse, 1996; Siskin, 1994; Sizer, 1984). Second, communities of practice, as potential sites for learning, only suggest the possibility of increased productivity or effectiveness. While communities of practice in schools, as in other organizations, may be vehicles for learning, they have a full range of other organizational impacts. They can perpetuate stereotypes, prejudice, and destructive practices as much as they result in productive change and innovation (Wenger, 1998). Communities of practice should not be romanticized: as an entity, they are value neutral, not intrinsically beneficial or harmful (Wenger, 1998).

Early ethnographic studies in organizations other than schools indicated that communities of practice can be instrumental in developing organizational competence and devising innovative solutions (Orr, 1996). Learning, working, and innovation tend to cohere within communities of practice (Brown & Duguid, 1996). Because of the learning potential inherent in communities of practice, they are an organizational form worthy of study. In schools, communities of practice can potentially improve teacher quality as well as bring needed change to educational processes.

In this dissertation, I investigate the importance of science and mathematics teachers’ participation in communities of practice to their professional capabilities. Simply put, I hypothesize that the learning opportunities inherent in community of practice participation encourage teachers to learn from others with expertise, improve teachers’ sense of competence, and increase the likelihood that teachers’ will use student-centered, problem-based instructional techniques. Learning that results in beneficial
change is not a certainty, so it would be useful to identify factors that encourage teachers’ participation in communities of practice that enhance their knowledge, dispositions, and skills.

**High School Teachers' Communities of Practice**

Communities of practice, within a single school, can exist in a multitude of configurations, comprising a “constellation” of such groups (Wenger, 1998). Each community of practice is shaped by the values of its members and by the social relations among its members. To illustrate how such elements might distinguish communities of practice, I present a series of vignettes that depict the relations among mathematics and science teachers in two high schools. Each community of practice is defined by a particular purpose, embraces different activities, and displays different social norms. The vignettes are based loosely on a number of studies by the Center for Research on the Context of Secondary School Teaching (CRC) at Stanford University (Grossman & Stodolsky, 1994; Little, 1995; McLaughlin, 1993; Talbert, 1995; Siskin, 1994). These studies argued that teachers’ daily work lives vary substantially and that this variability results from the strength and character of local teacher community.

For high school teachers, an important community of practice is likely to be the subject department, where teachers find colleagues to work closely with because they “have concrete things to tell one another and concrete instructional help to provide one another” (Huberman, 1993, p. 32). Studies of subject departments detail collaborative efforts among individual teachers, routinized norms of cooperation, shared orientation, and strong collective identities, all markers of communities of practice (Huberman, 1993;
Siskin. 1994). In some departments, even smaller groups of colleagues represent more immediate and more salient communities of practice. The images of mathematics and science departments in the vignettes give some indication of the range of experiences teachers have in their various worksites, often very different from department to department within the same school.

**Science Department at School A**

A chemistry teacher with a long and respected tenure at this large suburban school complains that things aren’t like they used to be: the kids are much more interested in their sports activities and their jobs than they are in school work. The makeup of the departmental faculty has also changed as many of the senior members have retired or moved on. At this point in his career, the chemistry teacher says he likes being left alone to do his job; he appreciates the fact that the administration does not interfere and that he can pretty much avoid contact with his departmental colleagues if he wants to. The department chair, who has been around almost as long as this teacher, focuses on clerical duties more than she does professional ones. She collects the supply orders from everyone, collates them, and sends them off in a timely manner so everyone has what they need. She arranges room assignments and funnels paperwork to the appropriate office. Course assignments are pretty much automatic because teachers have been hired over the years to teach in their specialty areas – biology, chemistry, physics – and enrollment is steady from year to year. Teachers in the department generally have developed friendships with others in the school; there are the smokers, the coaches, or the technology experts, for example. While the national science standards have been
discussed in broad terms, teachers are free to interpret them as they see fit. Some, like the physics teacher of the department, rely on professional associations with physics teachers in other schools for support in this regard.

Mathematics Department at School A

Teachers in the mathematics department of this suburban high school know each other fairly well and know exactly what goes on in everyone's classroom. Teachers take students' entering test scores and carefully place students in the appropriate class and section by ability. They operate with close coordination so that teachers cover the material necessary for their students to be advanced to the next level. Even with careful planning, however, a large number of students fail each year. Teachers attribute this failure to students' lack of motivation and effort, and they resist pressure from the district and school administration to stop the practice of ability grouping. Last year, they successfully scuttled a school effort to move to a block schedule. "These people just don't understand what we deal with in teaching math, how hard it is to control students at different levels," says the chair. He's worried that a beginning algebra teacher, fresh from the university, will not cover all the concepts students need to go on to the next level. "They cut up paper and build with blocks. She doesn't even use the textbook much," he groans.

Mathematics Department at School B

The members of the mathematics department in this mid-size, urban high school are a congenial group. They have room assignments in the same wing, and they often
talk with each other in the halls between classes or meet over lunch in the department office. These casual conversations frequently deal with student learning difficulties and instructional techniques, and teachers freely share strategies garnered from educational periodicals or university classes. To the outsider, these conversations would sound like "shorthand"—just bits and pieces that seemingly aren't connected—yet the teachers understand exactly the point being conveyed.

As a department, teachers meet regularly, trying to make sense of situations resulting from a convergence of external forces: a rapidly changing student body due to an influx of immigrants; continuing advocacy for the national mathematics standards by the National Council of Teachers of Mathematics; and increasing accountability for student learning as a result of state-mandated high-stakes subject tests. The teachers share the belief that all students can learn complex mathematics concepts when supported with appropriate instruction, and accept the fact that ensuring this end for students requires new learning on their part. Currently, they are focusing their professional development on analyzing the work students produce and, with the help of a university professor, understanding how young people learn.

Because working with diverse students in a classroom requires high energy, teachers rotate course assignments so as to prevent faculty exhaustion, and even the department chair takes her turn teaching algebra. For support, teachers assigned to a course for the first time pair with a more experienced teacher also teaching the same course. Teachers in the department arrived at these arrangements through consensus and all members accept responsibility for making them work.
Science Department at School B

The science teachers at this urban high school are polite and friendly when they pass in the halls, but there is a marked division in the department based on seniority and subject taught. Those who have been around for a long time – and particularly those who also teach biology – constitute the “insiders” who make the decisions and have access to the resources. For the most part, course assignments are up to the department chair, who, in assigning classes, doesn’t deviate much from the established pattern year to year. Veteran teachers can count on getting the same classes again because they are regarded as “experts” who know what students need to succeed in college. Having refined their instructional techniques over time, most in the department aren’t interested in making any changes in what they do in response to the changing student population; new students for whom English is a second language are routinely placed into a remedial physical science class. A new teacher, trained in biology but assigned to teach remedial physical science, felt out of place in the department until he connected with another teacher who had a similar assignment, but with one year of teaching experience. Their relationship began with complaining and sympathizing with each other, but soon evolved into planning, analyzing, and evaluating their instruction, particularly after another friend, a young mathematics teacher, told them about the development activities he was participating in. With no resources provided by the science department, the remedial teachers had to create a program for their students with nothing to start from, and they experienced success in their efforts. Reframing their situation into a challenge, they have made a special request to have the same assignments next year.
All of the teachers in the above vignettes have membership in a departmental community of practice, though each department functions quite differently from the others. Faculty relationships in the departments vary, even within the same school. The nature of the practice – determined by the purpose, the activities, and social norms – is critical for teachers in terms of whether learning occurs that will enhance their professional capabilities. The purpose of each practice, as indicated in the vignettes, reflects the values of its members and determines, to some extent, the kind of learning that will occur. For instance, teachers who maintain traditional instructional methods (mathematics department in School A) will learn different things from those who intend to improve instruction through innovation (mathematics department School B).

The activities members participate in together constitute the opportunities for learning. Learning is situated in the “fields of social interaction” between members, as is the case for the remedial science teachers (School B) who struggle together to teach students with language difficulties, those for whom English is a secondary language (ESL) (Hanks, 1991; Lave & Wenger, 1991). The normative social relations between members regulate the extent of learning. The chemistry teacher (School A) who avoids his departmental colleagues is unlikely to learn from someone else’s expertise. The biology insiders (School B) maintain a long-standing power differential that limits some departmental members’ access to learning resources. In contrast, all members of the mathematics department (School B) are welcome to participate in – and learn from – a wide range of valued activities, and veteran members regularly mentor new members, thus enriching their learning experiences.
As the vignettes demonstrate, the purpose, activities, and social relations that characterize communities of practice take many shapes, and each of these attributes has consequences for teachers' learning. To expand the discussion of communities of practice and to clarify the concept further, the next section introduces a framework for distinguishing communities of practice among high school teachers.

A Typology for Communities of Practice

Because communities of practice can have a range of organizational impacts, it is worthwhile to identify factors that enhance the professional capabilities of teachers. The purpose, activities, and social relations that distinguish communities of practice can improve teachers' content knowledge, attitudes related to students, and pedagogical skills. For instance, the purpose of the practice might be to continually test and refine shared understandings of the ways in which students learn and the pedagogical techniques that best help them learn. The range of activities could include classroom and related activities, such as developing and aligning curriculum, planning assessment, selecting textbooks and materials, and setting policy (e.g., regarding homework or student discipline). The social norms would enable all members of the community to have extensive opportunities to learn.

A community of practice focused on improving instruction can help students meet the high academic standards set for them. In this case, teachers intend to change their instructional work so as to improve student learning. The nature of the practice will reflect the values of community members, in that any number of valuable educational pursuits exists. A community of practice might provide social support for students with
difficult home situations, for example, or they might create a democratic environment that optimizes student choice in classroom decisions.

The typology that follows accommodates any kind of purpose that community members jointly understand to be important. Given that purpose, the typology classifies teachers' social learning as a function of increased participation and widespread interaction with other individuals throughout the school. (See Figure 1.1.)

![Figure 1.1](image-url)

**Figure 1.1**
A Typology for Communities of Practice

The typology for communities of practices results from the intersection of two axes, each of which has implications for teachers' learning. The vertical axis, capturing teachers' legitimate participation, ranges from peripheral participation to full
participation. The horizontal axis represents the span of engagement with school members in the department or outside of the department. While the typology presents the two extremes for each axis, resulting in four designations of communities of practice, each axis actually exists as a continuum. Teachers would generally not participate in a peripheral way or in a full way in all of their activities. Similarly, they would generally not interact only with other departmental members or only with individuals outside of the department. Realistically, teachers' participation would be peripheral in some activities and full in others, and they would interact with different school members depending on the activity. The resulting configurations of communities of practice that could potentially exist— as defined by position on the two axes— are unlimited.

**Legitimate Participation**

Professional certification or licensure positions a teacher to take part in a practice, such as high school mathematics or science instruction. Through training and socialization, a teacher acquires the valued core knowledge and instructional strategies common to the discipline as well as general assumptions about how students will best learn subject content. Although a certain element of legitimacy accompanies a teacher's initial hiring, what matters for participation in communities of practice is the legitimacy colleagues grant (Lave & Wenger, 1991; Wenger, 1998). In the science department in School B, individuals with power intentionally exclude the new remedial science teachers and deny them resources, including the opportunity to share in departmental decision-making. Because those in power do not recognize the new teachers as legitimate, they constrain the remedial teachers' opportunities to learn by engaging in important activities.
of the practice (even though they learn a great deal about working with remedial and ESL students through their own efforts.) In contrast, members of the mathematics department expect new teachers to contribute to important activities in the department, and this expectation enlarges their opportunities to learn. When teachers have legitimate access to the activities of a practice, they learn as they move from peripheral participation to full participation.

**Peripheral to Full Participation.** When new teachers enter a practice, they are immediately responsible for instructing students. Their participation is peripheral because they receive assignments that demand the least amount of time and skill, based on the complexity of the subject knowledge to be conveyed (Lave & Wenger, 1991; Siskin, 1994). Beginning teachers often teach classes at the lower levels of the subject hierarchy, such as general or remedial classes or those for freshmen students (Siskin, 1994; Weiss et al., 1993).

No different from other members of the department, new teachers participate in activities that occur at the end of the production process — instructing students in classrooms — but their participation is not full. Unlike veteran teachers, new teachers have not engaged in the many necessary activities that occur before teachers walk into classrooms with their lesson plans. They did not decide which students would be in which class. They did not select the textbooks for use. They did not contribute to plans for remediation of students having difficulty. They did not plan the scope and sequence for the courses they teach, nor did they contribute to the overall organization of the departmental curriculum. New teachers participate in the end of the instructional process before they take part in the beginning, foundational aspects of teaching.³
Over time, new teachers learn through observation, experience, and interaction with others. They come to understand the student population and contribute to collective understandings of how the department can best organize instruction. With greater competence, teachers begin to teach classes requiring more extensive knowledge of subject matter or more complex pedagogical skills. They take responsibility for additional work for the department, perhaps serving on a textbook committee, preparing a newsletter, or making a presentation. As they gain experience and take more responsibility, they move to the center of the community where they help set the foundation for instruction in the department (Lave & Wenger, 1991; Wenger, 1998).

Planning new courses, discussing alternatives for student assessment, seeking information about student cognition – these are activities that are fundamental to the teaching process and are most likely to be characteristic of mature, fully participating members of a community of practice. When teachers are core members who participate fully in every step of the instructional process, their workdays engage them in continuous opportunities for learning.

**Productivity.** As teachers learn by participating in more challenging activities, they acquire new knowledge and skills, thus increasing their competence and abilities to contribute as productive members of the practice. Individually, members enhance their instructional practice. The cumulative effect of individual improvement results in positive gains in productivity for the community as a whole. Teachers will offer better instruction, and, as a result, students will learn more.
Span of Engagement

Interaction with teachers who have different ideas is essential if schools are to draw on their best resources for improvement, teachers themselves (Hargreaves and Macmillan, 1995). Participation in communities of practice, through a process of social learning, allows teachers to continually test their understandings and ideas against those held by other members of the community (Bandura, 1977; Wenger, 1998). Learning also occurs through exposure to the beliefs and practices represented in other communities of practice, either through overlapping membership, when an individual belongs to more than one community, or through boundary encounters, when individuals in different communities come into contact (Wenger, 1998).

One of the remedial science teachers in School B also held membership in the community of practice of track coaches, where he interacted with a mathematics teacher. The mathematics teacher, as a member of a very active departmental community of practice working to develop instructional strategies for use with a new population of ESL students, had valuable knowledge which the science teachers could tap. As a result of their overlapping membership (each belonged to a separated departmental community and to the same community of track coaches), the mathematics teacher shared his new knowledge with the science teacher, who then shared the information with his departmental colleague. Together, the remedial science teachers applied these insights effectively to their own practice.

A boundary encounter would result if members of the science department heard members of the mathematics department present their “best practices” for working with ESL students. This type of situation could occur at a faculty meeting at a principal’s
request. Perhaps some veteran members of the science department would ask questions of the mathematics teachers in this boundary encounter, and as a result of their learning, might become more interested in the efforts of the two remedial science teachers.

**Departmental to Schoolwide Interactions.** High school teachers spend much of their time interacting with other teachers in their department because they share the same interests and because other departmental members understand their challenges and concerns and acknowledge their work as important. The physical layout of most high schools also places teachers within a department in close proximity, further increasing the likelihood of within-department interactions.

Studies of organizational behavior indicate that individuals who interact frequently share the same preferences and make similar decisions based on those preferences (March & Olsen, 1976; Scott & Cohen, 1995; Van Maanen & Barley, 1984). As a result, teachers find support for continuing practices that have worked for them in the past. When teachers interact only with others like themselves, conformity and perpetuation are the likely results (Van Maanen & Schein, 1979). On the other hand, innovation is likely to occur when learning experiences involve a variety (similar and dissimilar) of other organizational members (Van Maanen & Schein, 1979). Organizational gains result from diversity, so groups benefit from having heterogeneous group members (March, 1991). Based on these findings from organizational research, it is likely that teachers' interactions with school members outside of the department, in concert with interactions within the department, would result in changes to teachers' beliefs and practices.
**Stability and Change.** The learning that occurs within communities of practice can be a stabilizing force or a force for change (Wenger, 1998). Without some deliberate intervention or a cultural norm oriented toward innovation, high school departmental communities of practice will likely support the status quo, making at best small, incremental improvements in core practices within the department. Departmental boundaries, when impermeable, divide the school and reduce the chance that productive changes occurring within a department will diffuse widely throughout the school (Hargreaves and Macmillan, 1995).

Ideas are likely to spread, however, through overlapping membership in communities of practice or through boundary encounters, where exposure to opposing perspectives generates new ways of thinking (Wenger, 1998). Overlapping membership results when teachers take part in activities outside of their departmental community of practice and become members of another community (such as a community of advanced placement teachers within a school). Boundary encounters refer to interactions between members of different communities of practice such as might happen in a faculty meeting. Teachers learn what members of other departments are thinking and doing, and these insights might prompt new learning. To the extent that boundary encounters contribute to active interdepartmental engagement, they can foster new communities of practice with overlapping membership. Interactions through overlapping membership and boundary encounters build a web of relationships that allows for the transfer of knowledge throughout the school.

It is possible that communities of practice will require exposure to ideas and expertise outside of the school before change can occur in their central purpose (Argyris...
& Schön. 1996; March, 1991). Teachers can bring new ideas into the practice as a result of their membership in communities outside of the school, for example, through their enrollment in university courses. Boundary encounters also occur through contact with communities of practice outside of the school, such as when an outside expert is brought in to the school for a professional development program or when members travel to conferences and interact with teachers in other schools.

**High School Communities of Practice: Four Types**

As teachers participate in the practices of a community, their mastery of knowledge and skills deepens as involvement in central activities increases. When teachers interact with individuals inside and outside the subject department, they are exposed to a range of opinions, some similar to their own, and some different. With each new experience, with each new idea, teachers learn something that will have consequences for their own individual practices, but these learnings also feed back into the understandings held by the community of practice. In a reciprocal process, the nature of the community shapes the learning opportunities for community members, and the individual understandings that result from learning collectively shape the nature of the community.

Legitimate participation and span of engagement, the two dimensions of the typology for communities of practice, result in four community types: insular communities, maintenance communities, learning communities, and reform communities.

**Insular Community.** When members of a subject department are concerned only with what happens in their own classrooms, the departmental community can be
described as *insular*. Over time, teachers negotiate understandings that each teacher works independently and that the purpose of the community is to maintain teacher autonomy. Teachers participate in activities characteristic of the end of the instructional process, teaching students in their own classrooms, but there is little joint activity regarding the fundamentals of instruction: planning which courses to offer, choosing assessment options, or selecting books and materials. Social relations in the community, though perhaps congenial, do not enlarge teachers' opportunities to learn. There is no expectation that teachers will mentor others or that they will necessarily interact with others in the department, let alone out of the department. Teachers might work with a few close colleagues, but there is little motivation to learn due in large part to the lack of diversity in the ideas considered on a regular basis. While teachers individually might be regarded as effective, their involvement does little to contribute to departmental productivity or innovation or to schoolwide improvement.

**Maintenance Community.** Teachers who interact with other teachers throughout the school but who are not much interested in instructional improvement construct a *maintenance* community. When teacher engagement extends throughout the school, departmental communities of practice can integrate into a schoolwide community. However, when teachers participate only at a peripheral level, these interactions are superficial, and teachers' interest remains largely with what happens in their own classrooms. The respect for teacher autonomy might extend throughout the school such that all teachers have discretion over the instruction they enact in classrooms.

Peripheral participation results from lack of interest in activities or lack of access to activities. The end result is that teachers do not engage others in fuller forms of
participation that could potentially move them from a maintenance orientation. For instance, such teachers would not take part in schoolwide curriculum work and would not be present at the meetings that could occasion a great deal of learning. (There might not even be an opportunity in the school for this kind of work.) Without the learning that results from teachers’ full participation in interdisciplinary activities, the school’s instructional program would at best be marked by incremental gains, the combination of small efforts within separate departments. Even though the school might contain an exemplary department, such as the learning community described next, the overall program would not change much.

Learning Community. When members within a department move to ever increasing levels of participation, they become a learning community. Teachers share a belief-system within the department and work to refine their educational processes so that students benefit from their productivity. They discuss educational issues with other community of practice members and draw them into the fundamental work of the practice: planning for the instruction that will ultimately occur in their classrooms. Opportunities for learning are legitimately shared with all members. Veterans mentor newcomers, assisting them in the process of becoming full members of the practice. Within the department, teachers seek continuously to improve instruction for the students in their classrooms.

Learning communities, however, maintain impermeable boundaries and members do not engage others throughout the school. As a result, learning communities can come up short on two counts. First, even when instruction is carefully designed and executed by all community members, it is possible that it does not reflect recent understandings of
cognition and pedagogy. Diligent work to refine instructional processes might leave core values and fundamental beliefs about instruction unexamined when members do not test their ideas against differing perspectives held by others in the school.\textsuperscript{4} Second, a learning community can perpetuate inequitable learning experiences for students in a school. Students taking classes from teachers in a learning community, where instruction might be exemplary, experience relevant and engaging classes for only a small portion of their day. When teachers in a learning community resist broad interaction, they prevent the spread of knowledge throughout the school and limit the possibility that members of other communities might learn from them.

Reform Community. Rich interconnections among communities of practice augment the likelihood that active teachers will engage in a reform community. Shared goals and purposeful efforts toward reform by a wide range of school members make the school more effective in increasing student achievement through quality pedagogy (Varrella, 2000). Once teachers move beyond their subject departments to interact with peers in other disciplines, the web of relationships within the school strengthens. Such interactions have the greatest impact on teachers inclined to full participation. When active teachers are in frequent contact with teachers in other departments, they are likely to exchange their departmental perspectives for a school view, committing to full participation in schoolwide reform. As members of separate departmental communities of practice join the reform agenda, they bring with them their contacts, ideas, beliefs, values, and strengths, all of which increase the options for improvement.

The reform community represents interconnected departmental learning communities of practice oriented around a shared educational purpose. Members of
multiple communities participate actively in shaping the school's instructional program, building a coherent, integrated foundation for instruction through a process of consensus. They recognize the valuable contributions of all members and respect the potential for improvement inherent in conflicting viewpoints. The reform community captures the interconnected learning work of the entire school.

**Productive Communities of Practice**

The degree of teachers' participation and the extent of their interaction underlie the measure for communities of practice used in the empirical analyses in this dissertation, as I explain in Chapter 3. Unfortunately, the data for the study do not permit a full investigation of the effects of communities of practice, that is, one that examines the relationship of insular, maintenance, learning, and reform communities to various outcomes. The typology, however, presents a conceptual framework for thinking broadly about teachers' participation in departmental and schoolwide communities of practice that might improve their teachers' professional capabilities.

To express the benefit of participation and interaction to teachers' communities of practice in a broad way, I use the term "productive" to describe community participation distinguished by high levels of these characteristics. I derive the term from the production function of schools, which has two components: instruction and student achievement (Bidwell, 2001). Productive community of practice membership involves teachers in social learning that is likely to make them better teachers. Although beyond the scope of the study detailed here, it is also possible that teachers' productive community membership has a positive relationship to student achievement.
Research Focus: Communities of Practice for Instructional Improvement

Improving teachers' knowledge, skills, and dispositions has moved to the forefront as a strategy for school reform (Interstate New Teacher Assessment and Support Consortium. 1992; National Board for Professional Teaching Standards. 1994). Teachers need to learn new content knowledge and pedagogical skills, but their learning should lead them to examine their underlying attitudes, beliefs, and values about the nature of knowledge and the abilities of students. As the vignettes of different mathematics and science departments show, however, not all communities of practice have a natural inclination for this kind of work.

The research I undertake here tests Wenger's (1998) proposition that the differences in the effectiveness of teachers' community participation relate directly to the extent to which members of the community share a common purpose, engage in common activities, and experience open social relations. Empirically, the study attaches a positive value to productive membership, which occurs when teachers place improvement at the center of activities related to curriculum, instruction and student performance and engage with colleagues throughout the school in these endeavors.

Teachers who learn in such communities of practice are likely to experience positive changes to their knowledge, dispositions and skills. I investigate whether this type of community of practice participation actually has a professional impact in these areas. The study tests the assumption that teachers whose community participation is productive, as delineated in the study, learn things from other school members in ways that improve their instruction. It is also likely that teachers who participate as productive community members show an increased sense of both their ability and responsibility to
adapt their instructional practices to meet the needs of students. Teachers who benefit from the expertise and resources of their communities of practice should be better able to incorporate the student-centered, problem-based instructional techniques recommended by the mathematics and science standards documents (NCTM, 1989, 1991, 1995, 2000; NRC, 1996).

**Plan for the Study**

Chapter 2 continues the review of relevant literature regarding teachers’ professional communities, looking more closely at how the conceptualization of communities of practice for the current study compares to other researchers’ depictions of teachers’ communities. Drawing on previous research, I incorporate findings on the importance of subject area to teachers’ participation in communities of practice, the organizational management of schools, and social control within schools. Then, I review the literature relevant to teacher learning, teacher competence, and standards-based pedagogy. The chapter concludes with brief comments about instructional leadership related to communities of practice.

I detail the plan for analysis in Chapter 3. First, I present the research questions, a hypothesis, and an analytic model for the study. Next, I describe the construction of measures for the study. Finally, I describe specific analytic approaches, including the rationale for each approach.

In Chapter 4, I discern the extent to which teachers’ participation in communities of practice depends on their social or professional characteristics. Communities of practice are embedded within school contexts, so Chapter 4 explores the effect of schools
on teachers' community of practice membership. I also investigate the importance of organizational management to the extent of teachers' community participation and the influence of leadership and learning resources.

Seeking to verify the impact of communities of practice documented in case studies, I examine, in Chapter 5, the relationships of productive community of practice membership to teacher learning, teacher competence, and teachers' use of standards-based pedagogy.

Chapter 6 has a dual focus: interpreting the findings and considering the implications of the study. I concentrate on the effects of subject area, curricular track, professional development and instructional leadership on the social learning process captured in this study. I also detail the implications for teachers, school leaders, policymakers, and educational researchers.
Notes to Chapter 1

1Other studies for the Quantitative Understanding: Amplifying Student Achievement and Reasoning (QUASAR) Project by Brown and Smith (1994), Silver and Lane (1993), Stein, Grover, and Silver (1991), and Stein, Silver, and Smith (1998) also offer portraits of communities of practice.

2These science teachers, in fact, create a more immediate community of practice with a membership of two.

3Lave and Wenger (1991) studied apprentice tailors who begin by doing the finishing work on garments. In learning the craft, apprentices work backward to the beginning step, proceeding through stages in the construction of the garment and ending with the foundation of the process, the cutting of the fabric.

4A learning community might learn about new ideas from an outside expert or through members’ experiences outside of the school. Interaction with colleagues in other departments within the school helps to make sense of that information in the local context.
CHAPTER 2
LEARNING IN TEACHERS’ COMMUNITIES

Portraits of schools in the educational literature concerning teachers’ worklives range between two extremes: as organizations marked by fragmentation, where teachers work beside each other without really working with each other (Hargreaves, 1991; Lortie, 1975; Metz, 1990) and as schoolwide communities marked by shared goals and norms of collaboration (Louis, Kruse & Associates, 1995; Nias, 1989). Somewhere in the middle are smaller groups of teachers who negotiate their work in communities of practice. Teachers in high schools, who are the focus of this study, appear to associate with one another because of their school’s physical layout, structural features, organizational forms, or subject matter differences. This perception suggests that the formation of teachers’ communities might be arbitrary as much as it is deliberate. Such a perception does not acknowledge the complexity of the social learning process through which communities of practice emerge and from which community members derive meaning. Based on their conceptualization in the literature, in this chapter I compare communities of practice, the conceptual foundation of the present study, with other forms of community among teachers.

To begin the chapter, I extend the discussion of communities of practice introduced in Chapter 1 by detailing their characteristics and examining their relationship
to social learning. Then, I turn to studies examining other forms of teachers’ communities, drawing both on qualitative and quantitative research. I briefly discuss the theoretical bases and characteristics of these other conceptualizations of teachers’ community. Finally, I examine the professional impact of teachers’ work within their communities, particularly as it affects teachers’ knowledge, beliefs about competence, and instructional skills. I conclude with comments relating instructional leadership to teachers’ participation in communities of practice.

Communities of Practice

Communities of practice consist of members who share values and interests, who engage in shared activity, and who produce shared resources in the process. Through active participation in social communities, members gain knowledge and competence through a process of social learning (Wenger, 1998). Social learning, generally understood, refers to learning that results from the interactions between individuals. Social learning theories include those from the psychological perspective that emphasize modeling (Bandura, 1977), activity theories that focus on learning assistance (Vygotsky, 1934), and socialization theories that highlight internalization of group norms (Parsons, 1962). In their work on situated learning, Lave and Wenger (1991) focused on the learning inherent in active participation and identity formation within a community of like-minded individuals, the community of practice. The social learning theory reflected in communities of practice holds that, as teachers interact with other teachers in the course of their work, they are learning. Learning is situated in activity and is “ubiquitous” in activity (Lave, 1993; Lave and Wenger, 1991).
Social Learning

The social learning theory for communities of practice developed by Wenger (1998) is based on his earlier work with Lave (Lave & Wenger, 1991) and begins with four premises: 1) humans are social beings; 2) knowledge is a matter of competence with respect to valued activities; 3) knowing is a matter of being actively engaged in shared activities; and 4) learning produces meaning. Community evolves as participants interact with others around joint work and negotiate meanings, in the process developing resources, tools, and concepts.

Wenger (1998) places social learning at the center of multiple dualities – conceptual units that embrace "two inseparable and mutually constitutive elements" that are in tension with each other yet are also complementary (p. 6). An appreciation of the following dualities (Figure 2.1) enriches an understanding of the process of learning through participation: structure and agency (Dewey, 1922; Giddens, 1984, 1991; Lévi-Strauss, 1958; Schöhn, 1983); participation and identity (Bordieu, 1979, 1980; Giddens, 1991); collectivity and individuality (Lave, Duguid, Fernandez, & Axel, 1992); and power and meaning (Bordieu, 1972, 1979).

In a duality, both elements always contribute to learning. Learning results from the reciprocal interactions between the elements, as each element in the duality modifies and is modified by the other. To discuss these dualities more concretely, I use the example of Mary, the beginning algebra teacher in School A (see vignettes in Chapter 1). The structure of the mathematics department that defines Mary’s situation is in tension with her own sense of agency. The mathematics department organizes instruction by students’ ability level. Teachers rely heavily on textbooks and cover specific topics in
Figure 2.1
Dualities of Social Learning

designated courses, assuring that students have been taught what they need to know before they go on to the next class. Based on her university preparation, Mary has a
different set of understandings about knowledge and student learning. She has
experienced students' abilities to learn complex concepts in all classes, not just in
advanced ones. As much as structural realities impact her decisions regarding instruction.
however, Mary is an agent responding to her own situation. She might slowly socialize to
the accepted departmental practices focused on coverage and facts, using textbooks, or
she might go “against the grain” and continue her practice of teaching for deep
understanding. The tension between the two elements encourages learning – not only for Mary but for all members of the department as they interact over the course of time.

