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The Mathematics Excellence Partnership: Developing Professional Learning Communities

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Abstract

The Mathematics Excellence Partnership project was a professional development project aimed at supporting the development of 22 high school teachers of mathematics, including special education and bilingual teachers. In this paper, we share our school-based, bottom-up, collaborative design that supported the development of professional learning communities.

Achieving fundamental changes in teachers' content knowledge and instructional practices that influence student learning and performance requires new approaches to professional development (Bay-Williams, Scott, & Hancock, 2007; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Desimone, 2009; McLaughlin & Talbert, 2006). These new approaches entail more complex strategies that go beyond one-day professional development in which an expert in the field provides a workshop on a particular topic. Instead, these professional development approaches should be teacher-driven and shared collectively by all stakeholders. Key characteristics of effective professional development include, but are not limited to: a commitment to content and standards, such as the National Council of Teachers of Mathematics' (NCTM) *Principles and Standards for School Mathematics* (2000) and more recently the *Common Core State Standards for Mathematics* (Common Core State Standards Initiative [CCSSI], 2010); the use of assessment data to ascertain relevant learning and pedagogical actions; professional activities that span over time; and adequate time for teachers to engage in professional activities. Regardless of the design of the professional development, the goal is assurance that *all* students learn mathematics.

Toward meeting this goal, Loucks-Horsley, Stiles, Mundry, Love, and Hewson (2010) argued, "When a school community has a shared commitment to high standards for all students, it is better prepared to take an honest look at student learning data and is more likely to experience dissatisfaction with results that fall short of its commitments, rather than complacency, resignation or defensiveness" (p. 34). Therefore, to foster among teachers a level of shared commitment to high standards, a professional learning community is needed to provide learning opportunities that benefit, support, and sustain teacher development and student learning overtime. According to Fullan (2005), sustaining teacher development in such a collaborative culture requires building a collective competence that "is the daily habit of *working together*, and you can't learn this from a workshop or course. You need to learn it by doing it and getting better at it on purpose" (p. 69). In the mathematics education community, *doing it and getting better* involves a major focus on advancing teachers' pedagogical practices by targeting particular mathematical content knowledge (Cohen & Hill, 2001; Hill & Ball, 2004). Consequently, the context for this aspect of development necessitates positioning "teachers' knowledge, build[ing] on their questions, and help[ing] and support[ing] them

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in evaluating their beliefs, and sometimes changing deeply embedded behaviors" (Weinbaum et al., 2004, p. 17).

The purpose of this paper is to report on a university-school partnership that provided professional development opportunities and implemented activities for enhancement of mathematics teaching while establishing a culture of collaboration. Specifically, we will give attention to our actions that supported the development of professional learning communities. We begin by presenting related literature reflective of the perspective that to foster positive collaborative work "flexible and alternative methods for continuing education and self-improvement [should be] instituted to support ongoing learning of mathematics and mathematics education" (NCTM, 1991, p. 184). Next, we describe the professional development project, including the school context. This discussion provides some sense of how the professional development partnership involved a bottom-up collaborative approach in which the participating teachers took the lead in constructing their own professional learning activities.

Related Literature

A Vision for Professional Learning

In 1991, NCTM asserted that teachers needed to demonstrate "the value of mathematics as a way of thinking and its application in other disciplines and in society" (p. 104). Recent research in mathematics education reform suggests that embedded in this assertion is the mathematical idea that learning "is not merely accumulating facts and information but also a way of shaping our beliefs, ideas and lives" (Boaler, 2010, p. 1). It is a way of helping students and teachers think about mathematical sense making and reasoning that moves them beyond the historical stance in which students ingest considerable amounts of mathematics facts, and yet experience difficulty applying this information to new and more practical situations (Beswick & Dole, 2001; Boaler, 2008; Mansilla & Gardner, 2008).

Despite these reform messages, a succession of research studies suggests that pedagogical practices continue to follow a traditional path: the teacher checks homework, demonstrates problems for new skills, and assigns students a series of similar problems from the mathematics textbook. In this familiar scenario, the teacher seldom focuses on developing the underlying conceptual features of problems solved by students (Hiebert et al., 2003; Rowan, Harrison, & Haynes, 2004; Weiss, Pasley, Smith, Banilower, & Heck, 2003) "Today, the information revolution and the ubiquity of search engines have rendered *having* information much less valuable than *knowing how to think* with information in novel situations" (Mansilla & Gardner, 2008, p. 19, italics added). To support students' thinking in novel situations, teachers must provide meaningful contexts in which students may utilize their previous knowledge and acquire new knowledge. In this context, the mathematics is experienced in a dynamic way, a more fluid body of knowledge that allows for reaching conclusions and solving problems using a variety of methods and approaches (Mansilla & Gardner, 2008; NCTM, 2000).

