Collaborative Professional Development for Mathematics Teachers:

A Critical Element for Teacher's Work

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Over the past two decades educators, policy makers, and researchers have dedicated increased attention to teachers' professional development (PD) to improve students' mathematics learning. Researchers have found that high-quality PD makes a significant difference in students' learning and much has been learned about characteristics of PD that contribute to its efficacy (e.g., Garet, Porter, Desimone, Birman, & Yoon, 2001; Hill, Rowan, & Ball, 2005; Penuel, Fishman, Yamaguchi, & Gallagher, 2007; Smith, 2001). Drawing from this research and my own experiences working with and researching teachers' professional learning, I have come to believe that not only can PD make a difference for teachers and students' learning, PD should be a foundational part of teaching for today's learners, especially given the current contexts of schooling. However, PD must be designed to meet teachers' and their students' needs, and high-quality PD is not a part of all teachers' practices.

Although PD exists in many forms, I have focused on PD that is sustained over time and situated in teachers' inquiries about their work with their students. Slavit, Nelson, and Kennedy's (2009) construct for *supported collaborative teacher inquiry* (SCTI) aligns well with the work I have done with teachers. Slavit et al. describe SCTI as:

> *Classroom-based research that engages teachers in dialogue and collective activity to investigate and coconstruct understandings about teaching and learning… [that involves:] (a) teachers surfacing a focus around a meaningful dilemma, question, curiosity, or problem of practice; (b) teacher interactions, grounded in data, in the pursuit of resolution and answers to this focus; and (c) the presence of a support structure*. (p. xv)

In this paper I provide examples from my work with teachers who engaged in SCTI to illustrate: (1) why collaborative PD shoul become part of the infrastructure of teaching mathematics; (2) core activities, questions, and issues of effective collaborative PD; and (3) considerations and challenges for the field to ensure that collaborative PD truly becomes part of the profession of teaching mathematics.

Collaborative Professional Development as Part of the Infrastructure of Teaching

In order to establish why collaborative PD should become part of the infrastructure of teaching mathematics, I shall describe briefly a study in which I worked with two 7th grade mathematics teachers in SCTI project (for more information see Roth McDuffie [2008], Roth McDuffie [2009], and Roth McDuffie & Mather [2009]) and also discuss findings from collaborative PD with elementary teachers (Roth McDuffie & Eve, in press). By describing this work I shall illustrate the complexity of teachers' work and correspondingly the need for collaborative PD as an essential element of the work of teaching.

The 7th grade teachers were using *Connected Mathematics* (*CMP*, Lappan et al., 2002) as their curriculum materials, and they found that these materials closely aligned with their goals for and approaches to teaching and learning. Although the teachers perceived that they were working with well-developed curriculum materials, the teachers had many decisions to make in planning and implementing lessons. In the process of planning units and lessons collaboratively, I documented the nature and types of questions and issues that emerged for the teachers. I found that teachers repeatedly pondered questions such as:

- *What are the important mathematical concepts and processes in these curriculum materials for this lesson, unit, and year?*

- *How do the ideas in this lesson build on past learning and experiences?*
- *How do the curriculum materials align with my state and/or national standards?*
- *What might my students already know about these ideas?*
- *How might I need to adapt, supplement and/or omit portions of the curriculum materials to meet the needs of the students and of my standards?*

As I later worked with other teams of teachers, including elementary school teachers, I found that these types of questions regularly emerged in the process of planning and implementing mathematics lessons (Roth McDuffie & Eve, in press). The decisions teachers made in response to the above questions played a substantial role in how and what learning opportunities transpired. To address these questions they engaged in collaborative activities including: identifying problems and solutions to focus on, developing key questions and prompts to offer during interactions with students, planning how to facilitate students' discussion of ideas, anticipating key approaches and ideas for assessing students' thinking during the lesson, and planning ways to connect ideas that emerge during discussion. The thinking required for these decisions involved what we termed *curricular reasoning* (Roth McDuffie and Mather, 2009). *Curricular reasoning* includes thinking processes teachers engage in as they work with curriculum to plan, implement, and reflect on instruction.