The other dualities also shape the process of learning. As a result of her participation in the joint work of mathematics instruction, Mary's identity emerges – who she is, what she does, and how she interprets what she does. As a novice challenging the established practices of the department, she succeeds in getting her algebra students to engage complex concepts. In response to Mary’s use of innovative methods, other members of the department can either dismiss her work automatically or they can use her experience as a test against their own. Her individual understandings are in tension with the collective understandings of the department. Each set of understandings can be enlarged or modified as a result of interaction among departmental colleagues.

The extent of Mary’s learning also depends on the interaction between power and meaning. As a newcomer, Mary practices at the periphery, with fewer responsibilities and time demands. Those with power in the community of practice have some control over the legitimacy and extent of her participation. However, the meaning Mary makes of her situation is critically important in determining her response to power. If she understands the sources of authority to be legitimate, she might accommodate to the prevailing norms of the community. If the authority is supportive, she might advocate for wide consideration of her ideas. If she perceives that the authority is limiting or demeaning, she might withdraw from interaction and become isolated, or she might concentrate her efforts in another community of practice (perhaps with members outside of the department) where she is acknowledged for her competence.
As seen in this example, each element of the duality shapes the other, and the resulting tension encourages learning. The dualities can not easily be separated from each other, as situations for learning reflect the interconnections of the multiple dualities. The processes of learning within a community of practice also occur in interactions resulting from overlapping membership or across boundaries of communities of practice.

**Characteristics of Communities of Practice**

Though what members do together defines communities of practice, the essence of the interaction is more than being in the same place with others. When Wenger (1998) associates community and practice in the term “community of practice,” he defines a special type of community and makes the concept of practice specific: “practice” is the source of coherence for a “community.” This association manifests itself in three characteristic dimensions of communities of practice: 1) mutual engagement; 2) joint enterprise; and 3) shared repertoire. Each of these dimensions represents opportunities for learning.

**Mutual engagement** of participants is the first dimension that explains how practice creates coherence for a community. Practice is the process of participation: doing things, working out relationships, inventing, interpreting, producing, or resolving (Lave. 1988). For members of a mathematics department community of practice, for example, teachers participate when they attend in-service together, coordinate what should be taught in each course, invent ways to reward or sanction members, interpret standards documents, produce a curriculum, and resolve disputes over course assignments. Practice exists because the teachers engage in actions with each other and
negotiate meanings about what those actions mean. These negotiations can range from a
conscious process of give and take involving all members to a more subtle, almost
unconscious process of mutual adaptation by individuals over time. While factors such
as proximity or allegiance can facilitate interaction, mutual engagement depends on being
actively involved with others in the work community members are there to do (Wenger.
1998).

Being included in what matters is a requirement for being engaged in a
community of practice. Certainly this means being actively involved in the work of the
community, but it also refers to the social relations between community members. In
order to be mutually engaged, members must participate legitimately, as discussed in
Chapter 1. Each member develops his or her way to contribute to the practice, even as
the community develops shared ways of doing things. For instance, for science teachers
working collectively to improve instruction, one community member might be the
acknowledged expert in creating strategies for cooperative student work and another in
securing resources by writing grants. Each member contributes what he or she knows
and can do at the same time each connects meaningfully to the contributions and
knowledge of others (Wenger, 1998).

The second characteristic of practice that contributes to the coherence of the
community is negotiation of a joint enterprise. Joint enterprise refers to the negotiated
understanding of what the practice is about – what purpose the members of the
community of practice intend to accomplish (Wenger, 1998). Joint enterprise develops
from a collective process of negotiation as members respond to their situation. For
example, mathematics teachers, after noting the difficulty their students have in
responding to open-ended questions on state proficiency tests, might collectively agree that having students write about mathematics will be a fundamental part of their practice. By changing an instructional practice, the community of mathematics teachers shapes the enterprise at the same time they pursue it. Perfect agreement may not exist among community members about this practice, but disagreement is a natural part of finding ways of working together (Wenger, 1998).

Communities of practice do not exist as isolated entities; they are embedded within organizational and environmental influences and conditions. However, the power that external forces have over the practice of a community is always mediated by the community’s production of its practice. Community members decide what is important and what is not, what to do and not to do, what to pay attention to and what to ignore (Wenger, 1998). In the example just given, mathematics teachers decided that having students write about mathematics is important to students’ understanding of the subject. The process of selection that went into making this decision creates a sense among community members of what they are accountable for, in the sense that they are accountable to other members of the community. After a period of time, the mathematics teachers might decide that the resources spent on writing in their classrooms have not resulted in sufficient benefit to continue the practice. Writing about mathematics, then, might be de-emphasized. The joint enterprise is more than a statement of purpose; it is a dynamic process that “pushes the practice forward as much as it keeps it in check” (Wenger, 1998, p. 82).

The third characteristic of practice that provides coherence to the community is a shared repertoire. The elements of the repertoire include routines, processes, and
policies as well as words, ideas, concepts and symbols that become part of the practice and help coordinate elements of the practice (Wenger, 1998). Continuing the above example, the mathematics department adopted a policy requiring that teachers have students write about their understanding of mathematics concepts. Common resources such as policy documents, curriculum objectives, and teachers' lesson plans reflected the implementation of the policy. However, after a period of time, teachers became disenchanted with the policy and negotiated a modification of the practice. As this example shows, the resources all have a history or shared points of reference known to community members, yet they also are ambiguous in that they can take on new interpretations as negotiated by the community. In a sense, the resources are artifacts of the practice around which new learnings develop.

The inherent flux in the repertoire of a practice makes coordination and communication challenging, yet it opens the practice to the generation of new meanings. The problem is not to overcome all ambiguity to the point that there is common agreement among all community members; rather, it is to sustain open interaction among members to allow fresh insight and challenge to existing practices to enter the negotiation.

Research Applying the Communities of Practice Perspective

Wenger's (1998) treatment of communities of practice is based on an ethnographic study of insurance clerks, but the concepts apply equally to teachers. The community of practice perspective was especially useful for researchers analyzing the learning of teachers engaged in developing and implementing an innovative mathematics
program in an urban middle school (Stein & Brown, 1997; Stein, et al., 1998). These studies of teachers clearly document the process of legitimate peripheral participation (Lave & Wenger, 1991) and detail the social learning arising from the tensions between structure and agency, practice and identity, and power and meaning. The studies also support the necessity for different perspectives among community members in order to move forward in reform work, including the knowledge contribution of outside experts (Bredo & McDermott, 1992; Stein & Brown, 1997; Stein, et al., 1998). The studies reveal that informal conversation contributes value to teacher learning (Stein & Brown, 1997). Researchers realized that such experiences are not "secondary," but are integral to a full understanding of teacher development (Stein & Brown, 1997). Though the research that specifically applies the terminology of communities of practice has tended to focus on elementary or middle school math teachers, other research investigating teachers' communities can be reinterpreted through the communities of practice perspective, as is the case with the studies described in the following section.

**Departmental Teachers' Professional Communities**

Much of the extant work on teachers' professional communities emerged from a multi-year investigation of teachers' worklives in sixteen high schools conducted by researchers at the Center for Research on the Context of Secondary School Teaching (CRC) at Stanford University. While these studies are very consistent with the communities of practice perspective, the term has only recently been applied to this research in McLaughlin and Talbert's (2001) capstone work, which summarizes the ways in which local contexts (schools, departments, and communities) matter the most to
teachers’ work in the classroom. Because the departmental context is most consequential in this research (perhaps because the schools studied were primarily large, comprehensive high schools), I refer to these communities as “departmental communities” to distinguish them from “schoolwide communities,” which I discuss later in this chapter. Through their research, the CRC team came to understand departmental communities as the primary context of teaching and to realize that departmental communities construct their practices in widely different ways and with different effects on teachers as the vignettes in Chapter 1 show. In some departments, high levels of interaction and coordination are characteristic of all or most teachers. In other departments, teachers cohere into smaller sub-groups for joint work. In all cases, the effect of the departmental community mediates the effects of broader organizational and institutional contexts on the ways in which teachers work (McLaughlin & Talbert, 2001).

**Characteristics of Departmental Professional Communities**

In reviewing the CRC studies, McLaughlin and Talbert (2001) identified strong departmental communities of two types: those that maintained traditional practices of testing and sorting students, transmitting predetermined course material in teacher-centered classrooms, and those that adjusted conceptually-challenging course work to engage students, using innovative methods in student-centered classrooms. The type of community teachers enacted represented a local response to a complex interplay of external forces, including the policy context of the state, the changing student population, and institutionalized understandings of the subjects teachers taught.
Strong departmental communities resulted in large part from the vastly different policy contexts in place in the two states where the schools were located (California, which had statewide curriculum frameworks in place, and Michigan, which did not) and from the changing student populations, where immigration and desegregation policies rapidly transformed the social, linguistic, racial, and academic composition of schools (particularly in California). Strong innovative communities were found largely in California where teachers grappled with the complex challenges of educating diverse students to meet ever-increasing standards for learning. Without state pressure, and with a more stable student population, strong communities in Michigan schools tended to be traditional.

Teachers' understandings of their subject also proved important in the way departmental communities emerged. In the strong traditional communities, teachers enacted their practice according to long-standing, common understandings about the ways students learn and the best ways to teach different subjects. Teachers justified maintaining traditional instructional methods – even though the methods were ineffective with many students – in terms of professional standards and the integrity of their subject domain (Grossman & Stodolsky, 1994; Siskin, 1994). In the strong innovative communities, teachers departed from subject paradigms and fit the course work to the needs, interests, and academic ability of their students. Because these subject paradigms are so firmly entrenched and have important consequences for teachers’ work together. I summarize that work next.
Conceptual and Operational Contexts of Subjects

Stodolsky and Grossman (1995), two CRC researchers, showed that, for high school teachers, the subject department constitutes both a “conceptual context” (p. 228) and an “operational context” (p. 246) for instruction. Teachers’ subject affiliations influence how teachers think about curriculum, about teaching and learning, and about their individual and collective expectations of students. They also influence actual instructional practices and the manner in which departments enact curricular and organizational policies such as those regarding student placement, teaching assignments, and curricular coordination (Stodolsky & Grossman, 1995).

School subjects differ in a number of respects. Relevant features of subjects establish a conceptual context: the extent to which a subject is defined, is sequential, is static or dynamic, or is required or elective. These features of subjects then relate to the operational context: degree of curricular coordination, degree of curricular autonomy, and extent of standardization. Based on these features, Stodolsky and Grossman (1995) identify extensive differences between mathematics and science teachers, not only in how they understand their subject and the best ways for students to learn it, but also in how they work within their respective departments to organize instruction.

Defined subjects. Degree of definition refers to whether or not there is agreement as to the content of the school subject (Stodolsky & Grossman, 1995). Mathematics is a “defined” subject and the boundaries of the subject are rather clear. Science, in contrast, is less clearly defined (e.g., including “intelligent design” in the curriculum as a scientific theory) and is composed of a number of fields of study (e.g., biology, chemistry, and earth sciences).
Teachers of defined subjects are likely to have taken similar college courses in their undergraduate preparations. This preparation, as well as the accompanying socialization into the profession, tends to ensure that teachers of defined subjects are prepared to teach a variety of course offerings within the department. As a result, mathematics teachers' class assignment will likely result from rotation, random assignment, or decisions made by department members. (See Appendix A for a chart of class assignment patterns for teachers in the current study.) Teachers of less defined subjects generally take different majors as undergraduates. The result is that science teachers are likely to be regarded as experts in a particular field of science, so teaching assignments generally are given to teachers based on that expertise. The arrangements by which teachers are assigned to classes have consequences for their learning. For instance, mathematics teachers, who are more likely than science teachers to have the necessary preparation to teach most of the courses offered in the department, perhaps have greater opportunities to learn in the course of their teaching as they are exposed to different levels of coursework and different groups of students (Stodolsky & Grossman, 1995; Wenger, 1998).

The difference in subjects as defined or not has implications for the extent to which teachers interact broadly and coordinate closely with other teachers in the department. Mathematics teachers are more likely to come to agreement about curricular content. Science teachers generally are not as concerned with consensus about curriculum, though they are concerned with application of the scientific method (Siskin, 1994).
Sequential subjects. Teachers of some subjects, such as mathematics, perceive prior student learning to be prerequisite for later learning (Stodolsky & Grossman, 1995). The need to cover material in a certain order can exist within a particular course or can spread across different courses, resulting in across-course dependencies. "Sequential" subjects require more attention to content coverage and coordination of curricular content than subjects without sequential properties. Mathematics teachers, then, might place more importance on covering the curriculum than science teachers. Understanding a subject as sequential might also result in less autonomy in choosing curricular content, instructional techniques, and materials. Teachers of sequential subjects may also have more knowledge of one another's practices and curriculum content, which could be either a contributor to standardization or a result of standardization (e.g., common exams, similar materials and activities, using same course syllabi) (Weiss Banilower, McMahon & Smith, 2001).

The emphasis on sequentiality and coverage affects the organization for instruction. While most mathematics and science teachers depend on textbooks as the foundation of instruction, mathematics teachers are more likely to focus on coverage of all the material in the book (Weiss, Matti, & Smith, 1994). Mathematics teachers are also more likely than science teachers to believe that students learn best when they are grouped into sections by ability. In practice, incoming high school freshmen in mathematics classes are more likely to be placed by ability level into classes than freshmen in science classes (Weiss et al., 1994; Weiss et al., 2001).

Static subjects. Subjects also differ by the degree to which they are "static" or unchanging (Stodolsky & Grossman, 1995). Static subjects comprise content that
changes very slowly whereas dynamic fields are those where theoretical positions change, new knowledge appears regularly, and teachers perceive a need to stay up to date. Static subjects have curriculum stability over time; teachers who understand their subjects as static might resist content change more than teachers who understand their subjects as dynamic. It would seem logical, then, that mathematics teachers would be more hesitant to change their teaching practices or instructional organization than science teachers. On the other hand, science teachers might be more open to opportunities for change in instructional goals, content, and technique. Science teachers might also be more willing to search out opportunities for professional development outside of the school, seeking new knowledge and insights from other disciplinary experts.

Research Related to Departmental Communities

Researchers at Stanford who came after the first series of CRC studies have begun to look more closely at the processes for negotiation of meaning within teachers’ community through case studies. One study, examining how elementary teachers made sense of a state reading reform initiative (Coburn, 2001), pinpoints two factors that determine the effectiveness of the meaning making process. Though the study relates to elementary teachers, the findings have relevance to this dissertation study. First, less conservative change in instructional practice resulted when conversations occurred in a formal setting among heterogeneous group members. Second, substantive conversation translated into instructional practice more frequently when the conversation occurred naturally within the group rather than in response to administrative request. Coburn identifies teachers’ communities evolving at two levels: the school-level group where
heterogeneous school members negotiate meaning in formal discussions and the smaller
groups of homogeneous members that make sense of the initiatives in informal
conversations. While the smaller groups most closely represent the interactions that take
place within communities of practice, school-level communities, as I explain next, are
also important sites for learning and change.

Schoolwide Teachers' Professional Community

Teachers' work with students in classrooms contributes importantly to students'
academic achievement, but what teachers do outside their classrooms prepares them to
execute their central work with children better and is critical to school reform (Kruse,
Louis. & Bryk, 1995). Conceptualizing teachers' professional communities as a school
characteristic, Kruse, Louis. Bryk and associates advance the argument that the school,
rather than the individual or a small group, is the primary unit of change (Van Velzen,
Miles. Ekholm. Haneyer. & Robin. 1985). This is in line with the work of other
researchers who have shown that the school's interpersonal and structural conditions
affect the degree to which teachers impact student learning (see, e.g. Lee. Smith & Bryk.
Rosenholz. 1989).

The research on schoolwide professional community includes studies conducted
by researchers at the Center for the Organization and Restructuring of Schools (CORS) at
the University of Wisconsin-Madison. Most of the research involved schools that were
well along in the process of restructuring and departed significantly from the structural
arrangements of typical public schools, (Louis & Kruse. 1995; Louis. et al.. 1996;
Newmann et al., 1996), though some studies examined schoolwide professional community in the Chicago public school system (Bryk, Camburn & Louis, 1999; Camburn, 1997).

**Characteristics of Schoolwide Teachers' Professional Community**

The conceptualization of schoolwide teachers' professional community (Louis, et al., 1995) integrates two important perspectives for reform of teachers' work. The first perspective is teacher professionalism, emphasizing the importance of a technical knowledge base, control over the conditions of work, and a strong client orientation. The other perspective is community, encompassing a core of shared values, common activities, and structural features that allow networks of teachers to form. (Bryk & Driscoll, 1988; Bryk, Lee & Holland, 1993). The communitarian interest in the common good balances the emphasis on individual preparation, achievement, and rights associated with professionalism (Bryk et al., 1993; Louis et al., 1995).

Two central elements characterize schoolwide teachers' professional communities: core practices marking teachers' joint work and shared norms focusing teachers on the connections between their instructional practices and student achievement (Bryk, et al. 1999; Kruse et al., 1995; Louis et al., 1996). Optimally, teachers' collective work outside the classroom provides teachers with opportunities to learn new ways of teaching. Reflective dialogue, which progresses at individual and group levels, develops self-awareness and skills of inquiry. Deprivatized practice focuses discussion of instructional practice on real situations and real problems and provides value to the community in terms of trust, respect, and sense of efficacy. Collaboration involves the
co-creation of new knowledge and the co-development of new skills as faculty work together toward school improvement (Bryk et al., 1999; Kruse et al., 1995; Louis et al., 1996).

*Shared purpose* among faculty elicits the work behaviors described above and brings coherence to a professional community, particularly when attention has a *focus on student learning* (Bryk et al., 1999; Kruse et al., 1995; Louis et al., 1996). Shared norms about teaching extend to a collective responsibility for the core functions of the school and the necessity for socializing new members to these norms (Bryk et al., 1999).

While the researchers acknowledge that teachers often work collaboratively with small groups, central to the schoolwide conceptualization of teachers’ professional community is the idea that professional community is a generalized attribute of the school. In order for a school to make significant progress in improving student achievement, according to their view, the normative structure and collaborative working arrangements must extend throughout the school, across groups and through grade level or departmental boundaries.

**Empirical Research on Teachers’ Professional Community**

The characteristics detailed above, relating to the normative structure and collaborative relationships of teachers’ professional community, are subject to manipulation to the extent that policy or leadership can influence the way teachers work together. Other forces that affect teachers’ work together, however, are either not easy or impossible to change. Where the CRC studies identified the institutional impact of subject affiliation, the CORS studies demonstrate the effect of different school levels. In
the small set of restructured schools, the CORS researchers found only one high school (out of eight in the high school sample) where teachers' professional community flourished (Louis et al., 1996). Studies of teachers’ professional communities based on the Chicago public schools data include only elementary schools (Bryk et al., 1999; Camburn, 1997). Generally high schools are larger and more complex than elementary schools (Herriott & Firestone, 1984) and more intent on sorting students and certifying them for future positions (Parsons, 1959). This means that high school teachers, in relation to elementary teachers, have less opportunity for interaction and are more likely to be involved in diverse activities. They are also less likely to reach consensus on the purpose of schooling (Wilson, Herriott, & Firestone, 1991). These factors potentially limit high school teachers' desire for joint work.

Louis, Marks, and Kruse (1996) identified marked gender differences in schools with strong professional community, though these differences were confounded by differences in level. Others have pointed out the salience of gender as a mediating characteristic in schools (Hansot & Tyack, 1988), suggesting that the development of professional community is related to the presence of women on the faculty. Women are more likely to form dense networks with colleagues and to enjoy collaborative rather than individualistic work environments (Shakeshaft, 1987; Tannen, 1994). Effects of gender, however, differ depending on the makeup of the group. Social groups consisting of women have a marked feminine culture, whereas mixed social groups tend to have a masculine culture (Hofstede, 1991).

Community, related to shared values, is more likely to develop in homogeneous rather than heterogeneous groups (Bryk & Driscoll, 1988). As a result, the racial and
ethnic composition of faculty potentially affects schoolwide professional community. In the Chicago public schools, where African American teachers are more likely to constitute a sizeable portion of the faculty, African American teachers report higher levels of professional community than other groups (Bryk et al., 1999).

Several advantages accrue to schools organized as schoolwide professional communities. Teachers experience enhanced efficacy, greater satisfaction, and increases in motivation, and they take greater responsibility for student learning (Louis et al., 1995; Marks & Louis, 1997). Other studies indicate that teachers in strong professional communities are more open to instructional improvement (Marks & Louis, 1999; Marks, Louis, & Printy, 2000). Teachers’ participation in collaborative activities is conducive to individual learning (Camburn, 1997) and schoolwide professional community contributes importantly to the general orientation of the school faculty toward experimentation and innovation (Bryk et al., 1999). However, strong professional community does not necessarily preclude teachers from using traditional, teacher-directed instructional activities focused on the acquisition of knowledge and skills (Camburn, 1997). In this sense, a strong community can be a very stable – though conservative – force in schools.

Social Organization of High Schools

Two additional streams of research investigating the social organization of high schools provide insight into the importance of collegial relationships among teachers. One set of studies conducted by Rowan and his associates and another conducted by Bidwell and his associates explore exogenous factors that initiate the development of collegial faculty groups as well as the impact of collegial relationships on teachers’

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professional work (Bidwell, Frank and Quiroz, 1997; Bidwell & Yasumoto, 1999; Rowan 2002a; 2002b; Rowan, Raudenbush & Cheong, 1993; Rowan, Raudenbush, & Kang, 1991). Within each stream, initial studies took a schoolwide focus and were followed by studies that looked more discretely at the importance of teachers' interactions within their subject departments. In this section, I discuss the studies as they relate to the notion of teachers' social relationships, and I also return to these studies in the subsequent discussion of the professional impact of such relationships.

Using the CRC survey data, Rowan and his associates investigated the relationship between teachers' work and the organizational management of the school (Rowan 2002a, 2002b; Rowan, et al., 1993; Rowan, et al., 1991). According to contingency theory, organizational effectiveness is enhanced when there is a match between the types of work and the form of management. Workers doing routine work, where tasks are unvarying and repetitive, respond best to formally centralized and directive leadership; workers doing non-routine work, where there is more variability and uncertainty about the work, are more effective under organic forms of management. Organic management is characterized by participative decision making, collaborative problem solving, and supportive leadership.

Organic management represents a shift from hierarchical control to network control, where communication patterns are multidirectional and authority shifts to whoever has the requisite expertise (Burns & Stalker, 1961). Early studies in this stream of research found that teachers who used instructional practices consistent with reform ideas experienced increased complexity and uncertainty in their work and reported higher levels of organic management in their schools. Teachers sought out information they
needed to carry out non-routine work. In the course of talking to each other, they enacted an organic form of management. Teachers also reported greater commitment to work, higher expectations for success with teaching, and more professional growth (Rowan et al., 1991; Rowan et al., 1993).

Rowan's (2002a; 2002b) recent work improves the specification of teachers' tasks and argues a reciprocal relationship between the nature of teachers' work and organic management. In theory, the workplace learning provided for by organic management reduces the task uncertainty teachers face when using standards-based teaching practices, thus increasing their expertise. His findings support contingency theory — that organic management reduces task uncertainty — but the effects are very modest. He concludes that patterns of organic management and instructional practice are largely disconnected, though organic management does promote workplace learning and improves teachers' attitudes and beliefs, as indicated above (Rowan, 2002b).

A second set of studies investigates the extent to which variation in teachers' work is related to social control, defined as any process through which a social group is able to consider and affect the ends and means of its collective activity. Using network analysis to examine school workplace structure, Bidwell, Frank and Quiroz (1997) posited that school control systems are a function of school size and the power of clients relative to that of teachers. The "collegium," particularly relevant to this dissertation study, is related to small school size and high client power. Collegial workplace control results from frequent opportunities for face-to-face interaction throughout the faculty and clients' demands for professionalism in the staff. The study found that teachers in collegial workplaces were more likely than other teachers to use progressive instructional
methods stressing higher-order mental processes and that teachers' instructional orientation was the same no matter the course they were teaching or the curricular level at which it was taught. Further, they demonstrated that the effects of teaching field are stronger than school-level social control when teaching doctrines or norms are distinctively institutionalized, as is the case with mathematics. When teaching doctrines are less subject-specific, both school-level controls and personal characteristics of individual teachers may be more potent.

Another study in this research stream emphasized the collegial control of instruction within subject departments. Researchers found that strong and dense network relationships exist at the department level for sequential and defined subjects such as mathematics and at the sub-group level for non-sequential and less-defined subjects such as science. Further, the researchers concluded that strong departmental networks have a stronger association with pedagogical practices than departments characterized by different subgroups (Bidwell & Yasumoto, 1999).

The findings of the two research streams suggest that collaborative and supportive school cultures are important to the development of professional, committed teachers who have high expectations for student success. Departmental or sub-departmental cultures are important determinants of teachers' instructional practices and their instructional expertise.

Professional Impact of Teachers' Communities

This section explores the literature related to the impact of teachers' participation in communities of practice. In Chapter 1, based on the potential for social learning
inherent in participation, I hypothesized that productive communities of practice would increase the likelihood that teachers learn from others with expertise, feel competent in their instruction, and use standards-based instructional techniques.

Teacher Learning

Increasingly, educational practitioners, researchers, and policy makers agree that instructional change is the fundamental mechanism for school reform, and that change, in order to be productive, requires teacher learning (King & Newmann, 2000). From the communities of practice perspective, learning is interwoven with practice (Wenger, 1998). As members experience mutual engagement, they learn together. They collectively utilize the resources of the community's shared repertoire. Importantly, the reason for learning is determined by the community's joint enterprise.

As the community learns, it shares information and builds social capital (Wenger, 1998). Members learn how to interact productively and develop personal trust in others. They also develop trust in others' abilities to contribute to the enterprise of the community. “Through receiving and giving help [community members] ...gain enough awareness of the richness of the community to expect that their [own] contribution will be reciprocated in some way” (Wenger, 2000, p. 232). Within a community of practice, members are likely to draw on the expertise of other members. Concomitantly, they also expect that others will tap their own knowledge.

Empirical research has shown the connection between teachers' collegial relationships and teacher learning. Studies in Chicago schools indicate the positive relationship between teachers' participation in collegial activity and self-reports of
improvement in their instruction (Camburn, 1997). Schoolwide professional community, similarly, has a strong association with a general orientation of a school's faculty toward experimentation and innovation (Bryk et al., 1999), which, the researchers hypothesize, may accelerate professional learning in the organization. An important contributing factor in the Chicago studies was social trust, perhaps necessary to overcome the norms of autonomy that are so much a part of teaching (Hargreaves, 1991). A recent qualitative study by Grossman, Wineburg, and Woolworth (2002) has similar findings, documenting the importance of trust and reciprocity to community members' learning. Rowan's (2002b) study, showing that the collegial and supportive environments represented by organic management are likely to result in greater workplace learning, captures similar effects.

Teacher Competence

Teachers' work affects how students learn. School effectiveness research has shown that teachers' attitudes are instrumental in how they instruct students and in how students respond to instruction (Brophy, 1986; Cooper & Tom, 1984; Raudenbush, 1984). Because members of a community of practice determine what constitutes competence in a given context, teachers' community participation is likely to be related to their ability to affect student learning through their instructional practices (Wenger, 1998). Several considerations lead to this conclusion. First, to be competent is to be accountable to the joint enterprise. In a community of practice where the joint enterprise is defined by a continuous learning toward the goal of instructional improvement, the notion of competence indicates that teachers must adjust their instruction to meet student
needs. Second, through *mutual engagement,* teachers establish relationships and community norms. To be a competent member is to be able to engage with the community in improving instruction and to be a trusted partner in these interactions. Third, over time, communities develop a *shared repertoire* of resources. To be competent is to have access to the repertoire and to be able to use resources appropriately to improve students' classroom experiences.

The notion of competence for this study is related to the ideas of the expert teacher (i.e., high task variety, low task uncertainty) in Rowan's (2002b) exploration of contingency theory. The competent teacher recognizes that various instructional strategies can affect student learning and understands that changing teaching strategies is a necessary response to students' learning difficulties. When students bring their learning difficulties into the classroom, the competent teacher modifies instruction, which introduces task variety. Greater task variety results in greater task uncertainty (Rowan, 2002b). The extent to which teachers report their success in helping students overcome their learning difficulties (i.e., higher scores on the competence measure) indicates a reduction in task uncertainty. Thus, competent teachers are expert teachers.

Competence refers both to teachers' *ability* to modify instructional practice and their *accountability* to other community members for doing so. Other researchers have investigated teachers' ability, or sense of "efficacy," to affect student learning (Ashton & Webb, 1986; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). When teachers perceive that they can accomplish a task, they are willing to put forth more effort and to persist through stressful or difficult situations. The notion of accountability has also been investigated elsewhere, as teachers' "collective responsibility" for student learning (Lee
& Smith, 1996; Little, 1990; Louis et al., 1995; Marks & Louis, 1997). Responsibility, as an attribute of teachers, emphasizes the shared conviction among a school’s teachers that all students can and will learn if given opportunity and support (Lee & Smith, 1996). Collective responsibility for students has been empirically shown to result from schoolwide professional community (Marks & Louis, 1997).

The present study investigates the impact of communities of practice on teachers’ competence. At an individual level, competence is analogous to collective responsibility in that it taps both the ability of a teacher to adapt instruction to meet student needs and the responsibility of the teacher to do so.

**Use of Standards-based Pedagogy**

As society has considered the values, processes and problems of education over the last several decades, a hallmark of science and mathematics education has been standards-based reform, intended to dramatically change the way teachers work with students in classrooms in order to improve student achievement. A series of documents developed under the guidance of the National Council of Teachers of Mathematics (NCTM)⁶ and the National Research Council (NRC)⁷ set guidelines and procedures for curriculum, instruction, professional development, and assessment for mathematics and science teachers respectively. For both disciplines, standards documents take a systemic approach to reform and have a number of features in common:

- They focus on understanding, emphasizing comprehension of material rather than rote memorization of facts.
- They emphasize depth of knowledge about fundamental mathematics and science processes.
• They address content, teaching, professional development and assessment.