Research has demonstrated that these classrooms, which embody problem solving and collaborative grouping, tend to have positive effects on students' mathematical disposition and learning (Boaler, 2008, 2010; Steffero, 2010). Fundamental to this finding is the notion that problem solving and collaborative work need to engage teachers and their students in a rigorous intellectual process in which making sense of mathematics content is pertinent to their lives. "Teaching mathematics requires an appreciation of mathematical reasoning, understanding the meaning of mathematical ideas and procedures, and knowing how ideas and procedures connect" (Hill & Ball, 2004, p. 331). An essential way to influence the teaching of mathematics in classrooms is through quality professional development activities, which focus on mathematical knowledge for teaching (Hill & Ball, 2004). Furthermore, in order to develop the pedagogical skills necessary to convey mathematics in this way, teachers need professional development experiences that will provide them exposure to learning mathematics in this manner.

The Role of Professional Development in Developing Mathematical Knowledge

The most compelling argument for providing teachers with professional development experiences in which the focal point is mathematical knowledge for teaching is highlighted in research by Silver (2003), Sowder (2007), and Supovitz and Turner (2000). A valuable presumption from this research is that effective professional development may influence teachers' understanding of content and subsequent pedagogical practices. Sowder (2007) stated, "Professional development provides an opportunity for teachers to learn more mathematics, even when the focus is on student thinking or curriculum or classroom events" (p. 163). Further, professional development should involve reform-oriented activities and standards (Garet, Porter,

Desimore, Birman, & Yoon, 2001). In a report on the status of professional development in the U.S. and abroad, Darling-Hammond and her colleagues (2009) summarized the available research, revealing two key findings that were relevant to the project presented in this paper. First, "sustained and intensive professional development for teachers is related to student achievement gains" (p. 5). Second, "effective professional development is intensive, ongoing, and connected to practice; [focusing] on the teaching and learning of specific academic content" (p. 5). Such is the premise of professional learning communities, which may be the best way to attain truly momentous, broad range progress in teaching and learning (DuFour, Eaker, & DuFour, 2005).

The Professional Learning Community

Emerging from the literature are two relevant claims regarding professional learning communities. First, the hallmark of a professional learning community is the focus on learning, collaboration, and accountability (Banilower, Boyd, Pasley, & Weiss 2006; Darling-Hammond et al., 2009; DuFour, 2004; DuFour et al., 2005; Sparks, 2005; Sowder, 2007). With the support of their school leaders, teachers learn to work collaboratively through professional learning communities to advance pedagogical practices, improve student learning and performance, and hold themselves responsible for learning outcomes. These features require members of the learning community to organize their learning around three essential elements: what students need to learn, what indicators suggest that students have learned, and how to address the needs of students who are struggling to learn (DuFour, 2004). This argument is consistent with NCTM's Teaching Principle (2000) that states, "Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well" (p. 16). Moreover, as teachers embark upon attending to these features, they need to work as a group, developing an understanding of the importance of sharing and researching ideas, activities, and materials. Senge et al. (2000) offered this abridgment, suggesting, "A strong professional community encourages collective endeavor rather than isolate efforts" (p. 327).

A second claim emerging from the literature on professional learning communities is when professional activities are developed around subject matter chosen by teachers and last over a long period of time then the community's activities are more likely to be carried out by the teachers in their classrooms (Darling-Hammond et al., 2009; Graham, 2007). Darling-Hammond and colleagues' examination of research on teachers' professional relationships suggested that "schools where teachers were relatively more involved in educational decision-making [and were granted] blocks of time to meet and plan courses and assignments together" (p. 11) were more successful at their teaching and at solving problems of practice, thus providing evidence of the potential impact of professional learning communities.

The Mathematics Excellence Partnership

The *Mathematics Excellence Partnership* (MEP) involved a professional learning community undertaken by a university and Hayfield High School (HHS), which utilized a school-based, bottom-up, collaborative design focusing on mathematics curricula and student learning. In this section, we present the theoretical framework that informed the project, an overview of the project and its activities, a description of the school context, and a description of our development of a shared vision among project partners.