Over the past 20 years in the U.S., changes in the field of mathematics education have caused curricular reasoning to become and important process for teachers, and part of their daily work. In particular, two prominent shifts have contributed to the need for focusing on curricular reasoning. First, goals of curriculum materials (such as *CMP* [Lappan et al., 2002]) reflect an increased emphasis on problem solving, reasoning, and students' conceptual understanding of mathematics and a decreased emphasis on following procedures and pre-existing algorithms. This shift occurred after the National

Science Foundation (NSF) funded the design of materials to meet visions for reform in mathematics education set forth by the *Curriculum and Evaluation Standards* (NCTM, 1989; Dossey, 2007). Prior to the development of these and similar materials, mathematics textbooks in the U.S. typically served as a primary source of authority and explained mathematics to students through example problems and exercises. In contrast, NSF-funded materials aimed to develop knowledge from a problem-centered context, connect ideas, and develop communication and representation skills (Dossey, 2007). With these changes, it followed that teachers' use of curriculum required different thinking processes. In planning for and during instruction, teachers now need to anticipate and monitor the prior knowledge and experiences, skills, and approaches students use in reasoning about problems in the curriculum materials. With past curriculum materials, a teacher focused more on how to clearly present examples from, or similar to, the textbook. In assessing students, teachers need to look for valid and generalizable methods as contrasted with checking only for correct answers. With this shift in curriculum materials, teachers' work involves reasoning with the curriculum (curricular reasoning) that extends beyond only knowing the curriculum (*c.f., curricular knowledge* [Grossman, 1990]).

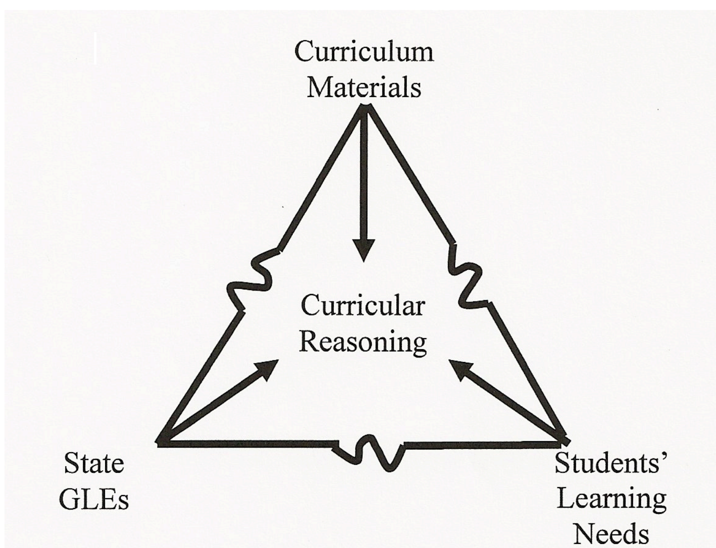
A second shift in the nature of teachers' work with curriculum has resulted from states' recent efforts to develop standards and/or grade-level learning expectations (GLEs) for students' mathematics learning (Reys et al. 2006). With GLEs as policy in most states, teachers are increasingly expected to interpret and align their curriculum materials with state GLEs. However, state GLEs vary widely from one state to another

(Reys et al., 2006), and therefore any nationally developed set of curriculum materials is unlikely to align perfectly with any particular state's GLEs.

Perceiving and using curriculum materials as a resource (that may need adaptations for students' needs and/or to align with GLEs) rather than a script is not a typical U.S. perspective. Teachers in the United States have a history of viewing curriculum as material to cover (Howson, Keitel, & Kilpatrick, 1981; Roth McDuffie & Mather, 2006; Stigler & Hiebert, 1999). This approach is not restricted to commercially developed curriculum programs. Lloyd (1999) found that high school teachers implementing *Standards*-based curriculum materials tended not to make changes in problems presented, despite their perceptions that features of problems caused struggles in teaching and learning. Given this history, we should not underestimate the challenges teachers face in transforming curriculum to meet students' needs and/or states' GLEs.