• They emphasize a comprehensive, focused, and coherent approach to mathematics and science education. (National Education Goals Panel, 1997)

Though more a conceptual approach than a prescriptive one, the standards call for a departure from traditional, teacher-centered, didactic instructional techniques.⁸

Within a short time following the release of the disciplinary standards, mathematics teachers reported that they were incorporating standards-based concepts into their practice and science teachers reported support for the reform approach, stating the belief that the standards could improve the way science is taught in classrooms (Weiss, et al., 1994). However, philosophical agreement with the standards is not the same thing as putting them into practice substantively. Research shows that teachers who believe they are using standards-based practices are often, in fact, incorporating them in only a superficial way (Cohen, 1990; Ferrini-Mundy & Schram, 1997; Stigler & Heibert, 1999). In many cases, teachers use innovative instructional methods but do not have students engage in complex thinking (Ferrini-Munday & Schram, 1997).

The research reviewed in this chapter sheds light on these findings. In essence, exogenous factors, such as standards documents, can set in play a causal chain that impacts teachers’ instructional practices (Gamoran, 1986; 1992; McLaughlin & Talbert. 2001; Rowan, 2002a). The studies detailed here also show that the very different conceptions of knowledge and student learning held by mathematics and science teachers are critical mediating variables in this causal chain (Bidwell & Yasumoto, 1999; McLaughlin & Talbert, 2001; Rowan, 2002a). Mathematics teachers, who teach a subject with strong institutionalized norms for teaching practice, are less likely to be
influenced individually by pressures outside of their departmental communities of practice than teachers of subjects with weaker instructional norms, such as science teachers (Bidwell & Yasumoto, 1999).

Regardless of subject, the learning inherent in social interaction around standards-based reform initiatives is likely to increase teachers' use of instructional methods consistent with the disciplinary standards. Social learning can also equip teachers to use practices consistent with reform effectively, though this effectiveness develops slowly over time (Bidwell, 2001; Coburn, 2001). Those who study how teachers incorporate standards-based practices seem to agree. Evidence indicates that when teachers analyze instructional practices and materials within their communities, they will learn how to use them (Bidwell et al., 1997; Bidwell & Yasumoto, 1999; Camburn, 1997; Marks & Louis, 1997; National Education Goals Panel, 1997).

As teachers come together in mutual engagement, they reach a common understanding of what their situation is in the context of pressure for instructional reform. Together, they negotiate the purpose of their joint work, that is, how their joint enterprise will respond to this pressure. In the process of shared activity, they develop a shared repertoire of practices on which community members can draw in carrying out instruction within their separate classrooms. Abandoning traditional, control-oriented classroom practices (Cusick, 1992; McNeil, 1986) and enacting student-centered practices is a venture into the unknown for teachers—a journey made more smoothly within the context of a community of practice.
Communities of Practice and Instructional Leadership

Communities of practice depend on the shared interest and the joint activities of their members; they are informal organizational forms that exist because members of the community have common understandings and knowledge to share with one another. To a large extent the character of a community of practice reflects the social relations of its members. I have elaborated on distinctions related to social norms among teachers in the vignettes, in the discussions of the various community types in the typology, and in the research reviewed in this chapter. The importance of these social relations extends as well to leadership, in terms of the informal leadership within the community and the formal leaders in the school.

Because communities of practice are informal groups that emerge around patterns of interaction among like-minded colleagues, they generally do not have a designated, formal leader. Nevertheless, the group requires informal leadership to keep its purpose at the center of activity and to shape social relations among members in order to facilitate learning (Wenger, 2000). Like communities of practice themselves, leadership within the community is informal and emergent, and is, perhaps, greater than any one individual, residing in the community itself (Wenger, 1998).

Leadership relationships involve formal leaders as well. In high schools, leadership responsibility is often distributed to subject-area department chairs. Most research into the role of department chair, however, documents the difficulty and ambiguity that accompany the role. While chairpersons have some measure of authority, they often lack clear direction in trying to merge teaching and administrative orientations (Schmidt, 2000; Weller, 2001). Goldberg (1996) suggests that the role of department
chair diminishes the stature of teachers and constrains the emergence of teachers as “complete professionals” (p. 327). (See also Grossman et al., 2001.) On the other hand, Weller (2001) highlights the importance of the department chair in the development of teachers, and indicates that the relationships between chair and teachers change over time as they shape each other. These findings underscore the complexity involved in departmental leadership as a result of shifting relationships. Research has not investigated the importance of the department chair in relation to high school teachers’ communities of practice, even though the department is the most likely site for community to develop.

Strong principals have long been considered important to effective schools, even when teachers have increased involvement in schools as a result of site-based management or participative decision making (Purkey & Smith, 1983). However, Donaldson (2001) details the inability of high school principals to provide “functional” leadership to all the individuals in a school and the propensity for principals to “burn out” because of the undue stress of trying to do so. Increasingly, researchers report forms of “distributed” school leadership. From this perspective, leadership enlarges beyond any one individual’s position to encompass a web of relationships throughout the school (Donaldson, 2001; Dunlap & Goldman, 1991; Ogawa & Bossert, 1995; Spillane, Halverson, & Diamond, 2001). (For a review, see Smylie, Conley & Marks, 2002.) Recently, educational theorists have sought to redefine the principal’s responsibilities as an instructional leader (Crow, Hausman, & Scribner, 2002; Furman & Starratt, 2002; Goldring & Greenfield, 2002; Larson & Murtadha, 2002; Leithwood & Prestine, 2002; Lugg, Bulkley, Firestone, & Garner, 2002; Murphy, 2002a; 2002b; Spillane & Louis, 2002). One study empirically demonstrated the importance of the principal involving 59
teachers in shared instructional leadership (Marks & Printy, 2002). Because teachers ultimately enact instruction in their classrooms, such an approach is critical (Coburn, 2001). To date, no empirical research has explored the relationship of principal leadership to teachers’ communities of practice. (See Bryk et al., 1999, for the importance of principals’ supportive and supervisory leadership to schoolwide teachers’ communities.)

Summary

Communities of teachers who engage in collective work appear in many configurations. Particularly in high schools, research has documented variation within schools, from small groups of close colleagues, to a subject department, to an entire school. No matter the level at which they occur, nor the perspective taken by the researcher, members of teachers’ professional communities enjoy enhanced professional capabilities as a result of a shared focus on educational goals and collaborative work arrangements with other school members.

The conceptualizations of teachers’ communities at the departmental and school level detailed in this chapter emerged from qualitative studies documenting the nature of teachers’ work in schools. While the CRC studies included elements of quantitative analysis, systematic, empirical studies of the effects of departmental communities on teacher outcomes are limited. Several quantitative studies by the CORS researchers have given strong evidence of the value of schoolwide teachers’ professional communities on both teachers (Bryk et al., 1999; Louis et al., 1996) and students (Louis & Marks, 1998; Marks & Louis, 1997). Informed by Wenger’s explication of communities of practice and by various studies of high school teachers situated in their
subject departments. in the next chapter. I make operational the concept of communities of practice for high school mathematics and science teachers, using a large, national database. I describe the study sample, the measures I constructed, and the analytical approach I subsequently used.
Notes to Chapter 2

1 Researchers McLaughlin and Talbert and their associates at the CRC examined teachers' work within embedded contexts to see how multiple influences shaped what happened in classrooms. They examined teachers' work in the context of their students (Metz, 1993), within departmental contexts (Little, 1995; Siskin, 1994; Talbert, 1995; Talbert & McLaughlin, 1994), within school organization contexts (Little, 1993; Talbert & McLaughlin, 1994), and within district and state policy contexts (McLaughlin, 1993; Talbert & McLaughlin, 1994). They also looked at the data through multiple theoretical lenses, including institutional theory, organizational theory, and social systems theory (McLaughlin & Talbert, 2001).

2 The CRC researchers refer to the various communities of teachers as professional communities primarily, although they are at times referred to as learning communities or communities of practice (McLaughlin & Talbert, 2001). The only schoolwide communities in the study sample were small alternative schools or schools with a specialized mission.

3 Because information is not included in the data set for the present study about the status of teachers' subjects as required or elective, this characteristic is not explored further.

4 In 11 of the 13 schools in the study, school policy required teachers to teach across ability levels each year. Of 26 respondents observed, 23 taught at least two ability levels.

5 King and Newmann summarize the literature on teacher learning by the following researchers: Corcoran, 1995; Darling-Hammond & McLaughlin, 1995; Hargreaves, 1995; Lieberman, 1995; Little, 1993; Lytle & Cochran-Smith, 1994; Renyi, 1996; and Richardson, 1994.

6 The demands of the information society and the need for mathematically literate workers, lifelong learning, and quality education for all provided the impetus for a series of documents in mathematics, developed under the guidance of the National Council of Teachers of Mathematics (NCTM). These addressed curriculum and evaluation standards (NCTM, 1989); professional standards for teachers (NCTM, 1991); and assessment standards (NCTM, 1995). In 2000, NCTM released a revised document, Principals and Standards for School Mathematics.

7 In 1991, the National Research Council (NRC) began to coordinate efforts to develop national science standards for science education. The National Science Education Standards (NRC, 1996) set out a vision of a scientifically literate populace by outlining what students need to know, understand, and be able to do after completing thirteen years of science education in school. The NRC document also contains standards for teaching science, professional development of teachers, assessment, science content, and school programs. Review and revision of the science standards is underway, with release of revised standards set for 2002 (National Education Goals Panel, 1997).
Several pedagogical frameworks align with the standards: progressivist, constructivist, teaching for understanding, and authentic pedagogy. The progressivist approach is a contemporary application of the instructional aims and methods of progressive education (Cremin, 1961), stressing higher-order mental processes and intellectual independence through the use of flexible, adaptive teaching methods. Constructivist teaching calls for students to create or build their own knowledge rather than receiving it from teachers (Brown, Collins, & Duguid, 1989). Teaching for understanding (Cohen, McLaughlin, & Talbert, 1993) stresses students' development of broad understanding, grasp of general principles, and cognitive power. Authentic pedagogy (Newman et al., 1996) advocates construction of knowledge, disciplined inquiry, and value of learning beyond school.

Studies by Rowan (Rowan, 2002a; 2002b) and Bidwell and associates (Bidwell, Frank & Quiroz, 1997; Bidwell & Yasumoto, 1999) do not adopt the perspective of teacher community, per se.
CHAPTER 3
MODEL, SAMPLE, AND METHODS

This chapter provides the empirical framework for the investigation of science and mathematics teachers' communities of practice, the subject of this dissertation research. Based on the theoretical model presented in the section that follows, I introduce the research questions and hypothesis that guide the examination of the links between teachers, their communities of practice, and enhanced professional outcomes: namely, learning, competence, and use of standards-based pedagogy. After describing the NELS:88 the database from which this study draws its sample, I compare characteristics of teachers and schools in the full sample to those in the final analytic sample. An explanation of how I constructed the measures employed in the investigation follows. The chapter concludes with a review of the methodology and the analytic approach.

Theoretical Model

All communities of practice are characterized by the mutual engagement of their members, a common understanding of the community’s joint enterprise, and a repertoire of shared resources that enable members to do their work. Communities of practice differ according to their purpose, activity and social relations. Communities emerge, and these distinctions evolve as members participate in joint work. Tensions inherent in any
working situation represent a set of opposing yet complementary influences that contribute to members' social learning. Through the process of social learning, members learn what others members of the community of practice value, how community members are expected to behave, and how to contribute to what the community intends to accomplish. For teachers, this social learning is important to their knowledge, beliefs, and skills.

The theoretical model guiding this study (Figure 3.1) integrates two stages of analysis. The first stage frames an exploration of teacher- and school-level factors that influence teachers' participation in communities of practice. I examine the contribution that teachers' social and professional characteristics make to their participation. Social background includes measures that refer to teachers' gender, race/ethnicity, experience in the school, and satisfaction with their teaching situation. Professional background measures include the teaching subject, the curricular track of focal classes, participation in school-offered professional development, and enrollment in college courses. These attributes have important implications for how teachers work together. Department leadership also contributes to shaping the purpose, activity, and social relations of the community. These constructs may have a direct relationship to communities of practice, as suggested by arrow a, at left in Figure 3.1.

School demographic and contextual characteristics have the potential to influence teachers' participation in communities of practice. Because previous research on communities of practice has used only small samples of schools or schools in the public sector only, the potential effects of school sector or location are unknown. It is possible, however, that Catholic schools, recognized in prior research as supportive of schoolwide
Figure 3.1
Communities of Practice and Their Professional Impact: A Theoretical Model of Social Learning for High School Science and Mathematics Teachers
professional community, are likely sites for communities of practice to flourish. Because teachers in urban schools, with a more diverse student population, might find themselves faced with challenging instructional problems, they might more readily develop communities of practice as they search for solutions. Large school size has the potential to inhibit the development of personal relationships. The average family SES can indicate external pressure such as the client power of affluent parents, also likely to affect the formation of teachers' communities.

Beyond these demographic differences, schools can influence teachers' participation in communities of practice through their policies and their personnel. Where the instructional management of the school is participatory and supportive rather than bureaucratic, teachers might have a greater inclination for joint work with their colleagues. Policies that provide teachers with tangible support for learning might encourage teachers toward community of practice membership. Principal leadership that maintains a schoolwide focus is likely to affect activities and relationships outside of the subject departments. School demographic and context factors may have a direct effect on teachers' participation in communities of practice, as shown by arrow b, lower left.

The second stage of analysis focuses on the impact of communities of practice on teachers' knowledge, beliefs, and skills. The model hypothesizes that social learning occurs as teachers participate in their communities of practice and that this learning may result in gains to teachers' professional capabilities. Specifically, participation may increase teachers' propensity to learn from others with expertise, their competence to
adjust instruction according to student needs, and their use of pedagogical techniques aligned to national mathematics and science standards. These direct effects are shown by arrow e.

Because teachers' background and professional characteristics may be related to their opportunities to learn, these characteristics may also have a direct effect on the professional outcomes: teacher learning, competence, and pedagogy, indicated by arrow d. Similarly, because school contextual factors may enhance or limit opportunities to learn and need to learn, they could also have a direct effect on the professional outcomes, as shown by arrow e.

**Research Questions and Hypothesis**

In Chapters 1 and 2, I developed a theoretical rationale for investigating the professional impact of mathematics and science teachers' participation in communities of practice. I characterized communities of practice as productive when curriculum, instruction and student learning are at the center of their collaboration and when members have abundant opportunities for learning as a result of rich interaction with school colleagues and full participation in departmental and school activities.

The following research questions guide the exploration of factors that might explain teachers' participation in communities of practice, the subject of Chapter 4.
• Research Question 1: What social and professional characteristics influence mathematics and science teachers’ participation in productive communities of practice?

• Research Question 2: To what extent do differences in mathematics and science teachers’ participation in such communities of practice relate to their professional development and the department chair’s instructional leadership?

• Research Question 3: To what extent do school demographics affect mathematics and science teachers’ participation in productive communities of practice?

• Research Question 4: How important are school context factors such as organic management, professional development support, and principal instructional leadership to the development of such communities?

The analyses in Chapter 5 test the following hypothesis:

• To the extent that teachers’ communities of practice are characterized by rich interactions among members and purposeful activities focused on instructional improvement, participation in such communities increases teachers’ knowledge, competence, and pedagogical skills.

I turn now to the technical aspects of the study, beginning with a discussion of the NELS:88 data and why these data lend themselves to a study of mathematics and science teachers’ communities of practice.
Data and Sample

The sample is drawn from the National Educational Longitudinal Study of 1988 (NELS:88) database. NELS:88 is a general purpose data set intended for the development and evaluation of federal educational policy related to school organization and programs, student achievement and transitions, and educational practices. Integrating student, school, teacher, and parent studies, NELS:88 permits researchers to study the effects of a wide variety of factors on students' educational attainment and other educational questions in a national sample of public, Catholic, and other private schools.

The Base Year study of NELS:88 collected data on a 1988 eighth grade cohort relative to various educational processes and outcomes related to student learning. The first of three biennial follow-ups, collected in 1990 when the cohort was in tenth grade, began the longitudinal measurement of the 1988 baseline sample and monitored the transition of the student population into secondary schooling. The Second Follow-up data were collected in 1992, when most sample members entered the second term of their senior year. In each wave of data collection, teachers and school administrators provided information about educational processes and school organization.

Data for the study detailed here come from a subsample of schools (1,500) enrolling NELS:88 seniors targeted by NCES for contextual data collection through administrator and teacher surveys in 1992. Departing from earlier rounds where teachers in four subject areas were surveyed, NCES collected teacher information only from mathematics or science teachers, thus selecting out participation of English and social studies teachers. Additionally, the presence of a teacher in the sample depended on his or
her linkage to a sampled student. Twelfth grade students who did not take mathematics or science in the semester during which data collection occurred were not accompanied by teacher or administrator data. Where two teachers could be considered for inclusion based on a single student, NCES applied the following decision rule: selecting first the teacher who taught the more advanced course, then selecting the teacher in whose course the student spent more time, and finally selecting teachers randomly. All factors considered, the Second Follow-up data are much more limited in comparison with those collected in the earlier two waves. The teacher sample in the Second Follow-up reflects 1,264 public, Catholic, and private schools which the sampled students attended.

Analytic considerations necessitated further reduction of the data. I eliminated schools without administrative data on important contextual factors such as school type, location, size, and student body composition. I also eliminated teachers who did not provide responses to survey items relevant to the measure for communities of practice. Additionally, because the teachers who were subject to investigation were nested within schools. I needed at least five teachers in a school to approach faculty representativeness (Lee & Smith, 1995; Lee & Smith, 1996). This consideration alone caused a huge reduction in the sample size, from 1,241 schools with adequate data to 423 schools. In the original Second Follow-up sample of 2,258 schools, over 87 percent had only one student - and thus only one teacher - because of dispersion of students to different schools after the Base Year.

NELS:88 sampled various private schools, including Catholic schools, member schools of the National Association of Independent Schools (NAIS), and other private schools. The study sample includes Catholic schools and NAIS schools that met the
selection criteria. Unlike other private schools, NAIS schools have a common organizational membership and a common identity as selective schools that prepare an elite clientele for admission to prestigious colleges and universities (Coleman & Hoffer, 1987; Lee & Marks, 1990). Catholic and NAIS private schools could provide important contrasts to public schools in how teachers work together. The final study sample is 2,718 teachers in 420 schools.

The NELS:88 teacher and administrator data are intended to be contextual data against which student outcomes and characteristics can be measured. Because they do not comprise stand-alone, nationally generalizable data sets, teacher and school weights are not provided by NCES (NCES, 1994b). Some researchers have dealt with this problem by constructing their own school weights when investigating school effects on student outcomes (Lee & Smith, 1995; Lee & Smith, 1996; Lee, et al., 1997). Other researchers do not use weights when investigating effects within the teacher data set alone (Taylor & Tashakkori, 1995). To my knowledge, my study is the first using Second Follow-up NELS:88 data to examine school contextual influences on teachers. I acknowledge the limitations of the data in terms of generalizability. However, because the data exist on a sizeable number of teachers and schools, I believe that even suggestive findings will be of interest to educational practitioners and researchers.

In a longitudinal study such as NELS:88, a core of questions is repeated in each wave to examine change over time. Many of these core questions, concerning relations among teachers, school culture, and school leadership, are modified in the Second Follow-up, perhaps to permit investigation of the impact of the departmental structure of American high schools on students’ transition into postsecondary education and adult
work life (a focus of the Third Follow-up). For instance, a set of questions about leadership, which in the earlier rounds relate to the school principal, is divided between the principal and the departmental chair in the Second Follow-up. Questions that earlier asked about teachers' discussions with other teachers more specifically inquire about discussions with teachers in the department or outside of the department. With these kinds of questions, the Second Follow-up data are preferable to the earlier waves for an investigation of subject departments, the most likely site of communities of practice for high school teachers (Grossman & Stodolsky, 1995; McLaughlin & Talbert, 2001; Siskin, 1994).

The Second Follow-up includes only mathematics and science teachers, an NCES decision that reflected the national interest in science and mathematics instruction at the time of data collection and that continues to the present day (U. S. Department of Education Goals 2000, 1993; National Education Goals Panel, 1997; No Child Left Behind Act, 2001). Research has shown that each teaching subject has its own conceptual context (Stodolsky & Grossman, 1995). Mathematics teachers are acknowledged to think differently from science teachers about student learning and how to organize instruction (Bidwell et al., 1997; Grossman & Stodolsky, 1995; Rowan, 2002a; Stodolsky & Grossman, 1995). Therefore, it is not reasonable to expect that mathematics and science teachers' responses are representative of teachers in other departments or in a school generally when they concern teachers' professional worklives. When teachers from a larger number of departments are included in the sample, as in the earlier waves of data collection, their responses likely give a better indication of schoolwide characteristics. Seeking a school measure that indicates the extent to which a school has a culture
conducive to teachers' collegial relations. I import data from the First Follow-up to construct such a measure. Because survey responses in that wave come from a greater number of teachers in four departments, the data should more fairly represent a school attribute.

**Study Schools: A Comparison with the Full Sample**

Because the application of filters reduced the original number of schools by two-thirds (Table 3.1) and the number of teachers by one-half (Table 3.2), the sample selected for study may have lost its resemblance to the full sample. For this reason, I compare schools on a number of characteristics, including school and student demographics, size of school, and twelfth grade attendance and retention data. School characteristics in both samples are comparable (Table 3.1). The combination of the filter for five teachers in a school and the smaller size of Catholic and NAIS schools accounts for the loss of private schools from the sample. The study sample includes a larger percentage of public schools (by 7 percent) and smaller percentages of Catholic (by 4 percent) and NAIS (by 3 percent) schools. The study sample also has a smaller percentage of urban schools (by 6 percent), with this difference taken up by an increase in percentage of suburban schools. The percentage of rural schools is the same in both samples (27 percent).

The sample schools have 235 students more, on average, than the full sample schools, probably the result of the analysis requirement for five teachers in a school. The racial/ethnic composition of the student body does not differ greatly between samples. The Asian and Hispanic representation between the samples differs by less than one
<table>
<thead>
<tr>
<th></th>
<th>Second Follow-up Schools</th>
<th>Study Sample Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Schools</td>
<td>1,241</td>
<td>420</td>
</tr>
<tr>
<td>% Catholic</td>
<td>7.7</td>
<td>3.6</td>
</tr>
<tr>
<td>% NAIS</td>
<td>8.8</td>
<td>6.0</td>
</tr>
<tr>
<td>% Urban</td>
<td>36.2</td>
<td>30.0</td>
</tr>
<tr>
<td>% Rural</td>
<td>26.5</td>
<td>26.9</td>
</tr>
<tr>
<td>Average Enrollment</td>
<td>1204</td>
<td>1439</td>
</tr>
<tr>
<td>% Hispanic</td>
<td>11.0</td>
<td>10.2</td>
</tr>
<tr>
<td>% African American</td>
<td>14.4</td>
<td>10.3</td>
</tr>
<tr>
<td>% Asian</td>
<td>3.9</td>
<td>4.2</td>
</tr>
<tr>
<td>School Socioeconomic Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Free/Reduced Lunch</td>
<td>21.1</td>
<td>19.2</td>
</tr>
<tr>
<td>Average Student Family SES</td>
<td>.00</td>
<td>.02</td>
</tr>
<tr>
<td>% Daily Attendance G-12</td>
<td>92.2</td>
<td>93.0</td>
</tr>
<tr>
<td>% Dropout G-12</td>
<td>3.8</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Table 3.1
School Demographic Characteristics: Full Sample and Study Sample Compared
percent. The relative percentage of African American students is smaller in the study sample by four percent. The students in these schools are slightly more economically advantaged than the students in schools in the full sample. The schools in the study sample have a free and reduced lunch rate that is 2 percentage points lower than schools in the full sample (19.2 vs. 21.1 percent), while the difference in average student family socioeconomic status between the samples is negligible. The attendance rate of students in the two samples is much the same (92 percent and 93 percent respectively) and the dropout rate is exactly the same (3.8 percent). The overall comparability of schools in the two samples indicates that the filters used to limit the sample did not skew the school level data (on average) to any great extent.

**Study Teachers: A Comparison with the Full Sample**

To determine the effect of the filters on the teacher sample, I compared the full and study samples on a number of social and professional characteristics. Social characteristics include teachers' gender, race/ethnicity, age, level of satisfaction with teaching at their school, and experience in the current school. Professional characteristics include the teaching subject, the curricular track of the focal class, and whether the respondent is the department chair.

As for teacher characteristics, the two samples are also comparable (Table 3.2). The gender distribution in both samples is quite similar, with about 16 percent more male teachers than female teachers in the full sample and about 13 percent difference in the study sample. The racial/ethnic distribution for teachers varies slightly between samples, with the largest shift being a 2.9 percent increase in the relative percentage of white
### Table 3.2
Teacher Social and Professional Characteristics: Full Sample and Study Sample Compared

<table>
<thead>
<tr>
<th></th>
<th>Second Follow-up Teachers</th>
<th>Study Sample Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Teachers</strong></td>
<td>5,657</td>
<td>2,718</td>
</tr>
<tr>
<td>% Female</td>
<td>41.3</td>
<td>43.5</td>
</tr>
<tr>
<td>% Hispanic</td>
<td>3.3</td>
<td>1.7</td>
</tr>
<tr>
<td>% African American</td>
<td>4.1</td>
<td>3.2</td>
</tr>
<tr>
<td>% Other</td>
<td>2.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Age in years</td>
<td>43.8</td>
<td>43.9</td>
</tr>
<tr>
<td>Satisfaction with teaching situation</td>
<td>2.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Experience in current school in years</td>
<td>12.0</td>
<td>12.2</td>
</tr>
<tr>
<td>% Science</td>
<td>40.5</td>
<td>40.3</td>
</tr>
<tr>
<td>% Mathematics</td>
<td>59.5</td>
<td>59.7</td>
</tr>
<tr>
<td>% Academic</td>
<td>62.3</td>
<td>60.8</td>
</tr>
<tr>
<td>% General/Vocational</td>
<td>11.0</td>
<td>34.9</td>
</tr>
<tr>
<td>% Remedial</td>
<td>26.8</td>
<td>4.3</td>
</tr>
<tr>
<td>% Department Chair</td>
<td>16.3</td>
<td>14.0</td>
</tr>
</tbody>
</table>
teachers. The study sample has a smaller percentage of Hispanic (by 1.6 percent) and a smaller percentage of African American teachers (by .9 percent) than the full sample. Teachers in both samples are very satisfied with their teaching situation, with the average score in both samples 2.9 (possible range is 1 to 4). On average, the teachers in both samples are nearly 44 years old and have 12 years experience in their current school.

In both samples, approximately 40 percent of the teachers teach science and approximately 60 percent teach mathematics. For both samples, over 60 percent of the teachers are academic teachers. The relative percentage of teachers teaching predominantly general/vocational students is nearly 25 percent greater in the study sample, while the relative percentage of teachers teaching remedial courses in the study sample is almost 23 percent smaller. This is the largest discrepancy between the samples, and might possibly be related to the shift in the study sample relative to location, from urban to suburban schools noted above. The study sample has a slight reduction in the percentage of respondents who are department chairpersons (by 2 percent).

To summarize the comparison of teachers, the modal respondent for the study sample is a white, male, mathematics teacher, assigned primarily to academic courses. This classroom teacher is in his mid-forties, is highly satisfied with teaching at this school, and has 12 years seniority in his present school. For almost all social and professional indicators, the study sample of teachers is comparable to the full sample.

Most empirical studies on teachers' communities have analyzed data from small samples. The CRC studies used data from 16 high schools (Rowan, 2002a; 2002b). Quantitative studies by CORS researchers included data on 24 schools, only 8 of them high schools (Louis et al., 1996; Louis & Marks, 1998). Bidwell, Frank and Quiroz
(1997) incorporated data from 13 public and private high schools. Using the largest data set to date for study of teachers' community in high schools, Yasumoto, Uekawa, and Bidwell (2001) analyzed data for 52 public schools. With 2,718 teachers in 420 public, Catholic, and NAIS private schools, the present study is the largest in the literature about teachers' participation in communities of practice, even given its limitations for generalizability.

Measures

Rasch Measures

The measures constructed for the study are of two general types: Rasch and non-Rasch measures. I employ the Rasch rating scale model to construct composite measures from continuous variables where the data fit the Rasch model (Wright & Masters, 1982). I chose to construct the measures using the Rasch model for three reasons: 1) it better utilizes missing data; 2) it reduces assumptions associated with ordered, nominal data; and 3) it provides a theoretical test for measures.

Data for this study are answers to survey items, with ordered, nominal responses (Likert scale). The Rasch scoring model organizes the nominal categories of observation into a step-wise order of preference. Then a stochastic measurement model, which can handle incomplete data and which takes into account the difficulty with which respondents indicate one answer over the other, is used to construct interval measures from these ordinal scores (Wright, 1996). Thus, intervals that were not necessarily equal in the Likert scales are equal intervals in the Rasch scale.

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The model applies to items with ordered response alternatives, or "steps." This step interpretation means that given a survey item with the following choices:

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

a person who chooses *Agree* can also be considered to have chosen *Disagree* over *Strongly disagree* (first step taken) and *Agree* over *Disagree* (second step taken), but not to have chosen *Strongly agree* over *Agree* (third step not taken) (Wright & Masters, 1982, p. 48). This assumption provides the foundation for a construct that establishes a hierarchical ranking for survey items from the easiest to agree with (frequent) to the most difficult to agree with (rare).

The Rasch rating scale model provides a simple, practical way to construct linear measures from any ordered nominal data by transforming the step data into logits, or probabilities that respondents will endorse the attitudes or behaviors represented by each scale item. The Rasch rating scale model is expressed as follows:

\[
\pi_{nx} = \frac{\exp \sum_{j=0}^{x} [\beta_n - (\delta_i + \tau_j)]}{\sum_{k=0}^{m} \exp \sum_{j=0}^{x} [\beta_n - (\delta_i + \tau_j)]} \quad x = 0, 1, \ldots, m
\]

where:

- \(\pi_{nx}\) is the probability that person \(n\) chooses category \(x\) of questionnaire item \(i\),
- \(\beta_n\) is a person measure indicating the location of person \(n\) on the variable being measured.
\( \delta_i \) is the "difficulty" of questionnaire item \( i \), and
\( \tau_1, \tau_2, \ldots, \tau_m \) are the "step" difficulties for each response category (Wright & Masters, 1982, p. 49).

The logit, or item difficulty, is one of a number of statistics that the model provides with which to evaluate a construct's validity and reliability. Rasch scales assign the largest "difficulty" scores to items respondents have the most trouble agreeing with. These items are understood to be "rare." Items with the lowest difficulty are easier to agree with, and thus, are "frequent." Examining the logit ranking of items in the scale, an analyst must agree that the hierarchical ranking of the items makes theoretical sense. For instance, the hierarchical ordering of the items used in the communities of practice Rasch scale theoretically supports my hypothesis that teachers have greater opportunities to learn when they participate in purposeful activities out of the subject department and interact with a wide range of school members. (See Appendix B for details of the Rasch scales). The higher difficulty scores in the scales for activities and interactions outside of the subject department represent the added opportunities for social learning inherent in those situations.