Theoretical Framework

Two theoretical perspectives served to inform our work: sociocultural practices and cognitive and social development. First, the professional development context for this work utilized sociocultural practices as originally advocated by Vygotsky (1978, 1994) and later by the work of Davydov (1990, 1995), Goos (1999), Kozulin (1998), and Wells (1999). Their research suggests that social practices need to be developed to engage learners, teachers, and students in activities that not only promote knowledge acquisition, but also to engage them in activities that further their intellectual development. Therefore, during the professional development sessions, opportunities were provided for social interaction aimed to benefit the teachers' goals and objectives about what they deemed as effective for improving their learning and understanding (e.g., developing a deeper knowledge-base of slope and improving student learning and performance on that concept).

Second, research supports the idea that collaborative group work influences cognitive and social development (Cohen, 1994; Jennings & Di, 1996). Research further illustrates that teachers' knowledge and classroom practices are readily influenced by professional development that focuses on content knowledge and active learning (Cohen & Hill, 2001; DuFour et al., 2005; Garet et al., 2001; Hill, 2004).

Thus, critical to the process of establishing a professional learning community at HHS was the employment of group dynamics that fostered interdependence, promoted shared commitment, and incorporated activities and discussions that sustained inquiry and debate (Cohen, 1994; Osana & Folger, 2000). The idea was to provide a professional learning community at the school level that subsequently influenced what happened in the classroom.

Professional Development Context

The Mathematics Excellence Partnership took a multidimensional approach in order to develop and hone a successful university-school collaboration. A major goal of the partnership was for a local university to collaborate with HHS's mathematics teachers and administrators to improve pedagogical practices and student performance. More specifically, this project aimed to achieve three important outcomes: to increase students' performance on the Comprehensive Assessment System exam (CAS) by targeting the mathematics disposition of the teachers and their students; to increase the number of students taking honors-level mathematics courses in grades 9–11; and to increase the number of students taking AP Calculus. In its collaborative role with HHS, the university faculty members monitored student progress, contributed ideas and classroom resources, and provided research-based insights when changes were needed or requested by the participating teachers.

The professional development activities consisted of three different types of sessions conducted over a four-year period: monthly sessions, biweekly sessions, and summer institutes. The monthly sessions and summer institutes involved all 22 mathematics teachers of grades 9-12 at HHS, including special and bilingual educators. These monthly sessions covered general mathematical topics that cut across the various content strands, from developing algebraic thinking to understanding practical applications of Calculus. The biweekly sessions involved a group of six core teachers who taught honors sections and AP classes. These core teachers convened for two hours per session to discuss and develop activities that would improve the teaching and learning of mathematics for high-performing students. The monthly and biweekly sessions were activities suggested by the collective group of teachers based on their perceptions of their pedagogical practices and needs. The summer institute consisted of a three-day mathematics and technology-based seminar, which included some general pedagogical topics such as classroom management and collaborative grouping. Often, the institute seminars were completed in collaboration with the district's instructional technology department and the university business school, as well as the university mathematics department. The summer institute sessions were driven by suggestions from the teachers, the project's collaborators (see Table 1), and the school district technology support specialists.

Table 1. Overview of Project Collaborators and their Contributions

Collaborators	Contributions
School of Management (SOM)	SOM finance and operations faculty instructed HHS teachers in uses of mathematics in business during the Summer Institute. Sessions included investing in stocks, real-world business problems that involved linear programming, and financial applications.
School of Arts and Sciences Mathematics Department	The faculty members provided expertise as advisors to the Partnership and were instructors during the Summer Institutes. Sessions focusing on hands-on geometry and advanced number sense were a popular request of HHS teachers.
Undergraduate Mentors	Students of color from the School of Management mentors assisted honors-level mathematics teachers in teaching and motivating HHS students throughout the school year. Mentors played a role in improving students' attitudes toward mathematics and understanding its connection to business. Mentors assisted in the after school program to provide homework help in mathematics, other subjects, and SAT Prep.
Project GEARUp	Graduate Assistants and mentors worked with the students throughout the year as well as in the after school program tutoring and assisting students with mathematics homework and SAT Prep.
School District's Office of Instructional Technology	The Office of Instructional Technology provided technological assistant to the teachers during the academic year as well as during the Summer Institutes, focusing on a district-wide initiative to integrate technology into mathematics.

Appendix A presents selected examples of the professional development activities in which the teachers participated during the sessions. As illustrated in the appendix, the mathematical topics and activities fell into three broad categories: analysis of assessment data, mathematics content, and pedagogical activities, both general and content specific.