Another statistic resulting from the Rasch model, the infit mean square, focuses on fit evaluation of inlying "on-target" responses (Wright, 1996). This statistic conveys the extent to which respondents' answers to an item are consistent with the hierarchical position of that item in the scale. Infit mean square statistics are preferable in the range of \( \geq .80 \) to \( \leq 1.20 \). The better fit is closer to 1.0, indicating that individuals are responding to the item in a manner consistent to the position of the item in the scale.

While the Rasch model as developed for use with testing has strict fit parameters for the
selection of items to include in tests, social scientists often apply less stringent criteria. In deciding how to proceed with marginal items, the researcher removes them to see if the fit statistics of the scale improve. If they do not, and if the items are important theoretically, the researcher generally retains the items. Evidence that the items in the scale tap a unifying dimension, such as a high Cronbach’s alpha, supports this approach.

The Rasch person separation reliability statistic is comparable to Cronbach’s alpha, in that it indicates the internal consistency of each scale. However, the separation ratio is more useful than a reliability correlation because quantitative comparisons are not distorted by an upper limit at 1.0 (Wright & Masters, 1982). In effect, the person separation reliability indicates that the measure adequately “sorts out” responses of individuals so as to rank them hierarchically.

Together, the logit ranking, the infit mean square, and the person separation reliability statistic provide assurance that the constructed measures are both valid and reliable.

Dependent Measures

Communities of Practice. Constructed as an index of three Rasch scales, Communities of practice taps the social learning inherent in teachers’ purposeful activity with a broad range of school members around curriculum, instruction, and student performance. The three component measures, mutual engagement, joint enterprise, and shared repertoire, are standardized (M=0, SD=1). These are summed to create the index, which is then standardized (M=0, SD=1). The Cronbach’s alpha reliability of the community of practice index is .71. Additional psychometric properties of the
communities of practice index are in Chapter 4. In the second stage of analysis, communities of practice is an independent variable.

A. **Mutual engagement.** A Rasch measure, *Mutual engagement* taps the interaction of science and mathematics teachers with others both in and out of the subject department around curriculum, instruction, testing, and student performance. The measure includes responses of teachers to ten survey items. Two of the items queried teachers about how much time they spent with (a) Teachers in the department and (b) Teachers outside of the department. Response options for these items were: (1) None of my time; (2) Little of my time; (3) Some of my time; and (4) Most of my time.

Four items asked whether teachers discussed with their colleagues: (c) Instructional techniques; (d) Subject area curriculum; (e) Curriculum for a course; and (f) Testing procedures. Response options were: (1) Never; (2) Sometimes; and (3) Often. Three questions asked teachers if they discussed curriculum with other teachers: (g) In the department; (h) Outside of the department; or (i) Outside the school. Possible responses included (1) Yes or (2) No, which I recoded (0=No, 1=Yes). The scale is standardized (M=0, SD=1). The person separation reliability of the Rasch scale for mutual engagement is .72. The Cronbach’s alpha is .69.

B. **Joint enterprise.** Five items comprise the Rasch scale for *Joint enterprise*. The measure indicates the extent to which teachers share departmental goals and a school mission and are oriented to learning and instructional experimentation: (a) R is encouraged to experiment with teaching; (b) Teachers in the department continuously learn; (c) Teachers in the department share beliefs about the mission; (d) Goals and priorities in the department are clear; and (e) There is agreement among the faculty about
the school mission. Response options were: (1) Strongly disagree; (2) Disagree; (3) Agree; or (4) Strongly agree. The scale is standardized (M=0, SD=1). The person separation reliability of the Rasch scale for joint enterprise is .73. The Cronbach’s alpha is .74.

C. Shared repertoire. Constructed of eight items, the Shared repertoire Rasch scale measures teachers’ cooperative and coordinated participation in valued departmental and school activities. Teachers indicate the extent of agreement to five statements concerning cooperation: (a) R is familiar with content of others’ courses; (b) R coordinates course with teachers in the department; (c) R coordinates course with teachers outside of the department; (d) There is cooperative effort among staff; (e) Grading practices are consistent and fair. Responses for these items included: (1) Strongly disagree; (2) Disagree; (3) Agree; or (4) Strongly agree. Three items asked whether the teacher participated: (f) In a schoolwide curriculum committee; (g) In a departmental curriculum committee; or (h) In another committee. Answer choices for these items were: (1) Yes or (2) No, which I recoded (0=No, 1=Yes). The scale is standardized (M=0, SD=1). The person separation reliability of the Rasch scale for shared repertoire is .69. The Cronbach’s alpha is .65.

Teacher Learning. Teacher learning, a dependent variable and hypothesized outcome of social learning in communities of practice, is a Rasch scale constructed from five items. The measure indicates the extent to which a teacher’s instruction has been improved through interaction with: (a) Teachers outside of the department; (b) Teachers in the department; (c) The department chair; (d) The principal; or (e) Another administrator. Possible responses included: (1) Strongly disagree; (2) Disagree; (3) Agree; or (4) Strongly agree. The scale is standardized (M=0, SD=1). The person separation reliability of the Rasch scale for Teacher Learning is .73. The Cronbach’s alpha is .74.
Agree: or (4) Strongly agree. The measure is standardized (M=0, SD=1). The person separation reliability for teacher learning is .62. The Cronbach’s alpha for the scale is .70. The psychometric properties of teacher learning are in Chapter 5.

**Teacher Competence.** *Teacher competence,* also a dependent variable and hypothesized outcome of social learning in communities of practice, measures the degree to which teachers perceive that they have the abilities to do their jobs. A Rasch scale, it comprises six items: (a) R can get through to difficult students; (b) R makes a difference in students’ lives; (c) R can do little to affect achievement (reversed); (d) R changes approach if students not doing well; (e) R is responsible to prevent dropouts; and (f) Different teacher methods can affect achievement. These items could be answered: (1) Strongly disagree; (2) Disagree; (3) Agree; or (4) Strongly agree. The measure is standardized (M=0, SD=1). The person separation reliability for teacher competence is .68. The Cronbach’s alpha is .66. The psychometric properties of teacher competence are in Chapter 5.

**Independent Measures**

Three independent measures are constructed with the Rasch rating scale model. Teachers’ active participation in communities of practice might be related to their perceptions of their department chairs as supportive and facilitative instructional leaders. Constructed at the teacher level, departmental instructional leadership contributes to the within-school explanation of teachers’ community participation. Two school level factors are likely to explain differences between schools that impact teachers’ participation in communities of practice. The extent to which teachers agree about the
principal’s instructional leadership is a school-level attribute that likely reflects teachers’ motivation to work together, particularly beyond department boundaries. The degree to which a school has maintained an organic, non-bureaucratic system of instructional management gives some indication of the general level of collegiality and support teachers in a school experience.

**Departmental Instructional Leadership.** *Departmental instructional leadership* is a Rasch scale constructed from six items on the teacher survey. These responses come only from teachers who are not department chairs. The scale gauges the support and facilitation the department chair demonstrates: (a) Chair is interested in innovation; (b) Chair is active in obtaining resources; (c) Chair is supportive and encouraging; (d) Chair carries out plans; (e) Chair tells what is expected; and (f) Chair consults with staff before making decisions. Answer choices for these items include: (1) Strongly disagree; (2) Disagree; (3) Agree; or (4) Strongly agree. The measure is standardized (M=0, SD=1). The person separation reliability is .85. The Cronbach’s alpha is .91.

**Principal Instructional Leadership.** *Principal instructional leadership* is a Rasch scale composed of four teacher survey items. Teachers report the degree of support extended by the principal: (e) Administrator communicates kind of school wanted; (f) Administrator deals with outside pressures; (g) Administrator knows problems of staff; and (h) Staff recognized for a job well done. Four responses were possible: (1) Strongly disagree; (2) Disagree; (3) Agree; or (4) Strongly agree. The Rasch scale is standardized (M=0, SD=1). The person separation reliability of principal instructional leadership is .76. The Cronbach’s alpha is .82. Principal instructional leadership was aggregated to the school level and standardized (M=0, SD=1).
Organic management. Organic management is an index constructed from two Rasch scales, using NELS:88 First Follow-up data. Organic management, characterized by participative decision-making, collaborative problem solving, and supportive leadership, indicates the extent to which a school environment is conducive to teachers’ problem solving efforts (Rowan et al., 1991; Rowan et al., 1993). Organic management has two constituent parts: teacher control and staff cooperation. Both Rasch scales utilize items employed by Lee and Smith (1996), who used these measures with NELS:88 data as indicators of the presence of professional community. Each scale is standardized (M=0, SD=1). The scales were summed to create the index. The index was aggregated to the school level. The index is standardized (M=0, SD=1). The Cronbach’s alpha for the index is .73.

A. Teacher control. Teacher control indicates the extent to which teachers can make decisions about instruction-related concerns. Four items investigate teachers’ influence over: (a) Ability grouping of students; (b) Discipline policy; (c) In-service policy; and (d) Establishing curriculum. Responses ranged from (1) No influence to (6) Great deal of influence. Five items inquire about the extent of teacher control over: (e) Texts and materials used; (f) Content taught; (g) Teaching techniques; (h) Disciplining students; and (i) Amount of homework. Responses for these items ranged from (1) No influence to (6) Great deal of influence. The measure is standardized (M=0, SD=1). The person separation reliability for teacher control is .72. The Cronbach’s alpha is .74.

B. Staff cooperation. Staff cooperation is a Rasch measure that indicates the degree to which all school members, including the principal, work cooperatively. The fourteen items in this construct include: (j) This school seems like a big family; (k)
Teachers' union and administration work together; (l) Principal consults staff before making decisions; (m) Staff members are recognized for a job well done; (n) Administration knows the problems faced by staff; (o) Broad agreement exists among faculty about mission; (p) Principal is interested in innovation and new ideas; (q) I am encouraged to experiment with my teaching; (r) Teachers at this school are continuously learning; (s) Principal lets staff know what is expected of them; (t) Great deal of cooperative effort occurs among staff; (u) I can usually count on staff members to help out; (v) I am familiar with the content of other courses in the department; and (w) Colleagues share beliefs about the school's mission. Response possibilities ranged from (1) Strongly disagree to (6) Strongly agree. The measure is standardized (M=0, SD=1). The person separation reliability for staff cooperation is .86. The Cronbach's alpha is .81.

**Non-Rasch Measures**

Several continuous variables are constructed as sums rather than with the Rasch rating scale model. These measures do not fit the assumptions of the Rasch model for a hierarchical ordering of items. Summing is an appropriate approach where I am interested in the total number of practices or activities or frequency of use.

**Dependent Measure**

**Standards-based Pedagogy.** Standards-based pedagogy, a dependent variable and the final hypothesized outcome of teachers' social learning within communities of practice, has separate measures for mathematics and science that reflect student-centered.
problem-based instruction aligned with national mathematics and science standards. The mathematics and science measures are combined into a single index for standards-based pedagogy, which is standardized (M=0, SD=1). The psychometric properties for standards-based pedagogy appear in Chapter 5.

Mathematics standards-based pedagogy incorporates ten responses from mathematics teachers. Seven items from the teachers' survey investigate teachers' instructional emphasis on: (a) The nature of proofs; (b) Representing problems; (c) Integrating math branches; (d) Multiple approaches to problems; (e) Solving problems; (f) Raising questions/conjectures; and (g) Raising students' interest in math. Each of these items had four response choices: (1) None, (2) Minor, (3) Moderate, or (4) Major. I recoded the responses (0=None, 1=Minor, 2=Moderate, 3=Major). Three items ask about the frequency of teachers' use of: (h) Student-led discussions; (i) Cooperative groups; and (j) Oral reports. Teachers reported the frequency of these events: (1) Never, (2) Once a month, (3) Twice a week, (4) Nearly every day, (5) Every day. I recoded the responses (0=Never, 1=Once a month, 2=Twice a week, 3=Nearly every day, 4=Every day) to reflect an emphasis similar to the responses above (None, Minor, Moderate, Major). The response values for all items were summed to create the measure. The measure is standardized (M=0, SD=1). Cronbach's alpha for the mathematics standards-based pedagogy index is .72.

Science standards-based pedagogy draws ten items from the teacher survey to create an index. Seven items from the teacher survey inquire about science teachers' emphasis on: (a) Developing lab skills; (b) Scientific methods; (c) Problem solving or inquiry skills; (d) Further study in science; (e) Student interest in science; (f) Importance
of science in daily life; and (g) Relating science to the environment. Answer choices for the items include: (1) None, (2) Minor, (3) Moderate, or (4) Major. I recoded the responses (0=None, 1=Minor, 2=Moderate, 3=Major). Three items ask about the frequency of use for instructional practices: (h) Student-led discussions; (i) Cooperative groups; and (j) Oral reports. Teachers responded: (1) Never, (2) Once a month, (3) Twice a week, (4) Nearly every day, (5) Every day. I recoded the responses (0=Never, 1=Once a month, 2=Twice a week, 3=Nearly every day, 4=Every day). The response values for all items were summed to create the measure. The measure is standardized (M=0, SD=1). Cronbach's alpha for the science standards-based pedagogy index is .70.

Independent Measures

Three sets of teacher variables account for individual attributes that potentially impact teachers' participation in communities of practice and professional outcomes. These relate to teachers' social background, professional background, and participation in professional development programs. School demographic characteristics and the school's professional development support might have an influence on teachers' community participation and instructional capabilities.

Teachers' Social Background. The social background variables include two dichotomous and two continuous variables. The dichotomous variables are: (a) Female, a dummy coded variable, (1=Female, 0=Male); and (b) African American, a dummy coded variable, (1=African American, 0=White, Hispanic, and Other). One continuous variable measures teachers' satisfaction with their teaching situation: (c) Satisfaction with the teaching situation. Response codes are: (1) Almost never; (2) Some of the time; (3)
Most of the time: or (4) All of the time. The measure is standardized (M=1, SD=0). The other continuous variable measures teachers’ tenure: (d) *Experience in the present school.* Teachers’ original responses are reported as a nine-level categorical measure, reflecting from 0 years to more than 25 years experience in the school. Each level of the categorical measure represents a three year interval. The categorical measure was recoded into a continuous variable using the midpoint of each interval. The measure is standardized (M=0, SD=1).

**Teachers’ Professional Background.** The professional background variables relate to the teaching assignment. Teachers’ subject, (1) Mathematics (2) Science, was dummy coded as (e) *Mathematics* (1=Mathematics, 0=Science). Two other dummy variables indicate the predominant curricular track of teachers’ focal classes as (f) *Academic* (1=Academic or College Preparatory, 0=General/Vocational or Remedial) or (g) *Remedial* (1=Remedial, 0=General/Vocational or Academic). An examination of the data at the student level indicated that teachers with classes at more than one level almost always taught either academic and college preparatory or general and vocational. ³

**Professional Development.** Teachers in the study participate in two types of professional development activities – within school development offerings and college or university courses. *School development programs,* constructed as a sum of the responses for four items, indicates teachers’ involvement in school-offered programs: (a) R participates in school system workshop; (b) R participates in school system summer workshop; (c) R participates in professional association’s activities; and (d) R attends
teacher enrichment programs. Responses were: (1) Yes or (2) No. I recoded these variables. (0=No, 1=Yes). The measure is standardized (M=0, SD=1). Cronbach’s alpha for this measure is .62.

College courses reports teachers’ enrollment in college courses: (e) R participates in college courses in education; (f) R participates in college courses other than education; (g) R participates in summer college courses in education; and (h) R participates in other summer college courses. Responses were: (1) Yes or (2) No. After recoding the responses (0=No, 1=Yes), I summed them for the college courses construct. The measure is standardized (M=0, SD=1). Cronbach’s alpha is .68.

School Demographic Characteristics. School demographic variables are employed as statistical controls. These include two sector variables, dummy coded as (a) Catholic (1=Catholic, 0=Public or NAIS) and (b) NAIS (1=NAIS, 0=Public or Catholic). School location is also indicated by dummy codes. (c) Urban (1=Urban, 0=Suburban or Rural) and (d) Rural (1=Rural, 0=Suburban or Urban). Size represents the number of students the school enrolls. The variable is standardized (M=0, SD=1). Average student family SES is a composite measure provided by NCES for use with NELS:88 Second Follow-up data. Five standardized components (M=0, SD=1), which include father’s educational level, mother’s educational level, father’s occupation, mother’s occupation, and family income, are summed. The measure is standardized (M=0, SD=1).

Professional Development Support. Constructed as the sum of four constituent items. Professional development support is a school context measure. In this capacity, it joins the Rasch measures principal instructional leadership and organic management. The measure asks about incentives for learning: (a) Release time for in-service; (b)
Travel expense for in-service; (c) Stipends for in-service; and (d) Professional credit for in-service. Teachers indicated if they received this support: (1) Yes or (2) No. Each item was recoded at the individual teacher level (1=Yes, 0=No), then summed. The measure is standardized (M=0, SD=1). Cronbach’s alpha is .61. The measure was then aggregated to the school level and standardized (M=0, SD=1).  

**Categorical Communities of Practice.** For use in descriptive analyses, I created a categorical measure of communities of practice. *Productive* includes teachers’ scores greater than +1 SD above the mean score for the communities of practice index. *Limited* includes scores between +1 SD and -1 SD. *Weak* includes teachers’ scores that are less than -1 SD below the mean. I coded the variable (1) Weak, (2) Limited, (3) Productive.

**Methods**

In this section, I discuss the basic analytic methods utilized for the study and provide a rationale for the selection of the particular method. I use bivariate techniques to explore descriptive relationships and observed differences in the study sample. Multivariate techniques identify interactions. Because the data is hierarchical, or nested. I employ a multi-level technique to estimate effects.

**Correlation**

One method for examining the relationship between two continuous variables is the Pearson’s product-moment correlation (r). The correlation coefficient represents the prediction of the value of one variable by knowing the other, according to the general linear model. If a high score is related to a high score, and a low score is related to a low
score, the relationship is a direct one and the correlation is positive. If a high score is related to a low score, and a low score is related to a high score, the relationship is said to be inverse or indirect, and the correlation is negative. A score close to 1.00 (or -1.00) is a near perfect correlation, while a score close to 0 shows little or no relationship.6

Cross-tabulation

To explore the relationships between two nominal, or categorical, variables, I use crosstabulation to compare observed percentages in each group to the expected percentages. In order to examine differences in teachers’ participation in communities of practice, for example, I constructed a categorical variable (i.e., productive, limited, weak) for the communities of practice index. (The rationale for this classification is given in Chapter 4.) Crosstabulation permits investigation of systematic variation across these categories by other categorical variables, e.g., by teachers’ subject area, curricular track, gender or race/ethnicity.

The relevant statistic is the independent-samples chi-square test. A significant finding indicates that the observed distribution of teachers (mathematics or science) across the categories of communities of practice differs significantly from what is expected based on the proportion of teachers for each subject. Again, I indicate the significance level of the distribution percentages as appropriate.

One-Way and Two-Way Analysis of Variance (ANOVA)

The relationships between continuous variables and nominal variables are described with one-way analysis of variance (ANOVA). ANOVA tests whether observed
mean differences in group scores are statistically significant. The use of one-way ANOVA allowed me to identify sources of variation in the dependent variables that could be attributed to differences in teachers’ personal characteristics, such as gender, and professional characteristics, such as teaching subject and the curricular track of the focal class. If there is a statistically significant difference between the groups, as indicated by the F-ratio (variance between groups / variance within groups), then the difference is attributed to the characteristic (e.g., subject, curricular track) that distinguishes the group, plus error.

Examining the distribution of a continuous dependent variable for two independent variables concurrently is possible using two-way analysis of variance. A significant interaction is present if the relationship between the dependent variable and one of the independent measures changes relative to the other independent measure. As an example, the relationship between communities of practice and curricular track might differ according to the subject being taught and whether the track was academic, general/vocational, or remedial. A significant interaction effect indicates that a corresponding interaction term must be included in any estimation of effects.

Hierarchical Linear Modeling (HLM)

Multilevel analytic techniques, such as hierarchical linear modeling (HLM) (Bryk & Raudenbush, 1992) present an integrated set of methods that permit efficient estimation of effects for nested data (e.g. teachers nested in schools). Due to its ability to model multilevel data, HLM eliminates several sources of bias encountered with single-level analytic techniques such as OLS regression, where all data is either disaggregated to
the individual level or aggregated to the school level. Two of these conditions are important to this study, namely, aggregation bias and misestimated standard errors.  

Aggregation bias occurs when the means of individual response data, aggregated to the organizational level, are used as outcomes. This approach makes it difficult to control for individual level covariates and can change the meaning of variables. Analyses such as this often do not account for sample size differences within schools that might bias the mean estimates (Bryk & Raudenbush, 1992). Misestimated standard error occurs as a result of dependence among individual responses within a unit due to shared experiences, and might result in an error term that is too small, increasing the risk of finding effects when, in fact, none exists (Type I error).

HLM addresses these potential difficulties with hierarchical data by partitioning variance to different levels and incorporating a unique random effect for each organizational unit. The variation in teachers' participation in communities of practice is partly attributable to characteristics of teachers (e.g., their gender, experience, and teaching subject) and partly attributable to characteristics of schools (e.g., size, style of management, and principal). HLM adjusts for dependency in nested data by generating a complex error term (using an Empirical Bayes algorithm) that explicitly models the dependency among individual responses in the same organization (Bryk & Raudenbush, 1992).

The theory and research I have presented thus far indicate that, for high school teachers, participation in communities of practice is expected to vary importantly based on the subjects they teach. Optimally, the data would allow a three-level HLM analysis with teachers nested within subject departments nested within schools. If I were to
extend the precedent for hierarchical investigation using NELS:88 data to three levels (Lee & Smith, 1995), such an analytic plan would require data from at least five teachers in each of five departments in a school. The sample for the current study has, on average, 6.5 teachers in a school in only two departments. The data permit only two-level HLM models, examining teachers within schools. Because I don’t have sufficient data for a separate level for subject departments, I must employ statistical controls for subject effects.

The first step in a hierarchical data analysis is to determine the allocation of variance at each level with a fully unconditional model, where no predictors are specified at any level. This model is equivalent to a one-way ANOVA with random effects. The model produces the intraclass correlation coefficient (ICC), given by the formula:

\[
ICC = \frac{\text{Tau}}{\text{Tau} + \text{Sigma Squared}}
\]

where tau is the measure of between-group variance on the outcome measure and sigma squared is the within-group variance, pooled across all groups. The ICC partitions the variance in the dependent variable, for example, teachers’ participation in communities of practice, into its within-school and between-school components.

The ICC measures the school-by-school variation in communities of practice. Determining the proportion of variance in the outcome that is between the Level-2 units is a necessary first step in the researcher’s decision whether or not to investigate school level effects. Where the researcher’s interest is in explaining “school effects,” a small proportion of between-school variance might preclude further investigation. However, if theoretical arguments suggest that Level-2 effects might be present, the analyst can
proceed in specifying Level-2 models for the outcome, even when the between-school variance in a dependent measure is extremely small (Bryk & Raudenbush, 1992).

The second step in a hierarchical analysis is to fit a within-school model that accounts for variation in the outcome due to individual teacher characteristics. In the within-school HLM model (Level 1), for example, I investigate the effect of teacher background characteristics on teachers' participation in communities of practice. At Level 1, the equation for the submodel is

\[ Y_{ij} = \beta_{j0} + \beta_{j1}X_{ij1} + \beta_{j2}X_{ij2} + \ldots + \beta_{jk}X_{ijk} + r_{ij} \]

where \( Y_{ij} \) is a teacher's participation in a community of practice, \( X_{ijk} \) are various background characteristics for teacher \( i \) in school \( j \) (i.e. female, African American, years experience in the current school, satisfaction with teaching in the current school, focal class track, and teaching subject), and \( r_{ij} \) is random error. The \( \beta_{jk} \) regression coefficients represent structural relations between characteristics of teachers in school \( j \) and their participation in a community of practice (Bryk & Raudenbush, 1992).

In an HLM analysis, some or all of the \( \beta_{jk} \) parameters of the within-school model can become outcome variables to be explained in the between-school equations. In the models presented for this study, however, only the Level 1 intercepts, \( \beta_{j0} \), which in the example case represents the school average for participation in communities of practice.
have significant variation to permit modeling by Level-2 predictors. The other $\beta_{j1...k}$ coefficients are fixed Level-1 coefficients (that is, the error term associated with this parameter is removed from the equation). This type of model is termed a random-intercept HLM (Bryk & Raudenbush, 1992).

The next stage of the example HLM analysis examines between-school or level-two influences on communities of practice, taking into account the within-school model. The between-school model investigates the variability in the intercept $\beta_{j0}$ as a function of school level variables $W_{pj}$ and random error, $U_{jk}$:

$$\beta_{j0} = \gamma_{0k} + \gamma_{1k}W_{1j} + \gamma_{2k}W_{2j} + \ldots + \gamma_{pk}W_{pj} + U_{0j}$$

The $\gamma_{1...k}$ coefficients represent the effects of school-level variables, $W_{pj}$, on the average participation in communities of practice within school $j$. The $W$ variables in this study represent school demographic characteristics (e.g., NAIS, School size) and contextual variables (e.g., organic management) that account for differences between schools. The Level 2 model takes into account the grand mean for teachers’ participation in the entire sample of teachers, $\gamma_{0k}$ (Bryk & Raudenbush, 1992).

For each model, I report the amount of within and between school variance explained by the model. The proportion of variance explained is calculated as a ratio. For the within-school and between-school variances respectively, the following formulas apply:
\[
\begin{align*}
\text{Level-1} & \quad R^2 = \frac{\text{Sigma squared} \text{ (unconditional)} - \text{Sigma squared} \text{ (explained)}}{\text{Sigma squared} \text{ (unconditional)}} \\
\text{Level-2} & \quad R^2 = \frac{\text{Tau} \text{ (unconditional)} - \text{Tau} \text{ (explained)}}{\text{Tau} \text{ (unconditional)}}
\end{align*}
\]

where "unconditional" refers to the fully unconditional model and "explained" refers to a model with predictors at the appropriate level (Bryk & Raudenbush, 1992).

Accompanying each model, a lambda reliability indicates the overall or average reliability for the least squares estimates of each randomly varying Level-1 coefficient across the set of \( j \) Level-2 units. Lambda (school), \( \lambda_j \), is the ratio of the true score, or variance of the parameter, to the observed score, or the total variance of the sample mean. The reliability, \( \lambda_j \), is close to 1 when (a) the group means, \( \beta_{j0} \), vary substantially across Level-2 units (holding group sample size constant); or (b) the number in each group, \( n_j \), is large (Bryk & Raudenbush, 1992).

HLM offers improved estimation of individual effects over other analytic approaches. It borrows strength from the entire "ensemble" of data to estimate effects. When reliability is high, HLM puts substantial weight on the group mean in composing \( \beta_{j0} \). When reliability is low, more weight is given to the estimated grand mean. Drawing on information for each school and the relations that exist in the overall sample, the
estimator for each school is the optimal weighted combination of the true unknown parameter and the estimated grand mean (Bryk & Raudenbush, 1992).

**Summary**

The study undertaken here is a systematic analysis of teachers’ participation in communities of practice and the impact of such participation on teachers’ knowledge, beliefs, and skills. Because communities of practice exist in many configurations and types -- some productive, some not -- it is essential that I carefully develop a conceptualization based on theory that would demonstrate the kind of community of practice likely to improve teachers’ professional capabilities.

The theoretical model I propose argues that teachers’ experience social learning as they participate in communities of practice. The nature and extent of the learning is dependent on the purpose, activities, and social relations that distinguish the community. Teachers’ communities of practice are productive to the extent that shared activities center on instructional improvement and the social relations are characterized by full, legitimate participation and broad interaction with a wide range of school members. The social learning that results from participation in productive communities of practice may enhance teachers knowledge, competence, and instructional skills.

Appropriate data for this investigation come from the First and Second Follow-ups to NELS:88. Using the Second Follow-up data, I am able to probe the effects of teachers’ social and professional characteristics and characteristics of their schools on teachers’ opportunities to learn in communities of practice. The First Follow-up data allowed importation of a representative school level measure of organic management that gives some indication of the collegial culture in the school. The data do not permit a
longitudinal examination of teachers' change in knowledge, skills, and beliefs over time. However, positive effects on the professional outcomes would be consistent with thinking that participation in productive communities of practice would lead to such change.

The Rasch model allows construction of variables that are in line with the theory of social learning that underlies the study. The multilevel analyses I employ permit investigation of important influences on teachers' social learning, primarily those that vary within schools but also those that result from differences between schools. I am also able to estimate the impact of productive communities of practice on important professional outcomes for teachers: learning, competence, and pedagogical skills.

Having set the stage for the analyses, it is to that work that I now turn. Chapter 4 examines factors that contribute to teachers' participation in productive communities of practice focused on instructional improvement. Chapter 5 investigates the professional impact for teachers in those communities.
Notes to Chapter 3

1For instance, Bidwell, Frank and Quiroz, 1997, accept an outfit of less than 2.00 (a statistic related to infit) as evidence that an item in the scale is conceptually related to the others. All items in the scales for this study fall within that range. See also Bryk et al., 1999.

2Systematic variation for Hispanic or Other teachers was not detected.

3In the NELS:88 data, a teachers' response is connected to a student in the survey. The original item in the teachers' survey inquired about the curricular track of the student's class. Many teachers reported on several students. Over 90 percent of the teachers taught sampled students at only one level. However, where teachers had students in classes at different curricular levels, I discerned that teachers almost always taught either academic and college preparatory or general and vocational. A few teachers were divided equally over the three categories. For those teachers where it was impossible to distinguish predominance, I placed teachers in the general/vocational contrast group. I acknowledge that these measures might not accurately represent teachers' actual class distribution at the time data was collected.

4I investigated several other school level predictors that were presumed to impact the development of teachers' communities of practice and possibly teacher learning, competence, and use of standards-based pedagogy. These include the percentage of the student body that are minority students, a high-stakes testing environment, the degree to which the department structure was institutionalized in the school, and an incentive system of rewards for teachers. None of these measures had any significant impact on any of the outcomes.

5I had some question as to whether professional support should be a teacher attribute or a characteristic of the school. After sorting the variables by subject, I aggregated them to the school level, where I applied a paired samples T test. This test compares the means of two variables for a single group. It computes the differences between values of the two variables for each case and tests whether the average differs from 0. Because the result of the paired samples T test was not significant, I concluded that mathematics and science teachers in a school perceived the professional support variables in the same way and that the measure most likely is a school level indicator of support.

6I employed other correlational techniques in preliminary analyses of the data, though the results are not reported here. Point biserial correlations examine relationships where one variable is continuous and one is dichotomous (e.g. teacher competence and subject). Phi correlations assess relationships between two dichotomous variables such as gender and teaching subject. Correlations between nominal variables (e.g. academic, general/vocational, remedial and white, African American, and Hispanic) require Cramers' V technique.
A third difficulty is heterogeneity of regression, which occurs when the relationships between individual characteristics and outcomes vary across groups. With HLM, the researcher is able to model these relationships, or slopes, as well as individual characteristics (Bryk & Raudenbush, 1992).
CHAPTER 4
TEACHERS' PARTICIPATION IN
COMMUNITIES OF PRACTICE

Communities of practice in schools, as elsewhere, come in many configurations and engage in activities of many sorts, with varying degrees of social learning and organizational impact. The typology for communities of practice, presented in Chapter 1, suggests that the variation in the character of communities of practice relates to the extent of legitimate participation and to the span of engagement of its members. Sharing a common purpose, teachers in a community of practice experience social learning, through which they shape and are shaped by community norms and expectations. I propose that productive membership in a community of practice has the potential to improve curriculum, instruction, and student performance. Members step out of their classrooms and even out of their departments to engage in discussion about educational concerns, coordinate their courses, develop common resources, and take part in committee work on the departmental and school level.

The social learning theory that is foundational to communities of practice indicates that learning results from the reciprocal influences of multiple dualities (described in Chapter 2). Social and professional characteristics of teachers and demographic and contextual characteristics of their schools suggest the influences...
teachers are subject to in their worklives which might have consequences for learning. For instance, female teachers and those in Catholic and NAIS private schools are more likely to adopt a collective rather than an individual perspective (Bryk & Driscoll, 1988; Bryk, et al., 1993; Shakeshaft, 1987). Conversely, male teachers and teachers in public schools might not as readily participate in productive communities of practice. African American teachers might be more likely to identify with members in communities of practice in schools where teachers of their race constitute a faculty majority and less likely to do so where they are in the minority (Bryk & Driscoll, 1988; Bryk et al., 1999).

The departmentalization of high schools has consequences for how teachers of different subjects understand knowledge and student learning (Grossman & Stodolsky, 1995). Thus, departments are conceptual contexts that influence participation and interaction as much as the structural arrangement of classrooms (Lortie, 1975; Siskin, 1994) and the size of the school do (Bryk et al., 1999; Louis et al., 1996). Status or authority differentials, with consequences for community participation, are likely to surface in schools (Ball, 1988; Goldberg, 1996; Siskin, 1994). In a science department, for example, teachers of more specialized classes (e.g., physics) might enjoy greater privilege than teachers whose classes have a more general focus. Teachers’ curricular track assignments, which are generally distributed within the department, have further consequences for teachers’ participation in communities of practice. Teachers of academic classes, for instance, might have strong relationships with the department chair and thus have greater access to resources for learning. They might also sense greater pressure from their students’ parents, which might then spur them to greater collaborative efforts (Bidwell et al., 1997).
Schools characterized by organic management, where teachers and administrators share school decisions and where social relations are supportive and collaborative, could experience a higher incidence of productive community of practice participation (Rowan, 2002a; 2002b). Facilitative leadership and access to information might prompt greater learning efforts among community members (Bryk et al., 1999; Camburn, 1997). With consequences for social learning, these teacher and school characteristics are likely to affect teachers’ participation patterns in communities of practice.

Objective

This chapter examines the participation of mathematics and science teachers in communities of practice. Certain factors may predispose or encourage teachers to participate in communities of practice, potentially enhancing their professional capabilities through social learning. The review of the literature in Chapter 2 identified a range of possible characteristics of teachers and characteristics of schools that might contribute to this participation.

Chapter 3 presented the research questions that guide the first stage of this dissertation study. The four questions pertain to factors that might vary systematically among teachers who participate in communities of practice: teachers’ social and professional characteristics, teachers’ involvement in professional development, their perceptions of departmental leadership, and school characteristics and contexts. Figure 4.1 depicts the analytic model that integrates the four research questions. Teachers’ social and professional characteristics may be related to their propensity to participate in communities of practice (a). Female teachers and teachers with more
experience in the school, as previous research has shown, are likely to have high levels of participation. Teachers in the study are predominantly white (see Chapter 3), which might discourage an African American teacher who is a minority in the school from actively participating in a community of practice. Satisfaction with the teaching situation serves as an omnibus control for the tendency of contented teachers to respond positively to survey items about their school. Because mathematics teachers place a greater value on close coordination of classes than science teachers do, teachers of mathematics will likely participate more fully in communities of practice. Teachers in the academic track may enjoy greater status than teachers in other tracks and may have greater access to learning opportunities than others.

Figure 4.1
Analytic Model to Investigate Teachers’ Participation in Communities of Practice
Teachers' involvement in school-based professional development programs and college courses represents a potentially important source of information for use in the social learning that takes place in communities of practice. Department leaders who control access to resources for learning might have an important influence on teachers' participation patterns and probably set the tone for interactions related to practice.

School demographics and contextual factors possibly help to distinguish community of practice participation (b). Catholic and NAIS private schools may have organizational qualities such as small size and selectivity that contribute to productive community membership. Research has shown that teachers' communities can take root in urban schools, but comparisons to suburban and rural schools remain unexplored. Studies of social control in schools suggest that teachers are more likely to develop collegial relationships in small schools where clients' relative power is high (as measured by students' family SES). Organic management, which captures a collaborative and supportive school culture, serves as a measure of social relations relevant at the school level. Professional support and principal leadership reflect school level resources and encouragement for learning that might contribute to teachers' active and purposeful participation.

Method

Much of the analysis in this chapter is descriptive, seeking to identify sources of variation in mathematics and science teachers' participation in communities of practice. The descriptive investigation includes a set of three analyses. In the first analysis, I examine whether teachers' attributes vary according to their teaching subject and
curricular track. Using two-way analysis of variance and testing for interactions between subject and curricular track. I probe the relationships for systematic differences among the social and professional characteristics of teachers, their involvement in professional development, and their perceptions of departmental leadership. In the second analysis, I examine the differences in these characteristics of teachers according to their level of participation in communities of practice. Using a categorical variable of communities of practice that I constructed for heuristic purposes, I apply one-way analysis of variance for continuous variables and cross-tabulations for categorical variables to detect systematic variation in teachers' attributes when their participation is classified as productive, limited, or weak. In the third analysis, I investigate the relationships of school context factors to a school-level measure of communities of practice through correlation analysis.

Incorporating the covariates identified as statistically significant in the descriptive analyses, I apply a multilevel analytic technique, hierarchical linear modeling (HLM), to estimate the contribution of these factors to teachers' participation in productive communities of practice. I fit a series of three within-school models to evaluate the relationship to participation of teachers' attributes, their involvement in professional development activities, and departmental leadership, respectively. Three between-schools models evaluate school demographic characteristics, organizational characteristics, and principal leadership in turn.
Results

Teachers’ Participation Related to their Social and Professional Characteristics

Differences in Teachers by Subject and Curricular Track. The social and professional characteristics of teachers differ according to their teaching subject and the curricular track of their focal teaching assignment, but none of the interaction terms is significant (Table 4.1). Women comprise just over half of the mathematics teachers in the sample, but represent only a third of the science teachers. The distribution of teachers by gender does not vary significantly across curricular tracks. African American teachers constitute a similar proportion of mathematics (4 percent) and science (2 percent) teachers, but a significantly greater proportion of remedial (9 percent) teachers relative to academic (3 percent) and general/vocational (4 percent) teachers.

The distribution of teachers by subject across curricular track varies significantly. Of teachers of academic and general/vocational courses, nearly 60 percent are mathematics teachers. For all remedial teachers, however, over 73 percent are mathematics teachers. This greater percentage probably results as much from the larger number of mathematics teachers in the sample as it does from the greater tendency of mathematics teachers to organize instruction according to students’ ability levels (Weiss, 1994; Weiss et al., 2001). Considering the full number of mathematics and science teachers in the sample, the relative distribution of each subset across curricular tracks is much the same.

Mathematics and science teachers report an equal number of years experience (12) in the present school. Teachers in the academic track have the most seniority (13 years) and teachers in the remedial track have the least (10 years). The level of
<table>
<thead>
<tr>
<th></th>
<th>Mathematics</th>
<th>Science</th>
<th>Academic</th>
<th>General/Vocational</th>
<th>Remedial</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1618</td>
<td>1091</td>
<td>1654</td>
<td>939</td>
<td>116</td>
<td></td>
</tr>
<tr>
<td>% Female</td>
<td>50.4***</td>
<td>33.7</td>
<td>44.1</td>
<td>41.0</td>
<td>54.3</td>
<td>n.s.</td>
</tr>
<tr>
<td>% African American</td>
<td>3.8</td>
<td>2.4</td>
<td>2.6</td>
<td>3.6</td>
<td>8.6***</td>
<td>n.s.</td>
</tr>
<tr>
<td>% Mathematics Teachers</td>
<td></td>
<td></td>
<td>59.7</td>
<td>58.1</td>
<td>73.3**</td>
<td></td>
</tr>
<tr>
<td>% Academic</td>
<td>61.0</td>
<td>61.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% General/Vocational</td>
<td>33.8</td>
<td>36.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Remedial</td>
<td>5.2</td>
<td>2.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience in present school in years</td>
<td>12.2</td>
<td>12.2</td>
<td>12.8***</td>
<td>11.4</td>
<td>10.0</td>
<td>n.s.</td>
</tr>
<tr>
<td>Satisfaction with the teaching situation*</td>
<td>-.01</td>
<td>.01</td>
<td>.09***</td>
<td>-.16</td>
<td>-.06</td>
<td>n.s.</td>
</tr>
<tr>
<td>Participation in School-based Professional Development Programs*</td>
<td>.01</td>
<td>-.02</td>
<td>.04*</td>
<td>-.07</td>
<td>-.02</td>
<td>n.s.</td>
</tr>
<tr>
<td>Enrollment in College Courses*</td>
<td>-.08</td>
<td>.12***</td>
<td>-.03</td>
<td>.05</td>
<td>-.04</td>
<td>n.s.</td>
</tr>
<tr>
<td>Departmental Instructional Leadership*</td>
<td>.08***</td>
<td>-.12</td>
<td>.05**</td>
<td>-.09</td>
<td>.01</td>
<td>n.s.</td>
</tr>
<tr>
<td>Communities of Practice*</td>
<td>.10***</td>
<td>-.15</td>
<td>.07***</td>
<td>-.11</td>
<td>-.03</td>
<td>*</td>
</tr>
</tbody>
</table>

*Standardized variable (Mean=0, SD=1)

*** p < .001; ** p < .01; * p < .05

Table 4.1
Teachers' Social and Professional Background by Subject and Curricular Track: Two-way Analysis of Variance with Interactions
satisfaction with the teaching situation expressed by mathematics teachers does not differ significantly from the level expressed by science teachers. Academic teachers, however, report significantly higher levels of satisfaction with teaching than general/vocational teachers (.2 SD) and remedial teachers (.3 SD).

Teachers participate in school-offered professional development programs at much the same rate for both subjects, but participation does vary significantly by curricular track. Academic teachers attend school-based development programs more frequently than general/vocational or remedial teachers, by a factor of .11 SD and .06 SD respectively. Science teachers enroll in college courses at a much higher rate than mathematics teachers with a difference of one-fifth of a standard deviation. The higher level for science teachers perhaps indicates their efforts to stay current with knowledge relevant to their dynamic courses (Grossman & Stodolsky, 1995; Stodolsky & Grossman, 1995). Curricular track does not significantly affect course enrollment.

Teachers' perceptions of departmental leadership vary significantly both by teaching subject and by curricular track. The difference of one-fifth of a standard deviation for mathematics teachers over science teachers likely represents the close cooperation teachers necessarily have with department chairpersons when the content area knowledge is considered "defined" and different courses are considered "sequential" (Grossman & Stodolsky, 1995; Stodolsky & Grossman, 1995). It is possible that the somewhat more positive perceptions of academic teachers compared to general vocational (.14 SD) and remedial (.04 SD) regarding the leadership of the department chair convey the privileged status and greater access to resources enjoyed by these teachers (Goldberg, 1996; Siskin, 1994).
Communities of practice also vary significantly across subject and curricular track. Participation of mathematics teachers in communities of practice is one-quarter of a standard deviation higher than that of science teachers. From the perspective of curricular track, academic teachers' participation in communities of practice is nearly one-fifth of a standard deviation higher than that of general/vocational teachers and one-tenth of a standard deviation higher than that of remedial teachers. Importantly, a significant interaction exists between subject and curricular track for communities of practice. The significant interaction indicates that the relationship between communities of practice and curricular track varies according to the teaching subject. The interaction will be taken into account in the within-school HLM model with interaction terms for subject by curricular track. Computed by multiplying the indicator for subject (1=mathematics, 0=science) by the indicators for academic (1=academic, 0=general/vocational or remedial) and remedial (1=remedial, 0=general/vocational or academic), the interaction terms result in indicators for academic mathematics teachers compared to all other teachers and remedial mathematics teachers compared to all other teachers.

**Variation in Teachers' Participation in Communities of Practice.** The Rasch analyses used to construct the communities of practice measure provide insight into teachers' participation patterns (see Appendix B). Mathematics and science teachers with high difficulty scores report that they are actively involved with a wide range of school members on both departmental and schoolwide curricular and instructional matters. They indicate that teachers in the department share goals and that teachers in the school share a common mission. Teachers who participate fully with others engage in social learning
and their work is likely to enhance the production function of their schools (Bidwell, 2001). As these teachers solve problems or collaborate, they experience productive community membership. The majority of teachers in the study claim limited membership, as their participation or interaction, or both, is at less than full levels. While such teachers take part in some activities and interact with some other teachers, they do not have the same learning opportunities through participation and interaction that teachers with productive membership have. Teachers with very low scores report weak community participation. These teachers, who most likely concern themselves only with what happens in their own classrooms, do not talk or participate in joint activities with other teachers. As a result, they have few opportunities for job-embedded, social learning.¹

Research on the organization of high schools indicates that teachers’ social and professional backgrounds might lead teachers to have different perceptions of their working conditions (Rowan, Raudenbush, & Kang, 1991). It is possible, then, that teachers’ social and professional background characteristics might predispose them toward or against community of practice participation (Table 4.2). To examine whether observed differences in teachers’ background exist among participants in communities of practice, I constructed a categorical measure that distinguishes teachers’ participation as productive, limited, or weak. I considered teachers whose scores are greater than one standard deviation above the mean for communities of practice to engage in “productive” participation. Those whose scores range from one standard deviation above the mean to

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one standard deviation below the mean report "limited" participation. Teachers whose scores are less than one standard deviation below the mean experience "weak" participation.²

Teachers' participation in communities of practice does differ according to their social and professional characteristics. Women report productive participation with greater frequency (53 percent) while men are more likely to experience weak participation (38 percent). African Americans tend to have weak community participation levels (5 percent vs. 2 percent for productive and 3 percent for limited). As expected, participation patterns differ significantly based on teachers' subject and curricular track with mathematics teachers (69 percent) and academic teachers (70 percent) more likely to claim productive membership in communities than other teachers in the sample. General/vocational teachers more frequently report limited (36 percent) or weak (38 percent) participation.

Teachers who report participating as a productive community member have 1.2 years more experience in their present school than limited members and 2.7 years more than members with weak participation, though the teachers in all categories, on average, are experienced. Teachers who report productive participation are satisfied with their teaching situation to a greater degree than are teachers with limited (.4 SD) or weak participation (.9 SD).

Teachers with productive membership participate in school-based professional development programs much more than other teachers. The difference between teachers with productive and limited levels is nearly one-third of a standard deviation. Between productive and weak levels, teachers' participation varies by over one-half of a standard deviation.
<table>
<thead>
<tr>
<th>Category</th>
<th>Productive (n=415)</th>
<th>Limited (n=1926)</th>
<th>Weak (n=377)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Female</td>
<td>52.8***</td>
<td>42.5</td>
<td>38.2</td>
</tr>
<tr>
<td>% African American</td>
<td>1.9</td>
<td>3.1</td>
<td>5.3*</td>
</tr>
<tr>
<td>% Mathematics Teacher</td>
<td>68.9***</td>
<td>60.0</td>
<td>48.3</td>
</tr>
<tr>
<td>% Academic</td>
<td>69.7***</td>
<td>59.6</td>
<td>57.2</td>
</tr>
<tr>
<td>% General/Vocational</td>
<td>25.2</td>
<td>36.3</td>
<td>38.3***</td>
</tr>
<tr>
<td>% Remedial</td>
<td>5.1</td>
<td>4.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Experience in present school in years</td>
<td>13.4***</td>
<td>12.2</td>
<td>10.7</td>
</tr>
<tr>
<td>Satisfaction with teaching situation(^{a})</td>
<td>.40***</td>
<td>.00</td>
<td>-.45</td>
</tr>
<tr>
<td>Participation in School-based Professional</td>
<td>.34***</td>
<td>-.02</td>
<td>-.27</td>
</tr>
<tr>
<td>Development Programs(^{a})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enrollment in College Courses(^{a})</td>
<td>-.09</td>
<td>.00</td>
<td>.08~</td>
</tr>
<tr>
<td>Departmental Instructional Leadership(^{a})</td>
<td>.89***</td>
<td>-.04</td>
<td>-.92</td>
</tr>
</tbody>
</table>

\(^{a}\)Categories of Communities of Practice created as follows: Productive is > 1 SD above the sample mean on Communities of Practice, Limited is between −1 SD and +1 SD, Weak is < 1 SD below sample mean.

\(^{a}\)Standardized variable (M=0) (SD=1)

\(* * * * p < 0.001, * p < 0.05, \sim p = 0.053.

Table 4.2
Participation in Communities of Practice Related to Teachers’ Social and Professional Background

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deviation. Offered through the school or a professional association, these programs are likely to be customized to teachers’ immediate classroom needs. Teachers with weak community participation enroll in college courses more frequently than other teachers, though the difference only approaches significance.

Differences in departmental instructional leadership account for variation of more than one and three-fourths standard deviation between productive and weak participation levels. Department chairs, as teachers, are members of departmental communities of practice. It makes sense that teachers with productive community of practice membership would have more favorable impressions of department chairs than teachers with limited or weak levels of participation, who probably have less interaction with the department chair.

High school mathematics and science teachers’ social and professional characteristics, their participation in professional development, and their perceptions of departmental leadership vary systematically by the subject and the curricular track of the classes they teach. These same attributes, activities, and perceptions account for variation in teachers’ participation in communities of practice, distinguishing participation that is productive, limited, or weak.

**Teachers’ Participation Related to School Factors**

**School Context Factors.** How important is school context to teachers’ participation in communities of practice? Within communities of practice, teachers make sense of their situations; they adjust their relations with each other, and they develop common perceptions about other individuals and about their environments. According to
both the social learning theory related to communities of practice and to the research that identifies paradigmatic differences between departmental communities, teachers’ participation in communities of practice is more likely to be related to differences within schools than to differences between them. However, systematic differences between schools may make some contribution to variation in teachers’ participation and interaction with school colleagues.

Other research has identified school level variables that might affect teachers’ tendencies to collaborate with other staff members (Bidwell et al., 1997; Rowan et al., 1991). Based on that research, I investigate school type (Catholic or NAIS vs public) and sector (urban or rural vs suburban) differences, school size, and the average student family socioeconomic status. I also consider professional development support (i.e., compensation for participation) and the impact of principal instructional leadership.

In order to examine relationships with school characteristics, I aggregate the communities of practice composite from the teacher to the school level. Though the communities of practice measure gauges the extent to which teachers experience active participation on school wide projects and broad interaction with other colleagues in the school, I have reservations about saying that the aggregated measure is a valid representation of communities of practice as a school organizational characteristic because the data concern only mathematics and science teachers.

In response to this limitation, I import a measure of organic management from the NELS:88 First Follow-up data, drawing on responses of teachers in four subject departments – English and social studies in addition to mathematics and science – as operationalized in earlier NELS:88 research by Lee and Smith (1996). Gauging the
extent to which the school has a collegial and supportive culture, this measure is
influenced by the work of Rowan and his associates (1993), who hypothesize that more
organic forms of management co-evolve along with collegial relationships among
teachers when they face ambiguous situations (see also Rowan, 2002a and 2002b).

Incorporating responses from a more diverse sample of teachers in the school,
organic management is a fair representation of an established schoolwide culture
characterized by collaboration and supportive social relations. Using this data, Lee and
Smith (1996), in fact, considered the constituent measures, teacher control and staff
cooperation, to indicate the presence of professional community. It seems probable that
schools with a high level of organic management will also have communities of practice
in which teachers' participate fully and interact with other teachers in the school.

To explore the extent to which organic management and other school context
factors are related to communities of practice, I examine correlations for the school level
continuous variables (Table 4.3). The communities of practice aggregated measure is
significantly related to these school level covariates except average student SES. The
correlation coefficients for organic management (.339) and for principal leadership (.398)
are positive, and moderate to strong. Professional support has a positive, though weaker
relationship to communities of practice (.211). As expected, school size is negatively and
significantly related to teachers' productive community participation (-.112).

The modest correlation between organic management and communities of
practice suggests that organic management might not contribute much in explaining
teachers' community of practice participation. While organic management and
communities of practice tap some different items, they are conceptually related by their
common focus on teachers' collaborative work and teachers' involvement in activities that impact school decisions. The moderate size of the relationship could possibly indicate that some schools had undergone dramatic change in the two years since the First Follow-up data were collected. More likely, the modest correlation cautions that distinctions in high school teachers' perceptions about schools, resulting from their experiences within subject departments and curricular tracks, are quite different from department to department – distinctions that might be more evident in communities of practice, with only two groups of teachers (Rowan et al., 1991). Lee and Smith (1996)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Communities of Practice</th>
<th>Organic management</th>
<th>Principal Instructional Leadership</th>
<th>Professional Support</th>
<th>School Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic management</td>
<td>.339***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principal Instructional Leadership</td>
<td>.398***</td>
<td>.225***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional Support</td>
<td>.211***</td>
<td>.020</td>
<td>.179***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School Size</td>
<td>-.112*</td>
<td>-.228***</td>
<td>-.054</td>
<td>.012</td>
<td></td>
</tr>
<tr>
<td>Student SES</td>
<td>.002</td>
<td>.031</td>
<td>-.076</td>
<td>.014</td>
<td>018*</td>
</tr>
</tbody>
</table>

Table 4.3
Relationships Among School Level Variables: Pearson Product Moment Correlations

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indicate that they did not detect any variation in their measures related to subject
differences. I retain organic management as a school level measure of a collegial and
supportive school culture.

The significant correlations of the other variables support their inclusion as school
level contributors to teachers' productive membership in communities of practice.
Average student SES, while not significant, is retained to control for socioeconomic
differences in a school's student population (Bidwell et al., 1997; McLaughlin & Talbert,
2001).

**Teachers' Participation in Communities of Practice: An HLM Analysis**

To evaluate teachers' participation in communities of practice as a function of
teachers' social and professional attributes, experiences, and attitudes as well as
contextual features of their schools, I employ 2-level HLM.

Using the fully unconditional model, I calculated the intraclass correlation (ICC)
or amount of variation in the dependent variable that can be explained by differences
between schools (Table 4.4). The ICC for communities of practice is 8.7 percent,
indicating that most of the variance is within schools. High school subject departments
differ in character within schools, but departments of the same subject between schools
tend to be similar. Because the dependent measure, communities of practice, is
standardized, the total variances before prediction (the unconditional models) sums to a
value of 1 (Bidwell et al., 1997).

The lambda reliability reported (.38) is lower than the Cronbach's alpha reliability
(.71). While alpha is a measure of the internal consistency of the dependent measure
itself. Lambda is a measure of the reliability of the estimated school mean for the dependent measure. Reliabilities are low when there is little variation between schools, as is the case with communities of practice, and the number of respondents in each school is low (7.5 average in this sample). The ICC and lambda together confirm that participation in communities of practice, as measured by these data, is a characteristic of teachers not a characteristic of a school (Rowan et al., 1991).

Dependent Variable: Communities of Practice

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Between-School Variance</td>
<td>8.74</td>
</tr>
<tr>
<td>Within-School Variance</td>
<td>91.26</td>
</tr>
<tr>
<td>Intraclass Correlation</td>
<td>8.74</td>
</tr>
<tr>
<td>HLM Reliability (Lambda)</td>
<td>.38</td>
</tr>
<tr>
<td>Cronbach's Alpha Reliability</td>
<td>.71</td>
</tr>
</tbody>
</table>

Table 4.4
Communities of Practice: Psychometric Properties

**Within-schools Models.** With communities of practice as the dependent variable, I constructed three distinct within-school models (Research questions 1 and 2) to investigate factors that might contribute to variation in teachers' participation in communities of practice (Table 4.5). Model one estimates the relationships of teachers' social and professional characteristics to their participation in communities of practice.
In the second model, I include teachers' involvement in professional development activities. I introduce a measure of departmental instructional leadership in model 3.

All measures in the HLM models are either standardized variables (M=0, SD=1) or dummy variables. For standardized variables, the coefficient indicates change (in standard deviation units) in the dependent variable as a result of one standard deviation increase in the independent variable. For dummy variables, the coefficient indicates the change in the dependent variable (in standard deviation units) for the specified group relative to the contrast group.

The social and professional backgrounds of mathematics and science teachers are significantly related to their participation in communities of practice (Model 1). African Americans' participation is much less than the participation of other teachers (-.3 SD). Women report higher levels of participation in communities than men do (.2 SD). Teachers with more experience (.1 SD) and those who are satisfied with their teaching situation (.3 SD) claim productive membership more frequently than other teachers.

As expected, mathematics teachers report productive membership in communities of practice to a greater extent than science teachers do (.2 SD). Neither the main effect for academic nor the interaction effect for academic and mathematics is significant, indicating that for all academic teachers, participation levels are no different than those of general/vocational teachers. The participation of remedial teachers, however, is much lower, on average, than academic teachers (.4 SD) or general/vocational teachers (.4 SD). The situation is much different for remedial mathematics teachers, as indicated by the significant interaction term. The strong positive effect for this subset of teachers (.5 SD)
Dependent Variable: Communities of Practice

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1 Teacher Background Characteristics</th>
<th>Model 2 Professional Development</th>
<th>Model 3 Departmental Leadership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-.22***</td>
<td>-.18***</td>
<td>-.10*</td>
</tr>
<tr>
<td>Teacher Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American</td>
<td>-.31**</td>
<td>-.32**</td>
<td>-.24*</td>
</tr>
<tr>
<td>Female</td>
<td>.22***</td>
<td>.17***</td>
<td>.16***</td>
</tr>
<tr>
<td>Experience in present school</td>
<td>.09***</td>
<td>.08***</td>
<td>.09***</td>
</tr>
<tr>
<td>Satisfaction with teaching situation</td>
<td>.25***</td>
<td>.23***</td>
<td>.17***</td>
</tr>
<tr>
<td>Mathematics Teachers</td>
<td>.15*</td>
<td>.13*</td>
<td>.04</td>
</tr>
<tr>
<td>Academic</td>
<td>.04</td>
<td>.01</td>
<td>-.05</td>
</tr>
<tr>
<td>Remedial</td>
<td>-.36*</td>
<td>-.39*</td>
<td>-.35*</td>
</tr>
<tr>
<td>Mathematics * Academic Interaction</td>
<td>.07</td>
<td>.08</td>
<td>.13</td>
</tr>
<tr>
<td>Mathematics * Remedial Interaction</td>
<td>.52*</td>
<td>.57**</td>
<td>.49**</td>
</tr>
<tr>
<td>School-based Professional Development Programs</td>
<td></td>
<td>.18***</td>
<td>.16***</td>
</tr>
<tr>
<td>College Courses</td>
<td></td>
<td>-.05**</td>
<td>-.03*</td>
</tr>
<tr>
<td>Departmental Instructional Leadership</td>
<td></td>
<td></td>
<td>.41***</td>
</tr>
<tr>
<td>Within-school variance explained</td>
<td></td>
<td>9.4%</td>
<td>12.2%</td>
</tr>
</tbody>
</table>

*aVariable standardized, M=0, SD=1
*** p<.001; ** p<.01; * p<.05

Table 4.5
Teachers' Participation in Communities of Practice: Within-school Hierarchical Linear Models
more than makes up the average difference between academic and remedial teachers, indicating that remedial mathematics teachers have a higher level of community participation, on average, than any other subgroup of teachers in the sample, and remedial science teachers have the lowest.

Calculations of the relative effects for each subgroup of teachers results in the following ranking: remedial mathematics teachers (.31 SD); academic mathematics teachers (.26 SD); general/vocational mathematics teachers (.15 SD); academic science teachers (.04 SD); general/vocational science teachers (.0 SD); and remedial science teachers (-.36 SD).

Taking part in school-offered professional development programs (Model 2) increases teachers' average level of participation (.2 SD). Enrollment in college courses, which moves the focus of learning away from the school, reduces the level of participation (-.1 SD). With the introduction of these potential resources for learning, the negative effect for remedial teachers intensifies slightly and the positive effect for remedial mathematics teachers increases slightly in magnitude and increases in significance.

The influence of the department chair (Model 3) increases the average participation in communities of practice (.4 SD). Importantly, the influence of the department chair also removes the significance of the subject effect. Apparently science and mathematics teachers in the sample, in terms of their community of practice participation, respond in an equivalent, positive manner to the strong leadership of their department chairs.
**Between-schools Models.** I also fit three distinct between-school models to estimate the importance of school level differences to teachers' participation in communities of practice (Research questions 3 and 4). The first model includes school demographic characteristics. The second model adds organizational characteristics of schools, specifically, professional development support and organic management. The third model considers the unique contribution of the principal's leadership (Table 4.6).

The only school demographic characteristic that makes a difference in teachers' participation in communities of practice is school size (−.02 SD). Teachers are more likely to report productive membership in smaller schools. Other differences in school type, sector, and socioeconomic status of students' families do not explain differences in community of practice membership.

Professional support for participation in development activities does not contribute to important differences in teachers' participation in communities of practice. Organic management does, however, increase teachers' participation significantly (+.1 SD). When this measure of schoolwide collegial culture is taken into account, school size loses significance.