School Context

HHS is an accredited public secondary school in an urban area and noted for having earned awards and recognition from state and national organizations. One of these acknowledgments was the Bronze Medal for "America's Best High Schools" ranking from *U.S. News & World Reports*. During the course of our project, the student body consisted of 1200 students, as well as 110 staff members, 80 of whom were teachers. Of the students, 42% were African American, 46% were Latino, 6% were Caucasian, 6% were of Asian descent, and about 1% was of Native American descent. The staff had very different demographics, as almost 66% of them were Caucasian. The remaining staff consisted of 18% African Americans, 15% Latinos, and 2% Asian Americans. Approximately 18% of the students were enrolled in special education, while 12% received bilingual education.

The *No Child Left Behind Act* of 2001 (NCLB, 2002) required that all schools make *adequate yearly progress* (AYP) towards all students becoming proficient in the core subject areas of English/Language Arts (ELA) and mathematics. At the time of this project, HHS had recently achieved a *Performance Rating* of "High" in ELA and "Moderate" in mathematics as well as an overall *School Improvement Rating* of "On Target" with the school's Restructuring Status goals.

During the course of the project, HHS subdivided into three small learning communities in order to provide more personalized attention to its students. Within this structure, the school operated on block scheduling and offered six Advanced Placement (AP) courses. Preparation for the CAS, the state's graduation proficiency assessment, and for the SAT was offered after school through various tutoring programs. In order to further prepare students for college and future careers, the school offered academic pathways in business and technology, health professions, media, arts and communication, law and government, and education.

Development of a Shared Vision

During the first phase of the project, we worked judiciously with HHS teachers and administrators to establish dialogue and a shared vision. This vision involved creating a professional learning community, which would support the teachers' aspirations for improving their knowledge of teaching mathematics that subsequently influences student learning and performance. This process consisted of identifying and combining the activities necessary to realize the vision, which included building credibility and trust, establishing benchmarks to target progress, recruiting college student mentors, and then identifying responsibilities. For the second phase of the project, we concentrated on the development of pedagogical content knowledge, and implementation of pedagogical strategies and techniques, which included the analysis of CAS performance data. A common thread throughout this process was the enhancement of a positive and more collaborative disposition or attitude toward mathematics teaching and learning. As effective practices and techniques emerged, whether they were centered on student performance or on successful teacher implementation of the use of technology tools, we worked to further improve them. When we found techniques that did not work, we modified them until we achieved a level of satisfaction agreed upon by the participating teachers.

Developing the Professional Learning Community

The teachers at HHS wanted opportunities for active participation and learning in designing their professional learning community, while lessening the disjointed arrangement that existed in the past. For example, in the past an expert for a particular topic (e.g., mathematics academic language) would provide a workshop on site with little, if any, follow-up, continuation, or discussion among the teachers. Furthermore, the decision of topics to be covered did not take into account the opinions and ideas of the mathematics, special education, and bilingual teachers. The participants of this project envisioned a professional learning community whose cultivated activities would be inclusive of their voices in which they worked together to build a culture of collaboration to make certain that their students learned mathematics. This practical perspective is consistent with a common theme highlighted in studies about effective professional development, which suggests that it is essential for teachers to engage in

characterizing their professional needs (Darling-Hammond et al., 2009; DuFour et al., 2005). An important notion is to attach professional development activities to student performance and instruction, and to implement strategies that are fundamentally associated with the day-to-day practice of teaching and learning (Marzano, 2003; Marzano, Waters, & McNulty, 2005; Hawley & Valli, 1998). It seems that the teachers' decision to focus on student performance data influenced their teaching practices in content and pedagogy. The next section demonstrates this insight.

A Glimpse into the HHS Professional Learning Community

During the third year of the project, six professional development monthly sessions focused on analysis of student performance on district and state examinations. During the first sessions, the analysis focused on the district's previous academic year's final exams. These examinations were based on the mathematics students engaged in their courses for the entire academic year. A standard item analysis report was given to each teacher by content (e.g., Algebra 1 or Geometry). Analysis included information about how HHS students performed across the content as compared to the district performance. Low scoring items were identified as any test item in which less than 50% of students taking the test received the correct answer. Those items were then cross referenced according to correct answer, mathematics standard, topic, concept or skill, and the pacing guide and textbook chapter in which the concept or skill was addressed. The teachers self-selected to meet in small groups clustered around their learning communities. In their small groups, they identified specific skills and knowledge that students lacked, determined why students were unable to master these skills, and assessed and developed strategies to achieve instructional change that would help students make sense of the concept(s). Several of the teachers reported that this format allowed them to address basic-skill errors and to think through how the skill might be presented to assist students in making sense of the mathematics. They were able to immediately review the items and discuss strategies regarding why the students might have achieved the incorrect answer, as well as examine what they considered to be the appropriate teaching strategy to implement in the classroom.

For the next five sessions, data analysis included a comparison of HHS performance on the CAS across three years of the project. Data analysis for these sessions centered on student performance on the multiple choice, short answer, and open response items of the test. Each teacher received copies of the test and graphs that compared student performance at HHS, the District, and the State, which included Item Number vs. Percent Correct on Multiple Choice, Item Number vs. Percent Correct on Short Answer, and Item Number opposed to Average Score on Open Response. Each graph highlighted items whereby student performance was below the district and state results. Teachers examined those items in regards to content skill assessed and item complexity (i.e., cognitive demands and language complexity), developed descriptions that might explain student performance, and discussed and recommended a primary and alternative teaching strategy or technique to assist students in developing their understanding of the concepts inherent in the item. This aspect also included thinking through what the implications for teaching might be at other grade levels or subject areas. These sessions seemed to be constructive for many of the teachers. Several of the small groups continued to work after our departure.

We believe that our bottom-up, collaborative approach was key to developing the professional learning community. By focusing on teachers' attitudes about teaching mathematics with a critical eye on improving performance, a consistent effort was made in addressing how to improve students' performance on the CAS. As indicated, the teachers themselves initiated analysis of the test. The PD sessions, thus, rallied around the teachers' efforts and provided them with methods to translate the trends in the exam data into more effective instructional practices.

Emerging Tensions Around Teaching

It is important to note that the professional learning community overall functioned well as a culture group; however, on a few occasions tensions emerged. The tensions were not among the teachers, but rather between the teachers and the researcher/teacher educator. The researcher concentrated on larger scale needs of developing mathematical thinking and reasoning; for example, trying to think about how problem solving facilitates understanding of basic skills and increases performance on tests, in general. By contrast, the teachers focused more on the content, trying to relate it to what was being assessed on the tests, so that they could ensure that students would understand test questions and perform well. Also, the school district's pacing guides directed what was taught and when it was taught in the classroom. Often, this drove teachers' ideas of what they wanted for professional development.

Eventually, through discussion that focused on how to best meet the needs of their students, a common goal was reached: to improve student performance in mathematics as measured by CAS, the district's semester and final exams, and their classroom assessments.

From this discussion, we settled on a set of instructional approaches. The teachers agreed to examine students' work samples and the teaching implications, think more thoroughly about content knowledge, and allow their peers and the researchers to observe their teaching for critical comments that would improve their pedagogical practices. Some specific approaches were designing questions to understand students' mathematical thinking and reasoning and to develop a better sense of students' misconceptions and errors; rewriting textbook problems to be more open-ended and multi-layered, which included discussing the underlying mathematical structure; incorporating at least one problem on their weekly quizzes or tests that required students to explain in writing or through a drawing how they did the work, providing justification for their solution to the problem; and using concrete and visual manipulatives for mathematical representations that would assist students in their mathematical sense making and thinking. The teachers worked together to learn how to develop these approaches through conversations about mathematics educational research and professional literature and through demonstrations and modeling of mathematics concepts and ideas.

Conclusion

Over the four years of the project, the MEP team worked to create credibility and trust with the HHS professional learning community. A change in teachers' disposition and attitudes was observed from what once may have been skepticism to one that was completely engaged in teaching and learning, striving for new levels of excellence. Research has found that it is essential for teachers to be engaged in characterizing their professional needs for professional development to be effective, and this partnership confirmed this claim. HHS teachers appreciated the opportunity to be actively engaged and to have a voice, which led to a more cohesive sequence of professional development activities, focusing on pedagogical content knowledge, student performance, instruction, and the implementation of strategies that are fundamentally associated with the day-to-day practice of teaching and learning. The structure of the professional learning community created "contexts for teacher collaboration, provide[d] a focus for the collaboration, and provide[d] a common frame for interacting with other teachers around common problem. When teachers have opportunities to continue to participate in communities of practices that support their inquiry, instructional practices that foster the development of mathematical [disposition] can more easily be sustained" (NRC, 2001, p. 397).

One theme that was consistent between this project and similar ones is the realization that it often takes more than a program change to sustain improvement in academic achievement. "Educators can create professional learning communities, but there are no easy shortcuts for doing so. It will require a staff to find common ground and to exert a focused coherent consistent effort over time" (DuFour et al., 2005). Built on teacher leadership and university collaboration, the professional development discussed in this paper can support others in thinking about how to develop professional learning communities. Program change necessitates a change in disposition, attitudes, and relationships that calls stakeholders to commit to engaging each other in reform efforts in which the main goal is to improve the academic success of all students. ✪

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