Principals who are supportive instructional leaders positively affect teachers' participation in communities of practice (+.1 SD). The introduction of this measure reduces the significance and magnitude of the effect for organic management. The more proximal effect of principal instructional leadership likely sorts out and absorbs the leadership influence that is a component of organic management.
### Table 4.6
Teachers' Participation in Communities of Practice: Between-school Hierarchical Linear Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>School Demographics</td>
<td>Professional Support and Organic Management</td>
<td>Principal Leadership</td>
</tr>
<tr>
<td>Intercept</td>
<td>-.22*</td>
<td>-.19*</td>
<td>-.10*</td>
</tr>
<tr>
<td>School Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catholic</td>
<td>.26</td>
<td>.19</td>
<td>.07</td>
</tr>
<tr>
<td>NAIS</td>
<td>.22</td>
<td>.11</td>
<td>.11</td>
</tr>
<tr>
<td>Urban</td>
<td>-.05</td>
<td>-.03</td>
<td>-.03</td>
</tr>
<tr>
<td>Rural</td>
<td>-.06</td>
<td>-.02</td>
<td>-.01</td>
</tr>
<tr>
<td>Average Student Family SES&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.01</td>
<td>-.00</td>
<td>.00</td>
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<tr>
<td>Size&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.02*</td>
<td>-.01</td>
<td>-.04</td>
</tr>
<tr>
<td>Professional Support&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td>.05</td>
<td>.01</td>
</tr>
<tr>
<td>Organic Management&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td>.12***</td>
<td>.06**</td>
</tr>
<tr>
<td>Principal Instructional Leadership&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td>.08***</td>
</tr>
<tr>
<td>Between-school variance explained</td>
<td>60.6%</td>
<td>65.2%</td>
<td>71.2%</td>
</tr>
</tbody>
</table>

Level-2 models are fully-adjusted for within-school differences (Model 3)

<sup>a</sup>Variable standardized, M=0, SD=1

*** p<.001; ** p<.01; * p<.05
The fully adjusted model explains 27 percent of the within-school variation and 71 percent of the between-school variation in teachers’ participation in communities of practice. The within-school percentage explained leaves much variation for researchers to explore.

Discussion

If productive community of practice membership proves to influence teachers’ professional knowledge, beliefs, and skills (the focus of the investigation in Chapter 5), it is important that educators understand how to create settings conducive to such participation. The results of the HLM analyses provide insight into high school mathematics and science teachers’ communities of practice where members are likely to benefit from learning that relates to their work with students and involves sharing of knowledge among colleagues.

The findings show that some groups of teachers are more likely to report productive membership than others. In a sample of predominantly white teachers, African American teachers report lower incidence of membership in communities of practice. This finding suggests that African American teachers in the sample are, on average, underrepresented in their departments or faculties and, perhaps as a result, less likely to identify with other teachers and to share in joint work (Bryk & Driscoll, 1988). African American underrepresentation among high school mathematics and science teachers is a national situation. While African Americans constitute roughly 12 percent of the United States population, African American faculty account for only 6 percent of secondary science teachers and 7 percent of secondary mathematics teachers. (Weiss &
African American teachers have shown strong membership in teachers' professional community (Bryk et al., 1999).

Women appear to have a greater propensity than men to engage in joint work with other school members (Shakeshaft, 1987). This finding is consistent with earlier research that showed men to be much less prone to staff cooperation (Rowan et al., 1991). In high schools, with faculty members of both genders, the predominant school culture is likely to be masculine, where individualistic work relationships are the norm (Hofstede, 1991). Within science and mathematics departments, female faculty membership might represent a smaller proportion of the department faculty than they do in the school at large. Nationally, women comprise 27 percent of secondary science teachers and 46 percent of mathematics teachers (Weiss & Raphael, 1996). The study sample is comparable: 34 percent of the science teachers and 50 percent of the mathematics teachers are female. In such an environment, women may actively seek out community membership more than men.

The positive effect for teachers with more experience reflects the important part that knowledgeable teachers make to social learning. These are teachers who may have insight that other teachers want to learn, so others might seek them out for their participation on committees or for discussions about instruction and student performance (Wenger, 1998). The strong effect for teachers' satisfaction with their teaching situation indicates that practicing as part of a productive community reaps personal benefit for teachers.
Subject makes a difference in teachers' participation in productive communities. The subject paradigm necessitating close coordination of mathematics instruction is likely the reason for mathematics teachers' tendency to participate. At the time data were collected, the national mathematics standards had been widely promulgated. A 1993 survey (administered shortly after these data were collected) indicates that 56 percent of high school mathematics teachers nationally knew of the content of the standards (Weiss et al., 1994). It is possible that the new policies fostered conversations and brought mathematics teachers together for specialized program offerings. This environmental factor might contribute some explanation for higher community participation levels among mathematics teachers in general.

Curricular track does not make a difference in participation for academic or general/vocational teachers. Participation patterns differ significantly, however, for remedial mathematics and science teachers. Remedial mathematics teachers report productive community of practice membership much more frequently than all other teachers. Quite the opposite, remedial science teachers more frequently report weak community membership.

The relative rankings of the subgroups begs the question, "Why is the level of community participation for remedial mathematics teachers so high?" Considering only mathematics teachers, two related explanations for remedial teachers' high levels of productive membership might apply. Remedial teachers might have a greater need to consult with teachers in other departments or with school specialists regarding their students, and thus record higher scores due to this increased interaction outside of their subject departments. The need to collaborate in this way might result from external

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pressures regarding their students' achievement. School exit exams in mathematics might place such pressure on remedial mathematics teachers with twelfth grade students.

Within the group of remedial teachers, paradigmatic differences related to subject could be operant. The cooperation and coordination required by mathematics teachers naturally increases their participation in activities and their interaction. In departments where a number of non-defined, discrete subjects are housed, such as science, it is also possible that status differences accrue to teachers based on the courses they teach. Teachers of remedial science classes (e.g., earth science or general life science) would likely be at the bottom of the status hierarchy relative to teachers of more specialized classes such as physics, chemistry, or biology. As a result, remedial science teachers might not be included in curricular planning and activities relating to physics, chemistry, or biology instruction. Mathematics teachers, who teach defined, sequential courses, would be less likely to experience such exclusion. If this is the case, the higher participation levels for remedial mathematics teachers might be, to some extent, a function of leadership.

Departmental leadership, which explains nearly 15 percent of the within-school variance, is the most important factor in contributing to teachers' participation in communities of practice. Teachers who have a favorable impression of their department chair report productive membership in a community of practice more frequently than other teachers. Strong departmental leaders – those who consult faculty before making decisions, communicate expectations, carry out plans, secure resources, and encourage and support department members in innovation – draw forth the collaborative energies of teachers and engage them in full participation. Whether strong leaders support voluntary
efforts from their faculty, assign them to shared tasks, or invite them to participate can
not be discerned in this data. What is clear, however, is that the mathematics and science
department chairpersons in this sample are instrumental in assuring that teachers have
opportunities for social learning through full participation and rich interaction.

Professional development programs also facilitate the emergence of productive
communities of practice. Opportunities for learning and access to information
represented in school-based development programs might address the specific learning
needs of teachers and serve to facilitate collaborative work around problems related to
their classrooms. It appears that remedial mathematics teachers have more opportunities
to participate in such programs than remedial science teachers. Enrollment in college
courses, reflecting individual efforts, perhaps draws teachers' interest for learning away
from their participation in communities of practice. College courses are attractive to
science teachers with an interest in staying current with discoveries in their field, but their
enrollment might contribute to lower community of practice membership.

Demographic differences among schools do not explain teachers' participation in
communities of practice, even though Catholic and NAIS schools are recognized as
having more communal orientations than public schools. The only significant variation is
due to school size, which has a negative relationship to communities of practice. This
effect disappears with the introduction of the imported measure of organic management.
Productive community membership is more likely to occur in schools that have strong
norms of collaboration and support. Because members of productive communities of
practice engage colleagues throughout the school, schoolwide norms for social relations and teachers’ responsibilities (e.g., what teachers have control over) are understandably important.

The contribution of principal instructional leadership, while much less than department leadership in terms of magnitude, is also important to teachers’ community of practice membership. At the school level, the principal most likely facilitates activities and interactions that reach across departmental boundaries. By establishing and communicating a tangible school vision, the principal encourages the integration of departmental efforts. The effective principal extends recognition and consideration to the faculty, thus encouraging them to do the school level work that demands more effort, more responsibility, and more expertise. Once the energies of the faculty are ignited, the principal allows teachers to do the work they are best suited to do – plan and carry out the instructional program of the school.

The results of the analyses detailed in this chapter reflect the reciprocal influences teachers experience in their school workplaces in the process of social learning. Women science teachers might have to reconcile the norms of autonomy prevalent in their departments with their natural tendencies for collegial interaction. African American teachers who feel marginalized may extend greater efforts toward finding meaning in their situations, perhaps in interaction with their students. As the result of higher levels of participation in departmental communities of practice, mathematics teachers who work with remedial students might have a qualitatively different self-identity than science teachers who do the same. Departmental colleagues who attend school-based professional
development programs as a group could have a greater transfer of knowledge to their classroom practice than an individual teacher sitting in the back of a college classroom.

Teachers' social and professional characteristics, their professional development opportunities, their school and departmental leaders, and the demographic and organizational contexts of schools have consequences for teachers' participation in communities of practice and the social learning that can result from such membership. The next chapter explores the professional impact of productive community participation on teachers' capabilities, including their willingness to learn from other school colleagues, their competence to adjust their instruction, and their use of instructional practices aligned with national disciplinary standards.
Notes for Chapter 4

1 Appendix C presents tables showing differences related to subject and curricular track for all items in the communities of practice construct.

2 Based on the scheme described, 13.9 percent of teachers report participation that is productive; 70.9 percent report participation that is limited; and 15.3 percent report participation that is weak.

3 Department chairpersons did not respond to survey items related to their position.

4 I considered numerous other contextual variables for use in multilevel analyses. All of these measures represented either a reason for learning, support for learning, barriers to learning, or experience with learning, which, I suspected, might have an influence on teachers' participation patterns in communities of practice. These included: high-stakes testing, departmental complexity, rewards for teachers, assignment change, and recent school change. None of these variables contributed any explanation to teachers' participation patterns, so I dropped them from the analyses.
CHAPTER 5
PROFESSIONAL IMPACT OF TEACHERS' PARTICIPATION IN
COMMUNITIES OF PRACTICE

If attention to communities of practice is to improve teacher quality, participation in such communities should enhance teachers' learning, improve their dispositions, and increase their pedagogical skills. The analyses in this chapter examine the impact of teachers' participation in communities of practice on three professional outcomes: teacher learning, teacher competence, and teachers' use of standards-based pedagogy.

Teacher learning measures a gain in knowledge that results in improvement to instruction. It also taps the social cohesion that develops when members know that knowledge held within a community of practice will be shared with others (Wenger, 1998). Teacher competence focuses on teachers' perceptions of their own abilities and their professional responsibilities (Wenger, 1998). At the same time, it suggests teachers' perceptions of their students. Standards-based pedagogy is a more instrumental measure gauging specific instructional skills teachers use in their classrooms. As well, it represents the external press of a challenging policy mandate.

If I am to correctly interpret the results of the analyses in this chapter, it is important that I have a clear sense of what these dependent variables might mean in teachers' actual experience. A survey, sponsored by the National Science Foundation.
profiled science and mathematics education in 1993 and is helpful in this regard (Weiss et al., 1994).1 I consider survey information in relation to each of the professional outcomes in turn.

Mathematics and science teachers surveyed indicated that they could learn valuable information from their teaching and administrative colleagues. Most teachers felt supported by their peers to try out new ideas for teaching. They indicated that teachers in their schools shared ideas and materials on a regular basis, that they had many opportunities to learn new things in their jobs, and that they felt supported by administrators. Generally, though, surveyed mathematics and science teachers agreed that lack of opportunities for teachers to share ideas created serious problems in their schools.

Various factors contribute to teachers' perceptions of their competence to teach. Most high school science and mathematics teachers have fairly extensive backgrounds in their field, though mathematics teachers reported being better prepared to cover a wide range of mathematics concepts than science teachers did in responding to a comparable question. Teachers of lower ability level courses were generally less well-prepared than teachers assigned to teach students with higher levels of ability. Teachers' major constraint was in the area of pedagogy. Many teachers reported some difficulty using student centered practices in classrooms where students were grouped heterogeneously. They also provided evidence that they did not feel well prepared to teach the diverse students in their schools. While generally feeling prepared to teach students of both genders and most minorities, teachers were less confident that they could provide
adequate instruction for students with cultural differences or learning disabilities. Only a small percentage of respondents felt well-prepared to teach students with limited English proficiency.

A primary goal of the survey was to assess the extent to which teachers supported the reform notions embodied in the NCTM Standards and the National Science Education Standards. While both mathematics and science teachers generally acknowledged familiarity with and support of the principles of the standards in 1993, many of them did not agree with specific pedagogical strategies. They supported including applications of mathematics and science to daily life and using hands-on, cooperative approaches to instruction. Teachers less frequently agreed that mathematics and science instruction should focus on deeper coverage of fewer concepts. Most high school mathematics teachers indicated their belief that students should master arithmetic before moving on to algebra, and over half of all science teachers indicated the importance of learning basic scientific terms and formulas before learning underlying concepts and principles. Mathematics classes were more likely than science classes to stress preparation for further study in the discipline and preparing for standardized tests. Lecture and discussion dominated both mathematics and science instruction.

In summary, high mathematics and science teachers nationally respect the knowledge of their peers and support collegial interactions, but they don’t have many opportunities to participate in collaborative activities in their workdays. They generally feel well-prepared in terms of pedagogical content knowledge, but they seem less prepared to meet the diverse challenges their students bring into the classroom. High
school mathematics and science teachers embrace the principles of the standards conceptually, but they often do not translate agreement with the principles into effective classroom practice.

**Objectives**

As the survey results indicate, teachers' professional knowledge, beliefs, and skills might vary according to their teaching subject and curricular track and other factors related to their professional situations. The survey results also suggest that important relationships might exist among the professional outcomes. One objective of this chapter is to conduct descriptive analyses in order to examine these possibilities.

In Chapter 3, I hypothesized that teachers' participation in communities of practice, to the extent that community membership is characterized by rich interactions among members and by purposeful activities focused on curriculum and instruction, might increase teachers' knowledge, competence, and pedagogical skills. In order to test this hypothesis, I estimate the effect of teachers' participation in communities of practice on each of three outcomes: teacher learning, teacher competence, and teachers' use of standards-based pedagogy.

The analytical model for this stage of the analysis is presented in Figure 5.1. Because teachers' social and professional background contribute to teachers' opportunities to engage in social learning through community of practice membership, these attributes might also contribute significantly to the results of that learning – teachers' knowledge, beliefs and skills (a). I test the importance of teachers' participation in communities of practice to teachers' professional outcomes: teacher learning, teacher
Figure 5.1
Analytic Model to Investigate the Professional Impact of Communities of Practice
competence, and teachers' use of standards-based pedagogy (b). School demographic and organizational characteristics, which partially explained teachers' community membership, might also contribute to teachers' professional capabilities (c).

Method

The analyses begin with descriptive techniques to determine sources of variation in the dependent measures related to subject and curricular track. To examine group differences for subject and curricular track in each of the three dependent measures, and to identify potential interaction effects, I employ two-way analysis of variance. Applying correlational analysis, I explore the relationships among the dependent variables (i.e., teacher learning, teacher competence, and standards-based pedagogy), the continuous teacher attribute variables, and communities of practice.

To estimate the impact of participation in communities of practice on teachers' professional practice, I conduct three parallel investigations, one for each dependent variable: teacher learning, teacher competence, and teachers' use of standards-based pedagogy. I apply a multilevel analytic technique, hierarchical linear modeling (HLM). To control for potentially confounding influences, the within-school models incorporate teachers' social and professional background characteristics that were statistically significant in the descriptive analyses, as well as gender and race.

For the between-school models, I include the same school demographic and organizational characteristics used in the investigation of teachers' participation in communities of practice, in Chapter 4. While only three of the variables (i.e., school size, organic management, and principal leadership) proved to be significantly related to
teachers' community of practice membership. Other research suggests that the variables might affect teachers' social relationships in schools (Bidwell et al., 1997; Rowan et al., 1991). Since the social learning that occurs within communities of practice is influenced by the social relationships among colleagues (Wenger, 1998), it is possible that these school-level measures will help to explain the professional outcomes.

I fit two within-school models for each dependent measure, investigating the effects of teachers' social and professional attributes and communities of practice, respectively. In the two between-schools models, I first evaluate the effects of school demographic and organizational characteristics and then the contribution of principal instructional leadership.

Results

Professional Outcomes Related to Teachers' Social and Professional Characteristics

Differences in Professional Outcomes by Subject and Curricular Track.

Teachers' professional outcomes vary either by subject or track, or both (Table 5.1). Teacher learning varies by subject, with mathematics teachers significantly more likely to benefit from the expert advice of their school colleagues than science teachers (.2 SD). Across curricular tracks, teacher learning does not vary, nor is there a subject by track interaction. Teacher competence is equivalent across subject areas; however, remedial teachers report significantly greater competence (i.e. ability and the responsibility to adapt their instruction to their students' needs) than general/vocational teachers (.2 SD) and academic teachers (.1 SD). Significant interactions are not evident.
<table>
<thead>
<tr>
<th></th>
<th>Mathematics</th>
<th>Science</th>
<th>Academic</th>
<th>General/Vocational</th>
<th>Remedial</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Learning&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.06***</td>
<td>-.09</td>
<td>-.01</td>
<td>-.00</td>
<td>.19</td>
<td>n.s.</td>
</tr>
<tr>
<td>Teacher Competence&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.02</td>
<td>.03</td>
<td>.03</td>
<td>-.08</td>
<td>.14***</td>
<td>n.s.</td>
</tr>
<tr>
<td>Use of Standards-based Pedagogy&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.14</td>
<td>.21***</td>
<td>.18***</td>
<td>-.22</td>
<td>-.71</td>
<td>***</td>
</tr>
</tbody>
</table>

<sup>a</sup>Standardized variable (Mean=0, SD=1)

<sup>**p< .001</sup>

Table 5.1
Observed Differences in Professional Outcomes by Subject and Track: Two-way Analysis of Variance with Interactions
Teachers' use of pedagogical techniques in line with the national disciplinary standards varies by subject and teaching assignment. Science teachers have a greater tendency to use standards-based pedagogy than mathematics teachers (.4 SD). Where mathematics teachers cohere around their defined subject area (Grossman & Stodolsky, 1995), science teachers tend to cohere around the scientific method (Siskin, 1994). The inquiry-based approach reflected in the pedagogy variables seems compatible with scientific processes. Academic teachers use these standards-based instructional methods more than general/vocational teachers (.4 SD) or remedial teachers (.9 SD). Because the techniques supported by the standards are intended to engage students in “deep” thinking about subjects, teachers in the other tracks might shy away from them. For standards-based pedagogy, the interaction between subject area by teaching assignment is significant. This analysis indicates that interaction terms are necessary when standards-based pedagogy is the dependent variable.

Looking down the columns, it is interesting to note that, while the range is not wide, means scores for mathematics teachers are highest on learning, and lowest on pedagogy. Just the opposite, mean scores for science teachers are highest on pedagogy and lowest on learning. This suggests that there might be weak, or even inverse relationships among some of the professional outcome measures.

**Relationships Among Professional Outcomes and Teacher Attributes.** The Pearson correlations, indicating the strength and direction of the teacher level relationships, are presented in Table 5.2. Among the dependent measures, the relationships, though significant and positive, are not particularly large: teacher learning and teacher competence (.192); teacher learning and standards-based pedagogy (.085);
### Table 5.2
Relationships Among Professional Outcomes and Teacher Attributes: Pearson Product-Moment Correlations

<table>
<thead>
<tr>
<th></th>
<th>Teacher Learning</th>
<th>Teacher Competence</th>
<th>Standards-based Pedagogy</th>
<th>Experience</th>
<th>Satisfaction</th>
<th>Development Programs</th>
<th>College Courses</th>
<th>Department Leadership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Competence</td>
<td>.192***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standards-based Pedagogy</td>
<td>.085***</td>
<td>.245***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience</td>
<td>-.069***</td>
<td>-.027</td>
<td>.002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction</td>
<td>.165***</td>
<td>.242***</td>
<td>.170***</td>
<td>.091***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development Programs</td>
<td>.119***</td>
<td>.163***</td>
<td>.154***</td>
<td>.000</td>
<td>.089***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College Courses</td>
<td>.014</td>
<td>.024</td>
<td>.076***</td>
<td>-.165***</td>
<td>.015</td>
<td>.111***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Department Leadership</td>
<td>.367***</td>
<td>.146***</td>
<td>.047*</td>
<td>-.022</td>
<td>.166***</td>
<td>.078***</td>
<td>-.029</td>
<td></td>
</tr>
<tr>
<td>Communities of Practice</td>
<td>.447***</td>
<td>.264***</td>
<td>.194***</td>
<td>.087***</td>
<td>.256***</td>
<td>.211***</td>
<td>-.048*</td>
<td>.563***</td>
</tr>
</tbody>
</table>

*Standardized variable (Mean=0, SD=1)

*** p < .001; ** p < .01; * p < .05
teachers competence and standards-based pedagogy (.245). The low correlations indicate that the professional outcomes are independent and tap different concepts.

Teacher learning has a significant negative relationship to experience (-.069), but significant positive relationships to satisfaction (.165), professional development programs (.119), and department leadership (.367). Competence is positively and significantly related to satisfaction (.242), professional development programs (.163), and department leadership (.146). Standards-based pedagogy is positively and significantly related to all the continuous teacher covariates except experience, though these are much lower in magnitude than the relationships for the other outcomes: satisfaction (.170), professional development programs (.154), college courses (.076), and department leadership (.047). Importantly, communities of practice has significant relationships with each of the dependent measures: teacher learning (.447), teacher competence (.264), and standards-based pedagogy (.194).

Professional Impact of Communities of Practice: An HLM Analysis

I test the hypothesis for each of the three parallel investigations in this chapter with 2-level hierarchical linear models. The fully unconditional model, with no predictors at either level, provides the basis for determining the intraclass correlation (ICC), or the amount of variation that exists between schools. As a group, the professional outcomes do not vary much between schools (Table 5.3). Teacher learning, competence, and use of standards-based pedagogy are, for the most part, within-schools phenomena (i.e. differences occur among individuals). The ICC for teacher learning is 7 percent; for competence, 3 percent; and for standards-based pedagogy, only 1 percent.
### Table 5.3
Professional Outcomes: Psychometric Properties

<table>
<thead>
<tr>
<th></th>
<th>Learning</th>
<th>Competence</th>
<th>Standards-based Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between-School Variance</td>
<td>7.40</td>
<td>2.97</td>
<td>1.05</td>
</tr>
<tr>
<td>Within-School Variance</td>
<td>92.60</td>
<td>97.03</td>
<td>98.95</td>
</tr>
<tr>
<td>Intraclass Correlation</td>
<td>7.40</td>
<td>2.97</td>
<td>1.05</td>
</tr>
<tr>
<td>HLM Reliability (Lambda)</td>
<td>.34</td>
<td>.16</td>
<td>.06</td>
</tr>
<tr>
<td>Cronbach’s Alpha Reliability</td>
<td>.70</td>
<td>.66</td>
<td>.72 (M)</td>
</tr>
</tbody>
</table>

The lambda reliabilities for all three dependent measures are extremely low: .34 for learning, .16 for competence, and .06 for pedagogy, as a consequence of the small number of teachers in each school (6.5 on average, but as few as 5) and the small percentage of between-school variation. Thus, the low reliabilities reflect the low ICC for each dependent measure, indicating that the professional outcomes are characteristics of individual teachers not characteristics of schools (Bryk & Raudenbush, 1992). Even in cases where the between-schools variation is extremely low, however, the analyst can proceed with hierarchical analysis if a theoretical interest in between-schools factors exists (Bryk & Raudenbush, 1992).

HLM offers improved estimation of individual effects over other analytic approaches, such as ordinary least-squares (OLS) regression. It borrows strength from...
the entire set of data to estimate effects. Specifically in terms of my analysis, the program considers the relationships within all schools, and puts more weight on the grand mean of the entire sample in estimating the intercept, $\beta_{j0}$, than on the group mean. With HLM, the estimation of fixed effects will be superior to a single level technique.

The Cronbach's Alpha reliabilities, measuring the internal consistency of the measures, are approximately .70. Two alphas are reported for standards-based pedagogy because the index is comprised of separate measures for mathematics and science teachers. These measures are merged into one variable for analysis.

**Within-school Models.** I fit two within-school models for each of the three professional outcome measures (Table 5.4). The first model investigates teachers' social and professional attributes. The second model estimates the influence of teachers' participation in communities of practice.

All of the social and professional attributes of teachers contribute significantly to at least one of the dependent measures. Race has a positive relationship with teacher competence (.3 SD) and in the use of standards-based pedagogy (.3 SD). Female gender is a significant factor only in women's more frequent use of standards-based pedagogy (.1 SD). Teachers' experience in the school has a significant negative relationship with teacher learning (-.1 SD). Teachers' satisfaction with their teaching situation contributes significantly to all three outcome measures, teacher learning (.1 SD), teacher competence (.2 SD), and standards-based pedagogy (.1 SD).

Mathematics teachers are more likely to capitalize on the expertise of other school members and learn from them (.1 SD) and to use standards-based instruction (.7 SD).
Dependent Variables: Teacher Learning Teacher Competence Standards-based Pedagogy

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 1</th>
<th>Model 2</th>
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<td>Communities of Practice</td>
<td>Professional Background</td>
<td>Communities of Practice</td>
<td>Professional Background</td>
<td>Communities of Practice</td>
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<td>.02</td>
<td>.01</td>
<td>.13**</td>
<td>.15**</td>
</tr>
<tr>
<td>Teacher</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>.08</td>
<td>.00</td>
<td>.30**</td>
<td>.35***</td>
<td>.33**</td>
<td>.37***</td>
</tr>
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<td>-.05</td>
<td>.07</td>
<td>.03</td>
<td>.13***</td>
<td>.10**</td>
</tr>
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<td>Experience</td>
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<td>-.10***</td>
<td>-.03</td>
<td>-.05**</td>
<td>-.01</td>
<td>.02</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>.12***</td>
<td>.06***</td>
<td>.22***</td>
<td>.18***</td>
<td>.14***</td>
<td>.10***</td>
</tr>
<tr>
<td>Mathematics</td>
<td>.09*</td>
<td>.04</td>
<td>-.08*</td>
<td>-.11**</td>
<td>-.66***</td>
<td>-.67***</td>
</tr>
<tr>
<td>Academic</td>
<td>-.08*</td>
<td>-.09*</td>
<td>.03</td>
<td>.03</td>
<td>.07</td>
<td>.08</td>
</tr>
<tr>
<td>Remedial</td>
<td>.10</td>
<td>.10</td>
<td>.17</td>
<td>.18~</td>
<td>-.54**</td>
<td>-.47**</td>
</tr>
<tr>
<td>Math*Academic</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.49***</td>
<td>.46***</td>
</tr>
<tr>
<td>Math*Remedial</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.16</td>
<td>.06</td>
</tr>
<tr>
<td>Development</td>
<td>.08***</td>
<td>.02</td>
<td>.13***</td>
<td>.10***</td>
<td>.12***</td>
<td>.09***</td>
</tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College Courses</td>
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<td>.02</td>
<td>.01</td>
<td>.01</td>
<td>.04*</td>
<td>.05**</td>
</tr>
<tr>
<td>Department</td>
<td>.27***</td>
<td>.09***</td>
<td>.08***</td>
<td>-.02</td>
<td>-.02***</td>
<td>-.07***</td>
</tr>
<tr>
<td>Leadership</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communities of Practice</td>
<td>.39***</td>
<td>.22***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between-school</td>
<td>10.6%</td>
<td>20.8%</td>
<td>8.4%</td>
<td>11.8%</td>
<td>14.3%</td>
<td>17.3%</td>
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<tr>
<td>Variance Explained</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b Variable standardized. M=0, SD=1
*** p<.001; ** p<.01; * p<.05; -p<.55

Table 5.4
The Professional Impact of Participation in Communities of Practice: Within-school Influences on Teacher Learning, Competence, and Use of Standards-based Pedagogy
Academic teachers, on average, are significantly less inclined to learn from colleagues (-.1 SD). Remedial teachers are much less likely than academic teachers (.6 SD) or general/vocational teachers (.5 SD) to use student-centered methods. Subject by track interaction terms are also included in the pedagogy models. The significant effect for academic mathematics teachers (.5 SD) indicates that they use standards-based pedagogy to a greater degree than their general/vocational colleagues. No significant difference is detected for remedial mathematics teachers. Calculation of the relative effects of differing teaching assignments and subject areas for the use of standards-based pedagogy gives the following ranking: academic science teachers (.1 SD); general/vocational science teachers (.0 SD); academic mathematics teachers (-.1 SD); remedial science teachers (-.5 SD); general/vocational mathematics teachers (-.7 SD); and remedial mathematics teachers (-1.0 SD).

Teachers' participation in school development programs has a strong relationship to their learning (.1 SD), their competence (.1 SD), and their pedagogical skills (.1 SD). Enrollment in college courses is important only in developing pedagogical skills that align with the disciplinary standards (.04 SD). Strong departmental chairs have a significant positive impact on teacher learning (.3 SD), on teacher competence (.1 SD), and a significant negative impact on standards-based pedagogy (-.02 SD).

The second model introduces teachers’ participation in communities of practice. In each case, community participation results in a moderate, positive, and significant increase in the professional outcomes. For a one-standard deviation increase in teachers' participation in communities of practice, teacher learning increases by four-tenths of a standard deviation, teacher competence by one-fifth of a standard deviation, and
standards-based pedagogy by one-fifth of a standard deviation. These findings support my hypothesis, that community of practice membership characterized by full participation and rich interaction will result in increases to teachers' knowledge, competence, and pedagogical skills. Productive community participation provides teachers ample opportunities to learn from those with expertise. Members establish normative expectations that teachers will offer responsive instruction. Teachers, within communities of practice, make sense of the disciplinary policy documents and plan strategies to innovate them.

Participation in communities of practice explains the relationships of other elements of teachers' background and experience to their professional outcomes. In the teacher learning model, mathematics and professional development lose significance. When teachers participate as productive community of practice members, they can overcome barriers to learning associated with subject paradigms (e.g., the science norm that teachers are experts in specific fields). Community membership provides ample occasions to learn, and thus, members are less dependent on professional development programs for learning opportunities. Strong department chairs are less important where community membership is productive. As community of practice members interact with school colleagues around instructional issues, expectations that knowledge is shared with others become normative.

In the teacher competence model, being African American is linked to higher levels of competence. As a result of community membership, teachers with more experience and mathematics teachers are even less inclined to modify their teaching in response to student needs. In terms of offering responsive instruction, the goals and
expectations established by strong department leaders are unimportant. The criteria for competence are established within the community.

Productive members find college courses to be more important to their use of standards based practices than other teachers. Department leadership appears to be at odds with productive community membership when it comes to embracing standards-based practices. Community of practice members who regard the department chair as a strong leader are significantly less likely to employ student-centered techniques in their classrooms.

The variation explained at Level-1 is calculated using the fully unconditional model and the three within-school models (Table 5.4). The total amount of within-school variance explained is 21 percent for teacher learning, 12 percent for teacher competence, and 17 percent for pedagogy. Communities of practice explains the largest portion of variance for teacher learning (10.2 percent). Teachers' professional background characteristics explain the largest portion of variance explained for teacher competence (8.4 percent) and for standards-based pedagogy (14.3 percent).

**Between-school models.** I also fit a set of two between-school models for each dependent measure in order to estimate the effects of school level influences on teachers' professional outcomes (Table 5.5). The first model in each set investigates the impact of demographic and organizational characteristics of schools on teacher learning, competence, and use of standards-based pedagogy. The second model examines the extent to which principal instructional leadership explains differences in these professional capabilities.
### Table 5.5
The Impact of Communities of Practice: Between-school Influences on Teacher Learning, Competence, and Standards-based Pedagogy

<table>
<thead>
<tr>
<th>Dependent Variables:</th>
<th>Teacher Learning</th>
<th>Teacher Competence</th>
<th>Standards-based Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
<td>Model 1</td>
</tr>
<tr>
<td></td>
<td>Demographics and Context</td>
<td>Principal Leadership</td>
<td>Demographics and Context</td>
</tr>
<tr>
<td>Intercept</td>
<td>.00</td>
<td>.01</td>
<td>-.01</td>
</tr>
<tr>
<td>School</td>
<td>Catholic</td>
<td>-.14</td>
<td>-.20</td>
</tr>
<tr>
<td></td>
<td>NAIS</td>
<td>-.33***</td>
<td>-.28**</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
<td>.13*</td>
<td>.11*</td>
</tr>
<tr>
<td></td>
<td>Rural</td>
<td>.13*</td>
<td>.11*</td>
</tr>
<tr>
<td></td>
<td>Size&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.05*</td>
<td>-.05*</td>
</tr>
<tr>
<td>Student Family SES&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.03</td>
<td>-.02</td>
<td>-.01</td>
</tr>
<tr>
<td>Professional Support&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.03</td>
<td>.01</td>
<td>-.01</td>
</tr>
<tr>
<td>Organic Management&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.05*</td>
<td>.02</td>
<td>.03</td>
</tr>
<tr>
<td>Principal Leadership&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.14***</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Between-school Variance Explained</td>
<td>42.2%</td>
<td>63.6%</td>
<td>21.8%</td>
</tr>
</tbody>
</table>

Level-2 models are fully-adjusted for within-school differences (Model 2).

<sup>a</sup>Variable standardized. M=0, SD=1

*** p<.001; ** p<.01; * p<.05
Teacher learning, which has the greatest amount of between-school variation of the three outcomes, is significantly influenced by most of the school level covariates. Teachers in NAIS schools learn significantly less from their colleagues than teachers in Catholic (.5 SD) or public school (.3 SD). Teachers in urban and rural schools are equivalent in gaining knowledge from colleagues, at a level that is significantly greater than the learning reported by suburban teachers (.1 SD). Large school size constrains the ability of teachers’ to benefit from other teachers’ expertise (.1 SD), though perhaps only marginally. Organic management, reflecting an established culture of collaboration and support, significantly influences teacher learning (.1 SD), though the effect is trivial. Principal leadership makes a significant contribution to teacher learning (.1 SD). School level factors do not directly affect teacher competence. Variation in this outcome relates only to differences between teachers.

Teachers’ use of standards-based pedagogy has the smallest amount of between-school variation of the three dependent measures. Even so, two school level variables reach significance in the first model. Teachers in rural schools use student-centered, problem-based instructional practices more often than teachers in suburban (.1 SD) or urban (.2 SD) schools. Large school size is positively related to increases in teachers’ use of standards-based techniques (.1 SD). Principal leadership has no direct effect on teachers’ use of standards-based pedagogy, but leadership brings the negative relationship of students’ family socioeconomic status and standards-based pedagogy into significance (-.1 SD).

The Level-2 variance (Table 5.5) derives from the fully unconditional model and the fully-adjusted two-level model (see Chapter 3). The between school-variance
explained is 64 percent for teacher learning, 21 percent for competence, and 12 percent for pedagogy. The sizeable amount of between-school variation for competence, with no significant between-school covariates, results from the fact that between-school variation is a function both of school level differences and differences among schools in the characteristics of the teaching staff. Thus, the between-school model is adjusted for the within-school model (Bryk & Raudenbush, 1992).

**Discussion**

As operationalized for the study detailed here, communities of practice reflect the natural participation and interaction patterns of high school mathematics and science teachers with their departmental colleagues, but they also represent the learning potential of participation and interaction beyond what is most familiar, including participation in school level activities and interaction with a broad range of school members. Productive community membership provides teachers with opportunities for learning of the sort that appears to significantly enhance teachers’ knowledge, dispositions, and skills.

**Personal Traits**

African American teachers, women teachers, and those who are satisfied with their teaching situation report higher levels on one of more of the professional outcomes generally. While I might speculate on the reasons why this might be the case, there is nothing in these data to support more than mere speculation. However, investigations into the relationships among teachers’ personal traits, their community of practice participation, and the resulting professional consequences might be fruitful.
Teacher Learning

From one way of thinking, teacher learning represents a straightforward exchange of information. Teachers report that their instruction has improved because they have learned things from other school colleagues. Set against the norms of autonomy so often associated with high school teaching, however, teacher learning also taps the willingness of teachers to open their practice to examination by another teacher or an administrator. Community of practice participation increases teachers' propensity for doing so.

In moving from peripheral participation to full participation, teachers learn both by gaining experience and by drawing on the knowledge of veteran members, who have longer tenures in the school and who teach the classes requiring more expertise. Through participation in valued activities, members of communities of practice come to expect that knowledge held within the community will be shared with others. Members of productive communities have more resources for information within the school and are less dependent on professional development programs for access to expertise.

The department chair, who has specialized subject or pedagogical knowledge, plays an important role in facilitating the transfer of knowledge among community of practice members. Department chairs bring teachers together around specific problems, protect time for them to work together, and provide resources for learning work.

School differences appear more consequential for teacher learning than any of the other professional outcomes. Teachers in NAIS schools report learning at a much lower level than their public or Catholic school counterparts. It is possible that teachers in
NAIS schools are "independent artisans" who learn alone (Huberman, 1993), regardless of the focused efforts of faculty in these selective schools.

In urban schools, teachers might face a greater need for learning as a result of the challenges presented by diverse student bodies. Urban schools might also provide teachers with greater internal resources, access to educational specialists or consultants, for example. In general, small school size, which makes interaction and formation of strong social relations easier, is associated with learning. Teachers in rural schools, which are smaller on average, also tend to learn more. Faculty in rural schools may also be more open or engage in more positive social relations. Organic management, representative of a collaborative and supportive school culture, encourages highly-interactive faculty relationships with attendant opportunities for learning from colleagues.

School principals are important to teacher learning. They establish learning needs by setting a vision for the school. They help establish norms for social interaction by modeling learning behaviors and by giving all members equal consideration, thus minimizing status differentials. They also have expertise to share with others.

**Teacher Competence**

Teacher competence, as defined for this study, derives its meaning from students' achievement. Competence incorporates teachers' acknowledgement that their teaching affects how students learn as well as their disposition to adapt their instruction as needed to insure that students learn. This conceptualization, admittedly, is at odds with a variety of other goals of education (e.g. credentialing) or purposes of instruction (e.g. controlling students).
Community of practice membership increases the likelihood that teachers will embrace the meaning of competence used in this study. Teachers who participate with school colleagues on important work and have frequent interactions with a wide range of colleagues more often indicate that they are able to change their instruction to make sure that students learn. What's more, they have a responsibility to do so. These notions of competence are negotiated within the community. Over time, community members come to understand the attitudes and behaviors that define a teacher, in terms of community expectations, as competent.

Participation in productive communities, however, strengthens the resistance of experienced teachers and mathematics teachers to modify their instruction. While competence increases overall as a result of community of practice membership, the normative influences of the community reinforce the notion that veteran members of the community, as expert teachers (such as the "master" teachers in the national survey), have less need to change their practices. The community of practice acknowledges the correctness of mathematics teachers' defined and sequential approach to instruction even as community participation encourages these teachers' to make changes to instruction.

School-based professional development programs are an important source of information to help competent teachers develop new strategies for improvement. Departmental leaders are not influential in shaping an understanding of competence as offering instruction responsive to student needs. No school factors exert significant influence.

Participating in communities of practice, teachers establish norms for practice and become accountable to each other rather than to any external agent (Wenger, 1998).
Teachers’ relationships to their students, perhaps, set a framework for this negotiation (McLaughlin & Talbert, 2001). Without any significant influence from leadership or from school contexts, competence appears to be a matter for negation among community members.

Standards-based Pedagogy

Standards-based pedagogy represents a specific set of student-centered, inquiry-based instructional practices that reflect the principles of the national mathematics and standards documents. As such, the pedagogy outcome reflects the implementation of a national policy initiative as well as the use of innovative teaching practice.

Participation in a productive community of practice contributes to higher use of these student-centered practices. Within their communities of practice, teachers can make sense of such policies and devise appropriate strategies for instruction. They find support for experimentation. The use of unfamiliar instructional methods, however, introduces uncertainty into the classroom. With established relationships among school colleagues, teachers have support and information to solve instructional problems. However, outside expertise is also important for implementing innovative instructional techniques. Both school-based professional development programs and college courses provide essential knowledge.

The strongest influences on teachers’ use of standards-based pedagogy relate to the paradigmatic differences between subjects that are entrenched, or institutionalized, in common understandings about instruction (Grossman & Stodolsky, 1995; Meyer & Rowan, 1977; Stodolsky & Grossman, 1995). Science teachers, with a commitment to the
scientific method, appear to have a greater natural affinity for problem-based instruction. Mathematics teachers' acknowledged concern with coverage of basic facts and preparation of students for subsequent courses leaves them little room to try out the new instructional approaches associated with the standards. It is possible that the national conversation about standards encouraged science teachers in the study sample to try these practices more than it did mathematics teachers. Teachers of subjects that do not have highly institutionalized norms for practice are more likely to be influenced individually by external factors than teachers of highly institutionalized subjects (Bidwell & Yasumoto, 1999).

While both mathematics and science instruction tend to be organized into curricular tracks, the contrasting effects for tracking-related terms might derive as much from external influences related to students as to these operational contexts. Standards-based practices are student-centered, collaborative approaches rather than teacher-centered, didactic approaches. Teachers with remedial classes might have greater need (or perceived need) for control oriented strategies than teachers of academic classes (Cusick, 1992; McNeil, 1986). Academic teachers, with more capable students, perhaps do not have as much need for control when using standards-based instructional techniques – practices that can introduce complexity into the classroom – as other teachers.

When teachers participate as productive community of practice members, the influence of strong department chairs does not support increased use of standards-based pedagogy, at best, and might detract from that use, at worst. Establishing goals and setting expectations might slow down the learning work of the community of practice.

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School contexts do have some influence on instructional practices. Teachers in rural schools report higher use, perhaps reflecting a hands-on vs. theoretical orientation that better serves a work-oriented culture. The association of pedagogy with large school size might represent more differentiated curricular-tracking in larger schools. Organic management does not have any relationship to teachers' use of standards-based instructional practices. Though organic management, according to contingency theory, should reduce the task uncertainty teachers face when using standards-based teaching practices, in this study it appears disconnected from teachers' instructional choice.

Student family SES, which has a negative relationship to standards-based pedagogy, is an external influence that might affect teachers' pedagogical practices in two ways. Parents of more advantaged students, who probably intend that their children pursue postsecondary schooling, might express the desire that teachers adhere to established practices rather than experiment with their children. It is also possible that teachers in schools where the student family socioeconomic average is low embrace these student-centered techniques to engage students in instruction that is more immediately relevant than traditional instruction (McLaughlin & Talbert, 2001).

The size of the community of practice coefficient (.20 SD) relative to the size of the mathematics coefficient (-.66 SD) and the remedial coefficient (-.54 SD) suggests the stability of the secondary educational system. The organization of mathematics instruction as teacher-centered and sequential, from these data, appears to be extremely resilient to change. The organization of secondary instruction according to ability level tracks is equally embedded in the institutionalized structure of secondary schools. The job-embedded learning work of teachers, while having a positive influence on the use of
non-traditional and, therefore, innovative instructional methods, will not result in a quick turn-around of teachers' understandings of instruction.

The analyses related to the impact of communities of practice on teachers' professional outcomes have varied and complex results. In Chapter 6, I discuss these findings in the context of school improvement and explore their implications for teachers, school leaders, policymakers, and researchers.
Notes for Chapter 5

1 The 1993 National Survey of Science and Mathematics Education involved a national probability sample of 1,250 schools and approximately 6000 teachers in grades 1-12 throughout the United States.

2 All of the hierarchical linear models are random intercept, fixed-effects models, due to the very small portion of variance to be explained at the school level.
CHAPTER 6

INTERPRETATION OF FINDINGS

AND

IMPLICATIONS FOR PRACTICE, POLICY, AND RESEARCH

Practitioners, researchers, and policymakers seem to agree that teacher quality is the fundamental key to effective schools. Increasingly, educators recognize that teacher quality is dependent on continuous learning that derives from and is connected to their work with students and that occurs through collegial interactions within a community of practice (Darling-Hammond & McLaughlin, 1995; INTASC, 1992; ISLLC, 1996; King & Newmann, 2000; NBPTS, 1994). This dissertation represents an empirical test of that strategy for teacher improvement by demonstrating that teachers’ participation in communities of practice can result in positive gains to teachers’ knowledge, dispositions and skills.

If communities of practice are to undertake learning work intended to significantly change the way teachers deliver instruction in their schools, their opportunities for learning must help them improve their skills and provide challenge to their existing ideas. Active participation in the full range of valued community activities necessitates development of new skills. Interaction with a wide range of school colleagues provides exposure to ideas that challenge the status quo.
The results of this study reveal a range of individual and school factors that determine the extent to which high school mathematics and science teachers might experience social learning that can enhance their knowledge, increase their competence, and incline them toward use of standards-based instructional practices. In this concluding chapter, I discuss the major findings of the study as they relate to teachers' participation in communities of practice and to the professional impact that results from that participation. I end the chapter, and this dissertation, with implications of the study for teachers, school leaders, policymakers, and educational researchers.

**Teachers' Participation in Communities of Practice**

The findings of the study suggest that teachers' participation in communities of practice is influenced by their personal traits, their legitimate access to participation, learning resources, departmental leadership, and organizational characteristics of the school, including organic management and principal leadership.

**Personal Traits**

The investigation into communities of practice revealed that women mathematics and science teachers in the study sample claim productive community membership more frequently than men. These results affirm other research suggesting that women prefer collaborative work arrangements (Shakeshaft, 1987; Tannen, 1994). While not pursued in this study, future research on the intersection of gender and subject in terms of community participation might be warranted. Generally, teachers who are contented with
their teaching situation are also more likely to be involved in shared activity. It is just as probable that this finding indicates that productive community participation is a satisfying endeavor.

**Legitimate Participation**

The patterns of teachers' participation in communities of practice suggest that some groups of teachers have legitimate access to community membership, and other groups do not. Experienced teachers appear to be core community of practice members. With experience come valuable knowledge and insight into the local situation. Veteran teachers, perhaps, have effective classroom routines that free them to focus on larger, schoolwide issues.

In some sense, the normative beliefs of the subject discipline, in this study either mathematics or science, establish expectations for appropriate interaction and activity, and thus, expand or limit opportunities for productive community membership. Mathematics teachers appear to value active community participation, while it appears less important for science teachers. Due to the defined, sequential nature of mathematics, the close coordination and extensive interaction required to maintain appropriate instruction establish conditions where departmental communities of practice emerge naturally. Regarded as experts in a specific field of study, science teachers may commonly form close relationships with only a few colleagues. Mathematics and science teachers' opportunities for social learning, then, are amplified or constrained accordingly by their subject paradigms.
Other groups of teachers do not experience legitimate access. African American teachers, who report very low levels of community membership, might be excluded from the opportunities for learning that accompany full participation in community activities. Underrepresented in both the sample population and in the national population, African American mathematics and science teachers' perhaps experience marginalization among primarily white departmental, or perhaps, school faculties.

Remedial teachers, in general, experience disadvantage in terms of community membership. Much research has documented remedial students' diminished opportunities to learn, and it appears that remedial teachers might suffer a similar deprivation. An important finding is the high level of community participation reported by remedial mathematics teachers. The large disparity between remedial mathematics and remedial science teachers relative to their community of practice participation suggests that other factors can mediate curricular track distinctions. Remedial mathematics teachers appeared to benefit from opportunities to participate in school-based development programs more than remedial science teachers. Department chairs are likely critical in this regard. Another possibility might be the exogenous pressure of accountability systems that require high school students to pass high-stakes exit exams. This kind of pressure, probably more frequent in mathematics than in science at the time data were collected, can spur teachers to seek out the guidance or help of their colleagues in search of solutions to their specific instructional problems.
Learning Resources

The study results indicate the part that traditional professional development forums play in teachers’ participation in communities of practice. School-based professional development programs, offered through the school or the professional association, contribute importantly to teachers’ community membership. Bringing teachers together around subject matter or local school issues provides both a reason and an occasion for rich interaction. Enrollment in college courses, on the other hand, works against community participation. If teachers’ learning energies are focused off-site, they are not predisposed to engage in productive community activities.

Departmental Instructional Leadership

Departmental leadership is the most influential factor in determining the quality of teachers’ community participation. The extent of mathematics and science teachers’ participation in productive communities is, on average, more strongly related to the strength of the department chairs’ leadership than to subject differences. Strong departmental leaders who communicate expectations, establish goals, secure resources, carry out plans, and promote innovation encourage other teachers toward full community participation. Strong leaders do not, however, eliminate the disadvantage African Americans or remedial teachers experience in terms of their legitimate participation.

Organizational Characteristics

Organizational characteristics can encourage teachers’ participation in communities of practice. The critical factors appear to be collaborative and supportive
relations between teachers and administrators, characteristic of an organic style of management, and strong instructional leadership of the principal. While interactions among high school teachers most commonly occur within their subject departments, these findings suggest that, in the presence of an established schoolwide culture of collegiality, teachers more naturally forge broad-based relationships and engage in activities of schoolwide import. Principals contribute importantly to these social relations when they establish a school vision that can serve as a guide for teachers' joint work, extend support for teachers' efforts, and protect teachers from external interference.

**Professional Impact of Communities of Practice**

Teachers' participation in communities of practice enhances their professional knowledge, dispositions, and skills. Community of practice membership also serves a mediating function between exogenous factors and teachers' work. Organizational features of schools can enhance the outcomes of community participation. Finally, participation in communities of practice provides teachers an arena for informal instructional leadership when they are well supported in doing learning work by departmental chairs and principals.

**Productive Community of Practice Membership**

The primary finding of this dissertation study is that teachers' membership in communities of practice, to the extent that it represents full participation in valued
community activities and interaction with a wide range of colleagues, is significantly related to increases in teacher learning, teacher competence, and teachers' use of standards-based pedagogy.

Productive membership brings teachers into contact with other teachers and administrators from whom they can learn. Participating with their colleagues on important tasks, teachers have opportunities to draw on others' expertise and to test their own ideas and ways of doing things against the experiences of others. Productive membership provides teachers the opportunities to look at students from different perspectives than they are accustomed to and to develop skills for working with diverse students. In doing shared work with a wider range of colleagues, teachers might open to inquiry their notions of what it means to be competent and, perhaps, re-negotiate new understandings that will prove beneficial to students. Productive membership allows teachers to make sense of policy initiatives that challenge their habitual practice.

Consideration of new ideas from a different mindset – one resulting from productive community membership – increases the likelihood that these ideas will be considered on their merit rather than from the perspective of institutionalized beliefs.

The results show how effective it is for teachers to adopt a perspective that is broader than their own classrooms or subject departments. In this sense, the study is important in that it represents an intermediate step between research investigating collegial networks within subject departments (Bidwell et al., 1997; Bidwell & Yasumoto, 1999) and those studies which conceive of teachers' professional communities as a characteristic of schools (Bryk et al., 1999; Kruse et al., 1995; Louis et al., 1996; Louis & Marks, 1998).
The Mediating Function of Communities of Practice

Focusing attention on teacher learning within communities of practice will not dramatically change the quality of teachers or the effectiveness of schools in short order. Social learning within communities of practice can equip teachers to make improvements in their instructional practices, but effective improvements develop slowly over time (Bidwell, 2001; Coburn, 2001). Communities of practice provide the capacity for teachers to make sense of their situations in their dynamic local environments, yet they are nested within the stable institutional framework of school organization (Bidwell, 2001; Wenger, 1998).

Examining individual teachers' communities, McLaughlin and Talbert (2001) suggest that strong communities either maintain traditional practices or innovate in order to engage students. In mediating the influences from the external environment on teachers' work, the community serves as a stabilizing force or a force for change. Bidwell (2001) argues that informal networks of faculty members stabilize formal structures of schooling even as they provide mechanisms for adaptation of those structures in response to uncertainties and local circumstance. The findings of this study support Bidwell's dual argument as tendencies of community participation toward adapting and stabilizing are both evident. Teacher's communities of practice maintain the institutional understandings associated with the disciplines even as they enhance teachers' knowledge, modify their beliefs, and increase their use of innovative instructional techniques. In essence, teachers' communities of practice help the school maintain legitimacy while helping teachers adapt as necessary in response to external influences.

**Institutional Effect of Subject.** What teachers of different subjects understand as important knowledge for students to learn influences the delivery of instruction. These conceptual and operational norms, very different for mathematics and science teachers, have important consequences for teachers' professional capabilities. Teachers' participation in their communities of practice can strengthen or moderate subject differences relative to the teacher outcomes.

Science teachers are less inclined to learn from their colleagues than mathematics teachers, an expected finding because science departments are organized into discrete subjects (e.g. chemistry, biology, physics), with teachers considered as expert in one of those fields. Science teachers, as a result, generally form close ties with only a few colleagues (Bidwell & Yasumoto, 1999). The resulting autonomy of science teachers is a stable, and legitimate, feature of secondary science instruction (Grossman & Stodolsky, 1995). Though department leadership reduces the differences somewhat, participation in communities of practice is the critical factor in the ability of a faculty to capitalize on the knowledge and skills held within their membership and improve, or adapt, their instructional practices.
As the national surveys of science and mathematics teachers suggested, respondents from both subjects, generally, felt qualified for instruction in terms of their content knowledge, but less qualified in terms of responding to diverse students' needs. The study findings indicate that mathematics and science teachers report equivalent levels of competence. Subject differences become important, however, under the influence of the department chair. The critical components of the teacher competence measure, in this regard, are teachers' recognition that different teaching methods can affect achievement and their agreement that they do change instruction if students are not doing well. Mathematics teachers, by and large, indicate resistance to changing their instructional practices. They maintain strong institutionalized beliefs that students must learn basic facts and algorithms before moving on to more difficult, conceptual material (Weiss et al., 1994; Weiss et al., 2001). Teachers' community of practice participation strengthens this effect. Even as participation in communities of practice increases teachers' sense of competence – the ability and the responsibility for adapting their instructional practice – it allows for maintenance of stable, institutionalized norms of instruction. The community allows for adaptation while also buffering the school from threats to its legitimacy (e.g., from national policies or from a changing student population).

These effects are very apparent relative to teachers' use of standards-based pedagogy. Mathematics teachers do not generally embrace the instructional practices advocated in the reform documents (Weiss et al., 1994). Strong departmental leaders do not support the use of standards-based practices. Further, the relative client power of parents works against their adoption. Against these odds, participation in communities of
practices does contribute to modest increases in teachers' use of standards-based practices. Learning in the company of colleagues encourages teachers to adapt their instructional techniques. Even so, community participation does not minimize mathematics teachers' preference for traditional, teacher-directed, sequential instruction. Incremental change proceeds within a stable, legitimate, curricular framework.

**Institutional Effect of Curricular Track.** Common assumptions regarding the organization of instruction by curricular tracks are also part of the institutional environment for schools (Gamoran, 1986, 1992). The results of this study confirm other research indicating that mathematics teachers experience status differences based on the curricular track of their teaching assignment less frequently than science teachers do (as evidenced here by their community of practice participation) (Ball, 1981; Siskin, 1994; Stodolsky & Grossman, 1995). An additional finding is that common beliefs about curricular track are not moderated by community of practice participation to the same extent that subject differences are.

Regardless of the level of community of practice participation, academic teachers gain knowledge from school colleagues less frequently than other teachers. The greater use of standards-based practices by academic mathematics teachers relative to other mathematics teachers is not related to community of practice influence. In these data, differences in teachers' professional outcomes explained by curricular track appear unaffected by the social learning that occurs as a result of community membership.
Organizational Factors Influencing Professional Outcomes

Differences in schools by sector or type did not contribute any explanation to teachers' community participation patterns. Several school differences, however, did contribute importantly to teachers' professional outcomes. Notwithstanding their generally small size, communal orientation, or focused approach to instruction, teachers at NAIS schools are less able to capitalize on their expertise of their colleagues. This finding might indicate a qualitatively different sort of interaction occurring among teachers in these schools, perhaps based on respect for autonomy.

Teachers in rural schools report higher incidence of learning from other teachers and higher use of standards-based practices. Urban schools also have faculties that learn more from each other. All of these results point the way to interesting future research.

School size is important for two outcomes, though with different relationships. Large school size constrains the interaction necessary for teacher learning. In large schools, getting out of the subject department and forging relationships that are productive in terms of learning might be harder to do. On the other hand, large school size is related to increases in the uses of standards-based pedagogy. I interpret this as being related to an increase in academic classes, where teachers use these practices more frequently.

Organic management structures represent a shift from hierarchical control to network control. Characterized by teacher collaboration, teacher control, and principal support, organic management should, theoretically, facilitate teachers' problem solving work. Organic management is related to one professional outcome: teacher learning. The study results are in line with earlier research on organic management in schools which

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found that organic management promotes workplace learning (Rowan et al., 1993; Rowan, 2002b) but is not as strongly related to non-routine instructional practices (e.g., standards-based pedagogy), as might be expected.

Organic management is important for the development of communities of practice, particularly those whose membership and activities cross departmental boundaries, as with this study, but it does not appear to be related to the disposition to change instruction or to specific instructional skills. It is in communities of practice — that is, in groups of teachers who have common concerns about instruction and important knowledge to share — that teachers negotiate shared beliefs, develop joint resources, and improve instructional skills that have consequences for the classroom. These informal teacher groups, closer to teachers’ work with students than shared decision making forums or relationships with the principal or the faculty at large, are, as a result, more consequential for teachers’ day to day classroom practice.

**Instructional Leadership**

Communities of practice develop naturally within organizations. Capitalizing on the learning and innovation that occurs within communities of practice requires that formal leaders acknowledge, support, and integrate them into the school operation without disrupting the informality, collegiality, self-organization, and internal leadership that are critical to their learning and innovative capacities (Wenger & Snyder, 2000). Because the measures in this study relate positively to the technical core of schools — instruction — I term both principal and departmental leadership as instructional leadership. The leadership influences detected in this study concern both formal and informal
leadership, with the principal and department chairperson fulfilling formal roles and teachers — within the community of practice — providing informal leadership.

**Formal Leadership.** Communities of practice have the potential to improve school effectiveness if they produce useful knowledge (Wenger, 1999). The literature on communities of practice suggests that school principals can attend to the social learning system of the school by supporting the learning work of communities, by facilitating interactions between communities, and by integrating the knowledge generated in the separate communities (Wenger, 1999). The findings from this study suggest that the principal can motivate teachers toward community of practice participation by shaping a commonly-held vision of where the school wants to go and by supporting the work of teachers to enact that vision. Strong high school principals can facilitate teacher learning, but they do not appear to have any influence over teachers’ dispositions to change instructional practices or the kind of practices ultimately used in classrooms.

Department chairs’ attention to communities of practice, drawing from the literature, should constitute “nurturing” rather than management, in keeping with their informal nature. Even official sanction of a community’s learning work, along with resource support to advance the work, should be “lighthanded” in that it should not be attached to expectations or certain end goals (Wenger, 1998). A recent study, detailing the history of a learning community composed of teachers from two subject departments, tells of a mathematics teacher who did not want to continue his membership in the group because he did not want to say anything that might offend his department chair, who controlled what classes the teacher would teach (Grossman et al., 2001). The power of
the chair to distribute class assignments not only affected community membership but also the ability of community members to speak truthfully (Argyris & Schön, 1996).

The evidence from this dissertation study related to department chairs seems to support the idea that instructional leadership and learning leadership might be different things, and that balancing the two might be a challenge for any one individual. Department chairs, as instructional leaders, coalesce the energy of the faculty around teaching and student learning. Strong departmental leaders consult with their faculty, encourage innovation, establish learning needs, gather resources, and then support and encourage teachers' work. These leadership behaviors enhance teachers' overall community participation, facilitate the transfer of knowledge among colleagues, and increase teachers' competence to provide instruction that will help students learn.

These same leadership behaviors, however, do not advance the use of innovative standards-based practices. Strong department leadership has a negative relationship with student-centered instructional practices, and this influence becomes stronger when teachers are members of productive communities. In the context of this study, department chairpersons, then, slow down the adoption of standards-based instructional practices. In this sense, they also serve to stabilize the school within the institutional environment. With the external press of standards-based policies counter posed against public misunderstanding (Weiss et al., 1994), the department chair, perhaps accommodating to the desires of the central administration, maintains the legitimacy of the department and the school (Bidwell, 2001).

The survey of mathematics and science teachers, conducted in 2000, provides a critical piece of information in this regard. While standards-based reform of mathematics
and science instruction has been part of the national dialogue for over a decade. schools have not adjusted their evaluation procedures for teachers accordingly (Weiss et al., 2001). It is more likely that schools evaluate teachers on their success rates in getting students to pass tests of basic mathematics or science competencies than on their use of instructional practices that reflect an emphasis on deep knowledge over superficial coverage. The public expects high passage rates on accountability tests, and schools devote extraordinary resources toward that end. Strong instructional leadership of the department chair, then, enables schools to deliver consistent, and legitimate, instruction.

While departmental leadership “positions” teachers to engage in learning work, by encouraging community of practice membership, the leadership actually required for learning is more likely to emerge from within the community of practice.

**Informal Learning Leadership.** Communities of practice benefit from formal leadership, but they also depend on internal, informal leadership provided by teachers. This leadership is diverse and distributed, constituting an ecology of leadership (Coburn, 2001; Grossman et al., 2001; Spillane, et al., 2001; Wenger, 1999, p. 13). Within a community of practice, informal leaders change over time, and individuals will emerge as leaders as needed. Community members who undertake leadership, however, must have intrinsic legitimacy in the community by having participated sufficiently that they are considered more than peripheral members (Grossman et al., 2001; Wenger, 1999).

Formal leaders can shape knowledge needs, but informal learning leaders will shape the particular focus and pace of learning (Coburn, 2001). As King and Newmann (2000) pointed out, teachers learn more when they have control over the content and the process for learning. The study results indicate that teachers, working and learning
together with other teachers in a community of practice, more often departed from traditional practice and made standards-based changes to instruction. Struggling to make sense of the complexities surrounding implementation of standards-based practices, they found support within their communities of practice. While impossible to detect empirically in this study, it is likely that informal learning leadership of teachers relates directly to the effectiveness of teachers’ community participation.

Research increasingly documents the informal learning leadership of teachers (Coburn, 2001; Grossman et al., 2001). Over the last decade, new approaches to teacher leadership have concentrated on the social influence process through which teachers lead others to engage in beneficial activities rather than looking for teacher leadership only in formal roles (Smylie, et al., 2002; Yukl, 1998). Specific instances of this social influence process include teachers doing research, leading teams, or functioning as part of a distributed leadership network. Each of these approaches is consistent with the work teachers in productive communities of practice might do.

**Formal and Informal Leadership Together.** Can department chairs and high school teachers forge an effective leadership balance? Department chairs face a dilemma. As fully-participating, veteran members of a departmental community of practice, department chairs have valuable experience to bring to discussions about substantive changes in instruction. If they remain in their instructional leadership role—the person who facilitated teachers’ participation in the community of practice and the person who upholds disciplinary standards—strong departmental leaders can constrain the learning work of the community and the emergence of teachers as professionals (Goldberg, 1996). If the learning work of the community is to involve honest inquiry,
department chairs may have to step outside of their formal roles and participate as equal members of departmental communities of practice. In a sense, they need to create a leadership space within which teacher learning leadership can emerge. This is not an easy matter to accomplish.

Implications for Practice, Policy, and Research

Instructional improvement, as the result of the No Child Left Behind Act of 2001 (2002), has become a matter of national urgency. The results of this study indicate that, despite the best intentions of teachers and administrators, instructional improvement will not result from short-term strategies that leave unexamined the systemic forces that affect the ways in which teachers work together and that ultimately find their way into teachers' classrooms in the form of instruction (McLaughlin & Talbert, 2001). These findings have clear implications for teachers, school leaders, policymakers, and researchers.

Implications for Teachers

High school teachers operate most frequently within their own "realm of knowledge," the subject department, where they are understood and where they find answers to problems they encounter in their work with students (Siskin, 1994). The research presented here indicates the benefit of interactions with teachers outside of one's own subject department. It is important that teachers understand the different subcultures in a typical high school and how the different ways of understanding knowledge, students, and instruction affect the purpose, activities, and social relationships of the communities of practice within the school. Knowledge of these paradigms can make
interactions involving members of different departments progress more smoothly. When teachers understand why perspectives different from their own are valued by others, they are more open to re-examining their own assumptions. Thus, the potential that they might learn something beneficial is greater.

Because communities of practice are acknowledged to have a range of organizational impacts, it is important that teachers appreciate the factors that distinguish teachers' community participation as productive. I make no claims that the factors I have identified — full participation and engagement with individuals throughout the school — are the only factors that might earn community membership this designation, but the benefits of teachers' taking a perspective wider than their own classrooms are clear.

In some measure, adopting this orientation requires that teachers take on additional responsibilities and expend greater effort in activities that pay dividends in terms of improved instruction and, potentially, increases in students' achievement. Exerting initiative individually and exercising social influence in the company of other teachers are forms of teacher leadership. As Wenger (1999) points out, internal leadership is integral to the productive contributions of communities of practice. Whether teachers realize it or not, they do exercise social influence within their communities of practice (Smylie, et al., 2002).

When teachers acknowledge their influence, own it by using it consciously, and keep student learning at the center of their negotiations, they emerge as leaders within the community. As teachers' learning efforts within their communities of practice cohere, and as these efforts are integrated across the school, a critical mass builds with potential to move the school forward in reforming its educational processes and increasing its
effectiveness. At such a stage, it would be fair to say that teacher leadership resides within teachers' communities of practice as much as it does in any individual.

Implications for School Leaders

Formal school leaders, both principals and department chairpersons, play an integral role in the development of productive communities of practice. That school leaders impact the instructional process—and by extension student learning—through teachers is not a new finding. However, the empirical results of this study, identifying two dynamics that might improve teacher quality, suggest areas where formal leaders might concentrate their attention. By encouraging teachers to participate fully in departmental or school activities and by facilitating broad interaction, within and across departments, department chairs and principals can increase the likelihood that teachers will learn in the course of their work and that the learning will enhance their knowledge, beliefs, and skills. Acting this way, formal leaders also encourage teachers to step forward in a leadership capacity among their community peers.

Results of this dissertation study indicate that teachers of remedial classes have fewer opportunities to learn through participation in communities of practice, and they are least likely to use innovative instructional practices. Remedial teachers, who generally have less incoming preparation than teachers assigned to other curricular tracks (Weiss et al., 1994), perhaps remain "stuck" in those courses for much of their career and don't have access to teaching opportunities that might help them develop better pedagogical skills (Siskin, 1994). School and departmental policies that involve all teachers in challenging tasks and that function to systematically develop teachers toward
those tasks can pay off in benefits to teachers' professional capabilities. For example, normative school expectations for collaboration and mentorship encourage such participation and can increase learning opportunities across the school. Within a subject department, policies that establish a course rotation and a process for preparing teachers for new assignments would also enhance the learning within the community of practice.

The study findings suggest that the definition of a strong departmental leader might differ depending on the intention of the leadership influence. The leadership effects detailed earlier in the chapter indicate that strong departmental leaders who establish goals through consultation with teachers, communicate progress toward those goals, and encourage and support teachers as they continue in that work, can facilitate steady, incremental instructional improvement.

To effectively influence substantial changes in instruction, however, it is possible that the department chair might have to abandon his or her formal role, encourage inquiry into disciplinary paradigms, and join as an equal member of the community of practice if the community is to challenge long-held institutionalized notions of instruction. This finding underscores the ambiguity department chairs experience, and identifies a specific source of tension. Learning work is directly in conflict with the legitimating function of their strong leadership role. When the instructional work calls for innovation or reorienting teachers' beliefs or technologies, department chairs might not be able to support or engage in the learning work without consciously and publicly changing their leadership posture. The study results add to an understanding of the difficulty chairs face, knowing that they live out a delicate balancing act without, perhaps, understanding

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exactly why. This study makes a contribution to an understanding of both the benefit of department chairpersons and of certain challenges inherent in the position.

School leaders need to recognize that communities of practice can stall progress as much as they can initiate it. The paradoxical ability of communities to stabilize at the same time as they adapt means that change will occur only incrementally and will move forward irregularly (Bidwell, 2001). While in most cases school leaders will appreciate that the tendency toward stability maintains school legitimacy, certain principals interested in quick and dramatic change can be frustrated by the difficulty in overcoming institutionalized norms. Understanding the part communities of practice play in this change and the factors that can enhance innovation will help leaders plan more effectively and more realistically.

The study counters the notion that traditional forms of professional development serve no purpose. Rather, the results indicate that school-based development programs increase the likelihood that teachers will participate in productive communities of practice. Teachers who take part in development programs and who attend college courses report enhanced competence and try innovative instructional methods. It is important that school leaders recognize the value of these development processes working in conjunction with the social learning that occurs among teachers within communities of practice. Access to new ideas and to outside expertise is a critical component of job-embedded learning.
Implications for Policymakers

Policymakers can also benefit from understanding the part teachers’ communities of practice play in improving teacher quality and in implementing new policy initiatives. Focusing on learning within productive communities of practice appears to be an effective strategy for increasing mathematics and science teachers’ knowledge base, their ability and willingness to adapt instruction to ensure student learning, and their use of student-centered instructional techniques as advocated in national disciplinary standards. The study also shows that these expectations for improvement should not be overly optimistic. Communities of practice are embedded within a school system and within an institutional context, elements of which impact the social learning of the community. Within any policy initiative relating to teachers’ work, each of these elements – for example, departmental leadership and subject paradigms – needs to be addressed.

Policymakers, similar to school leaders, can use their understanding of the incremental nature of change to maintain support for policy initiatives for extended periods of time. For instance, many state accountability frameworks have very short time horizons in which change is expected. Understanding the stability-adaptability paradox inherent in communities of practice makes clear that expecting dramatic change in a short period of time is unrealistic.

Those who direct teacher and administrator preparation programs might incorporate knowledge about communities of practice into their curricula. Teachers need to enter the profession understanding the different conceptual and operational contexts they will encounter in interaction with other teachers outside of their own areas, and they need to appreciate the valuable experiences represented by those interactions. Further.
they need to understand why they should be encouraged (even expected) to adopt a schoolwide, rather than classroom, focus. Understanding the dynamics of communities of practice will allow school administrators to support teacher learning rather than constrain it, and to draw forth the leadership potential of teachers, especially necessary to bring about innovative and responsive instruction.

**Implications for Researchers**

Findings from a growing body of research on teachers' communities lend credence to the idea that research into schools as organizations should account for the influences of informal collegial networks of teachers (Bidwell, 2001). Viewing high schools as singular units rather than as a "constellation" of teachers' communities of practice oversimplifies reality in light of evidence that shows distinct differences in the purpose, values, and social relations of these subgroups (McLaughlin & Talbert, 2001).

Qualitative researchers have begun to document the processes of negotiation that occur within communities of practice (Coburn, 2001, Grossman et al., 2001), and quantitative researchers are building a body of research estimating the effects of teachers' collegial groups on both teachers and students. This dissertation adds to that growing knowledge base, but this work is still in its beginning stages.

Most of the research includes a focus on mathematics teachers because the conceptual and operational contexts of mathematics instruction differ greatly from those of other disciplines. Many studies contrast mathematics teachers with English, social studies, or science teachers (as the current study does). Research that presents a more complete picture of high schools would be welcome, though I acknowledge the time and
expense such work would entail. The cumulative work of various researchers will contribute to a more complete understanding of how teachers in different subgroups, in different departments, and in different school contexts come to understand their situations. However, a national high school database with data sufficient for hierarchical analysis of teachers nested within departments, nested within schools would provide for more accurate investigations of the factors that contribute, ultimately, to differences in teachers' job-embedded learning. Given the importance of teacher quality to success for all students, such research is essential.

Until such data are available, independent quantitative researchers can design their studies to account for teachers' communities of practice to the extent possible. While much of the extant research considers subject departments to be the likely site for the most salient community of practice, future studies might investigate teams, cross-disciplinary groups, and groups related to curricular track as important communities of practice. Studies of this nature might also consider teachers' membership in multiple communities of practice to determine effects of such interaction on the quality of teachers' worklives, on teachers' beliefs and skills, and ultimately, on student achievement.

Qualitative researchers should continue their examination of the processes of social learning within communities of practice, perhaps guided by the dual tensions which serve to hold the community in check at the same time they encourage it to change (Wenger, 1998). I plan to pursue a research agenda examining the complex leadership influences this dissertation study identified.
Conclusion

Improving the quality of teachers in the nation’s schools is a keystone to educational reform. To most effectively improve teachers’ knowledge, dispositions, and skills, professional development efforts should capitalize on the natural process of social learning that takes place among teachers in their communities of practice.

Acknowledged or not, teachers everywhere are members of communities of practice. The impact of these communities on schools varies dramatically. Some communities enhance teachers’ capabilities and bring beneficial knowledge to schools, while others serve to keep teachers chained to long held and unchallenged assumptions and mired in staid educational programs.

Advocating strongly that communities of practice are the optimal site for teacher learning, I have proposed that the productivity of community membership depends on two factors. The first factor is the extent of teachers’ legitimate participation in activities valued by the community of practice. The second factor concerns the span of teachers’ engagement – whether they interact only with teachers in their subject department or whether they interact broadly with colleagues throughout the school. In schools where participation and interaction are high, communities of practice represent a rich web of relationships that can support productive change efforts. Teachers experience learning that improves their instruction, they feel able and responsible to adjust their instruction for student needs, and they report greater use of student-centered, problem-based instructional techniques.

The increases in teachers’ professional outcomes represent the adaptive capacity of communities of practice. Because of the dynamics involved in social learning,
communities of practice have an equal tendency toward stability. In schools, these
tendencies continually reproduce commonly held understandings of schools as
institutions, manifest in the organization of instruction by different academic subjects and
curricular tracks. Without deliberate will on the part of teachers and formal leaders to
open these understandings to scrutiny, the collective learning of a community of practice
will not bring about change.

Supported by opportunities for broad interaction, by access to information and
expertise, and by encouragement for continuing work, the capacity for communities of
practice to bring working, learning, and innovation together engenders a moderate sense
of optimism for schools, for teachers, and for students. The learning work of teachers in
their communities is complex, and research into understanding its rich dynamics has only
begun. It is an area of inquiry that holds much promise for the future.
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### APPENDIX A

**TEACHING ASSIGNMENT DISTRIBUTION METHOD BY SUBJECT AND CURRICULAR TRACK**

Teaching Assignment by Subject

<table>
<thead>
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<th>Science</th>
<th>Mathematics</th>
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<tr>
<td>Assignment</td>
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<td>49%</td>
</tr>
<tr>
<td>Expertise</td>
<td>58%</td>
<td>27%</td>
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<tr>
<td>Decision</td>
<td>14%</td>
<td>22%</td>
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<tr>
<td>Rotation</td>
<td>0%</td>
<td>0%</td>
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</table>

Teaching Assignment by Curricular Track

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<th></th>
<th>Academic</th>
<th>General/Vocational</th>
<th>Remedial</th>
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<tr>
<td>Assignment</td>
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<td>47%</td>
<td>57%</td>
</tr>
<tr>
<td>Expertise</td>
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<td>29%</td>
<td>18%</td>
</tr>
<tr>
<td>Decision</td>
<td>17%</td>
<td>21%</td>
<td>22%</td>
</tr>
<tr>
<td>Rotation</td>
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<td>3%</td>
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</tbody>
</table>
APPENDIX B

CONSTRUCTION OF RASCH MEASURES FOR ANALYSIS

Dependent Variables

COMMUNITIES OF PRACTICE: The index is constructed by summing three Rasch scales. The scales include Mutual Engagement, Joint Enterprise, and Shared Repertoire.

*Mutual Engagement:* A Rasch scale comprised of ten items

<table>
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<tr>
<th>Item</th>
<th>Difficulty</th>
<th>Infit Mean Square</th>
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<tr>
<td>Time spent with teachers outside of the department</td>
<td>1.52</td>
<td>1.23</td>
</tr>
<tr>
<td>R discusses testing procedures with teachers</td>
<td>1.05</td>
<td>1.00</td>
</tr>
<tr>
<td>R discusses curriculum with teachers outside dept.</td>
<td>.86</td>
<td>1.03</td>
</tr>
<tr>
<td>R discusses curriculum with teachers outside the school</td>
<td>.63</td>
<td>1.09</td>
</tr>
<tr>
<td>Time spent with teachers in the department</td>
<td>.43</td>
<td>1.09</td>
</tr>
<tr>
<td>R discusses new instructional techniques with teachers</td>
<td>.37</td>
<td>.84</td>
</tr>
<tr>
<td>R discusses curriculum for a course with teachers</td>
<td>-.02</td>
<td>.79</td>
</tr>
<tr>
<td>R discusses subject area curriculum with teachers</td>
<td>-.20</td>
<td>.75</td>
</tr>
<tr>
<td>R discusses student performance with teachers in dept.</td>
<td>-1.33</td>
<td>1.04</td>
</tr>
<tr>
<td>R discusses curriculum with teachers in the department</td>
<td>-3.45</td>
<td>.87</td>
</tr>
</tbody>
</table>

*Joint Enterprise:* A Rasch scale with five component items

<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty</th>
<th>Infit Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is agreement among faculty about mission</td>
<td>.98</td>
<td>1.11</td>
</tr>
<tr>
<td>Teachers in the department continuously learn</td>
<td>-.09</td>
<td>.84</td>
</tr>
<tr>
<td>Goals and priorities in department are clear</td>
<td>-.09</td>
<td>.88</td>
</tr>
<tr>
<td>Teachers in the department share beliefs/mission</td>
<td>-.33</td>
<td>.67</td>
</tr>
<tr>
<td>R encouraged to experiment with teaching</td>
<td>-.47</td>
<td>1.44</td>
</tr>
</tbody>
</table>

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**Shared Repertoire: A Rasch scale with eight component items**

<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty</th>
<th>Infit Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>R coordinates content with teachers outside department</td>
<td>1.36</td>
<td>.98</td>
</tr>
<tr>
<td>R takes part in schoolwide curriculum committee</td>
<td>1.22</td>
<td>1.07</td>
</tr>
<tr>
<td>R takes part in non-curricular school committees</td>
<td>.15</td>
<td>1.18</td>
</tr>
<tr>
<td>R takes part in department curriculum committee</td>
<td>.08</td>
<td>1.00</td>
</tr>
<tr>
<td>R familiar with the content of others' courses</td>
<td>.41</td>
<td>.97</td>
</tr>
<tr>
<td>Grading practices are consistent and fair</td>
<td>-.42</td>
<td>.77</td>
</tr>
<tr>
<td>R coordinates course with department teachers</td>
<td>-.78</td>
<td>.91</td>
</tr>
<tr>
<td>There is as cooperative effort among staff</td>
<td>-1.20</td>
<td>1.08</td>
</tr>
</tbody>
</table>

**TEACHER LEARNING: A Rasch scale comprised of five items**

<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty</th>
<th>Infit Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers out of department improved R’s teaching</td>
<td>.61</td>
<td>1.00</td>
</tr>
<tr>
<td>Other administrator improved R’s teaching</td>
<td>.54</td>
<td>.85</td>
</tr>
<tr>
<td>Principal improved R’s teaching</td>
<td>.49</td>
<td>.99</td>
</tr>
<tr>
<td>Department chair improved R’s teaching</td>
<td>-.48</td>
<td>1.14</td>
</tr>
<tr>
<td>Teachers in department improved R’s teaching</td>
<td>-1.15</td>
<td>1.05</td>
</tr>
</tbody>
</table>

**TEACHER COMPETENCE: A Rasch scale with six component items**

<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty</th>
<th>Infit Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>R can get through to difficult students</td>
<td>1.29</td>
<td>1.06</td>
</tr>
<tr>
<td>R changes approach if students are not doing well</td>
<td>.56</td>
<td>.96</td>
</tr>
<tr>
<td>Different teaching methods can affect achievement</td>
<td>-.15</td>
<td>.79</td>
</tr>
<tr>
<td>R responsible to prevent dropouts</td>
<td>-.21</td>
<td>1.09</td>
</tr>
<tr>
<td>R can do little to affect achievement (reversed)</td>
<td>-.67</td>
<td>1.06</td>
</tr>
<tr>
<td>R makes a difference in students’ lives</td>
<td>-.82</td>
<td>.96</td>
</tr>
</tbody>
</table>

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**Independent Variables**

**DEPARTMENTAL INSTRUCTIONAL LEADERSHIP:** A Rasch scale with six component items

<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty</th>
<th>Infit Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department chair carries out plans</td>
<td>1.09</td>
<td>.91</td>
</tr>
<tr>
<td>Department chair tells what is expected</td>
<td>.80</td>
<td>.91</td>
</tr>
<tr>
<td>Department chair consults before making decisions</td>
<td>-.16</td>
<td>1.17</td>
</tr>
<tr>
<td>Department chair gets resources</td>
<td>-.19</td>
<td>.97</td>
</tr>
<tr>
<td>Department chair is interested in innovation</td>
<td>-.56</td>
<td>1.06</td>
</tr>
<tr>
<td>Department chair is supportive</td>
<td>-.98</td>
<td>.89</td>
</tr>
</tbody>
</table>

**PRINCIPAL INSTRUCTIONAL LEADERSHIP:** A Rasch scale comprised of four items

<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty</th>
<th>Infit Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff recognized for a job well done</td>
<td>.59</td>
<td>1.15</td>
</tr>
<tr>
<td>Administrator knows problems of staff</td>
<td>.03</td>
<td>.78</td>
</tr>
<tr>
<td>Administrator deals with outside pressures</td>
<td>-.21</td>
<td>.94</td>
</tr>
<tr>
<td>Administrator communicates kind of school wanted</td>
<td>-.41</td>
<td>1.07</td>
</tr>
</tbody>
</table>
ORGANIC MANAGEMENT: The index is constructed by summing two Rasch scales, Teacher Control and Staff Cooperation.

**Teacher Control:** A Rasch scale comprised of nine items

<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty</th>
<th>Infit Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of influence over ability grouping of students</td>
<td>1.24</td>
<td>1.07</td>
</tr>
<tr>
<td>Degree of influence over discipline policy</td>
<td>1.13</td>
<td>.92</td>
</tr>
<tr>
<td>Degree of influence over inservice policy</td>
<td>.87</td>
<td>1.06</td>
</tr>
<tr>
<td>Degree of influence in establishing curriculum</td>
<td>.37</td>
<td>.92</td>
</tr>
<tr>
<td>Teachers’ control over texts and materials used</td>
<td>.25</td>
<td>.96</td>
</tr>
<tr>
<td>Teachers’ control over content taught</td>
<td>-.03</td>
<td>1.05</td>
</tr>
<tr>
<td>Teachers’ control over teaching techniques</td>
<td>-.54</td>
<td>1.06</td>
</tr>
<tr>
<td>Teachers’ control over disciplining students</td>
<td>-1.58</td>
<td>1.07</td>
</tr>
<tr>
<td>Teachers control over amount of homework</td>
<td>-1.71</td>
<td>1.32</td>
</tr>
</tbody>
</table>

**Staff Cooperation:** A Rasch scale constructed using fourteen items

<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty</th>
<th>Infit Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>This school seems like a big family</td>
<td>.65</td>
<td>.82</td>
</tr>
<tr>
<td>Teachers union and administration work together</td>
<td>.58</td>
<td>1.17</td>
</tr>
<tr>
<td>Principal consults staff before making decisions</td>
<td>.56</td>
<td>1.03</td>
</tr>
<tr>
<td>Staff members are recognized for a job well done</td>
<td>.47</td>
<td>1.00</td>
</tr>
<tr>
<td>Administration knows the problems faced by staff</td>
<td>.10</td>
<td>1.02</td>
</tr>
<tr>
<td>Broad agreement among faculty about mission</td>
<td>.03</td>
<td>.72</td>
</tr>
<tr>
<td>Principal interested in innovation and new ideas</td>
<td>-.06</td>
<td>.94</td>
</tr>
<tr>
<td>I am encouraged to experiment with my teaching</td>
<td>-.07</td>
<td>1.11</td>
</tr>
<tr>
<td>Teachers at this school are continuously learning</td>
<td>-.13</td>
<td>.76</td>
</tr>
<tr>
<td>Principal lets staff know what is expected of them</td>
<td>-.13</td>
<td>.84</td>
</tr>
<tr>
<td>Great deal of cooperative effort among staff</td>
<td>-.23</td>
<td>.78</td>
</tr>
<tr>
<td>Can usually count on staff members to help out</td>
<td>-.50</td>
<td>1.26</td>
</tr>
<tr>
<td>R familiar with content of other courses in dept.</td>
<td>-.54</td>
<td>1.44</td>
</tr>
<tr>
<td>Colleagues share beliefs about school’s mission</td>
<td>-.74</td>
<td>1.10</td>
</tr>
</tbody>
</table>
APPENDIX C

VARIATION IN TEACHERS' RESPONSES BY SUBJECT
AND CURRICULAR TRACK

<table>
<thead>
<tr>
<th>Subject</th>
<th>Mathematics Teachers N=1623</th>
<th>Science Teachers N=1095</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mutual Engagement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time spent with teachers outside of department</td>
<td>2.39***</td>
<td>2.26</td>
</tr>
<tr>
<td>R discusses testing procedures with teachers b</td>
<td>2.06***</td>
<td>1.91</td>
</tr>
<tr>
<td>R discusses curriculum with teachers outside dept. c</td>
<td>.55</td>
<td>.52</td>
</tr>
<tr>
<td>R discusses curriculum with teachers outside school c</td>
<td>.61**</td>
<td>.55</td>
</tr>
<tr>
<td>Time spent with teachers in the department</td>
<td>2.75***</td>
<td>2.61</td>
</tr>
<tr>
<td>R discusses new instructional techniques with teachers b</td>
<td>2.15</td>
<td>2.13</td>
</tr>
<tr>
<td>R discusses student performance with teachers outside dept. c</td>
<td>.68</td>
<td>.66</td>
</tr>
<tr>
<td>R discusses curriculum for a course with teachers b</td>
<td>2.27***</td>
<td>2.15</td>
</tr>
<tr>
<td>R discusses subject area curriculum with teachers b</td>
<td>2.29***</td>
<td>2.21</td>
</tr>
<tr>
<td>R discusses student performance with teachers in dept. c</td>
<td>.89*</td>
<td>.85</td>
</tr>
<tr>
<td>R discusses curriculum with teachers in the dept. c</td>
<td>.98***</td>
<td>.96</td>
</tr>
<tr>
<td><strong>Shared Repertoire</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R coordinates course with teachers outside department a</td>
<td>2.18*</td>
<td>2.11</td>
</tr>
<tr>
<td>R takes part in schoolwide curriculum committee c</td>
<td>.32</td>
<td>.35*</td>
</tr>
<tr>
<td>R takes part in non-curricular committee c</td>
<td>.52</td>
<td>.55</td>
</tr>
<tr>
<td>R takes part in department curriculum committee c</td>
<td>.57*</td>
<td>.52</td>
</tr>
<tr>
<td>R familiar with content of others' courses a</td>
<td>2.91***</td>
<td>2.71</td>
</tr>
<tr>
<td>Grading practices are consistent and fair a</td>
<td>2.83</td>
<td>2.80</td>
</tr>
<tr>
<td>R coordinates course with teachers in department a</td>
<td>3.09***</td>
<td>2.73</td>
</tr>
<tr>
<td>There is a cooperative effort among staff a</td>
<td>3.12***</td>
<td>3.03</td>
</tr>
<tr>
<td><strong>Joint Enterprise</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is agreement among faculty about mission a</td>
<td>2.80*</td>
<td>2.74</td>
</tr>
<tr>
<td>Teachers in the department continuously learn a</td>
<td>2.99</td>
<td>3.07**</td>
</tr>
<tr>
<td>Goals and priorities in department are clear a</td>
<td>3.09***</td>
<td>2.93</td>
</tr>
<tr>
<td>Teachers in the department share beliefs/mission a</td>
<td>3.08</td>
<td>3.08</td>
</tr>
<tr>
<td>R encouraged to experiment with teaching a</td>
<td>3.10</td>
<td>3.11</td>
</tr>
</tbody>
</table>

*a* range of variable is 1-4

b range of variable is 1-3

c range of variable is 0-1

*** p<.001; ** p<.010; * p<.050
<table>
<thead>
<tr>
<th>Curricular Track</th>
<th>Academic N=1659</th>
<th>General/Vocational N=943</th>
<th>Remedial N=116</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mutual Engagement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time spent with teachers outside of department</td>
<td>2.32</td>
<td>2.36</td>
<td>2.43</td>
</tr>
<tr>
<td>R discusses testing procedures with teachers</td>
<td>2.02*</td>
<td>1.97</td>
<td>1.95</td>
</tr>
<tr>
<td>R discusses curriculum with teachers outside dept.</td>
<td>.55</td>
<td>.52</td>
<td>.55</td>
</tr>
<tr>
<td>R discusses curriculum outside school</td>
<td>.61***</td>
<td>.55</td>
<td>.47</td>
</tr>
<tr>
<td>Time spent with teachers in the department</td>
<td>2.74***</td>
<td>2.62</td>
<td>2.67</td>
</tr>
<tr>
<td>R discusses new instructional techniques with teachers</td>
<td>2.17***</td>
<td>2.11</td>
<td>1.99</td>
</tr>
<tr>
<td>R discusses student performance with teachers outside</td>
<td>.68</td>
<td>.67</td>
<td>.65</td>
</tr>
<tr>
<td>dept.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R discusses curriculum for a course with teachers</td>
<td>2.26***</td>
<td>2.17</td>
<td>2.06</td>
</tr>
<tr>
<td>R discusses subject area curriculum with teachers</td>
<td>2.30***</td>
<td>2.20</td>
<td>2.11</td>
</tr>
<tr>
<td>R discusses student performance with teachers in dept.</td>
<td>.87</td>
<td>.86</td>
<td>.84</td>
</tr>
<tr>
<td>R discusses curriculum with teachers in the dept.</td>
<td>.98</td>
<td>.97</td>
<td>.96</td>
</tr>
<tr>
<td><strong>Shared Repertoire</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R coordinates course with teachers outside department</td>
<td>2.17</td>
<td>2.13</td>
<td>2.17</td>
</tr>
<tr>
<td>R takes part in schoolwide curriculum committee</td>
<td>.35</td>
<td>.31</td>
<td>.28</td>
</tr>
<tr>
<td>R takes part in non-curricular committee</td>
<td>.56**</td>
<td>.50</td>
<td>.49</td>
</tr>
<tr>
<td>R takes part in department curriculum committee</td>
<td>.56</td>
<td>.53</td>
<td>.53</td>
</tr>
<tr>
<td>R familiar with content of others' courses</td>
<td>2.85</td>
<td>2.79</td>
<td>2.76</td>
</tr>
<tr>
<td>Grading practices are consistent and fair</td>
<td>2.83</td>
<td>2.79</td>
<td>2.95*</td>
</tr>
<tr>
<td>R coordinates course with teachers in department</td>
<td>3.00***</td>
<td>2.87</td>
<td>2.87</td>
</tr>
<tr>
<td>There is a cooperative effort among staff</td>
<td>3.09</td>
<td>3.06</td>
<td>3.17</td>
</tr>
<tr>
<td><strong>Joint Enterprise</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is agreement among faculty about mission</td>
<td>2.78</td>
<td>2.76</td>
<td>2.86</td>
</tr>
<tr>
<td>Teachers in the department continuously learn</td>
<td>3.02</td>
<td>3.02</td>
<td>3.11</td>
</tr>
<tr>
<td>Goals and priorities in department are clear</td>
<td>3.02</td>
<td>3.01</td>
<td>3.14</td>
</tr>
<tr>
<td>Teachers in the department share beliefs/mission</td>
<td>3.09</td>
<td>3.05</td>
<td>3.15</td>
</tr>
<tr>
<td>R encouraged to experiment with teaching</td>
<td>3.13</td>
<td>3.04</td>
<td>3.18**</td>
</tr>
</tbody>
</table>

*a range of variable is 1-4   *** p<.001; ** p<.01; * p<.05
*b range of variable is 1-3
*c range of variable is 0-1

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