Figure 1 is shown to capture the primary objects of, and influences on, curricular reasoning that emerged in the in teachers' work. Because the curriculum materials were often the starting point for teachers with whom I worked and served as a continual referent, *curriculum materials* appears at the top of figure 1. For students to learn to their potential, teachers need to anticipate and build on what students might bring to the mathematics tasks by considering students' prior knowledge and experiences (including prior mathematics learning, cultural and language backgrounds, any exceptional needs, etc.) and design instruction accordingly (Smith, Bill, & Hughes, 2008; represented by *students' learning needs* in figure 1). As Darling-Hammond et al. (2005) contended, "No textbook writer, curriculum developer, or department head can know exactly what it is that a particular teacher must do within a classroom" (p. 172). In addition, teachers increasingly are expected to interpret and align their materials with state learning expectations (represented by *State GLEs* in figure 1). The broken sides of the triangle indicate how these influential factors indeed could be out of alignment or represent differing goals and needs. In summary, teachers must use curricular reasoning to reconcile, develop, and implement their curriculum materials while considering their students' needs, and their state's learning expectations, to create a coherent learning experience. This work is in sharp contrast to, and much more challenging, than following a textbook with a lecture-style approach combined with individual seatwork (see Stigler & Hiebert, 1999).

Figure 1: Influences on Curricular Reasoning (Roth McDuffie & Mather, 2009)



Given these complexities and contexts of teaching, I shall return to discussing the role of collaborative PD for teachers. In my work with teachers, SCTI was a critical and necessary support system for enabling teachers to navigate and reconcile these sometimes competing forces involved in curricular reasoning – this type of reasoning is too complex for teachers to undertake in isolation. Although curricular reasoning captures only a fraction of the processes and knowledge involved in teaching, focusing on curricular reasoning as a central process of teaching helps illustrate the need for collaborative PD as essential and on-going support for teaching. In sum, given that teachers need to negotiate among these influences, they need opportunities and support systems to generate and pursue questions about teaching and learning. SCTI is not the only form of professional development that could provide this type of support and yet some form of school-based, collaborative PD is needed for teachers.

Core Activities, Foci, and Culture for Effective Collaborative Inquiry

In addition to finding that teachers have a need for collaborative PD as part of the infrastructure of the profession, I have found that SCTI serves to support specific activities that focus on specific aspects of teaching. I categorized PD activities as occurring *inside* or *outside* the classroom (Roth McDuffie, 2009). The *inside* activities included intensive study of: lessons and unit design; pedagogical practices (e.g. facilitating discussions); and students' thinking, learning, and work. Teachers' study focused on examining curriculum materials and planning, implementing, analyzing, and reflecting on teaching and learning. These activities were categorized as *inside* the classroom because all of the work was based in teachers' immediate context of work with curriculum materials, students, and colleagues from their schools. The *outside* activities included participating in experiences such as: district-organized meetings (in-service workshops, curriculum adoption committees, mathematics teachers' book study groups), regional or national mathematics education workshops or conferences, and National Board Certification support groups (see National Board, 2006).

In my work with elementary (Roth McDuffie & Eve, in press) and middle school teachers (Roth McDuffie, 2009; Roth McDuffie & Mather, 2009), I found that while the inside activities that were embedded in teachers' daily practice were most critical for teachers' change, *outside* activities complemented *inside* support. Outside activities (e.g., reading the books with a book study group and attending workshops) helped teachers to gain information about alternative practices and identify a focus area for inquiry and improvement in practice. For example, after reading a book that focused on teaching through problem solving and facilitating classroom discourse (Lampert, 2001), one teacher became more aware of the role of classroom discourse for learning and gained a general understanding of strategies to use in facilitation (Roth McDuffie, 2009; Roth McDuffie & Mather, 2009). She also reflected on her own practice from a new perspective, critically examining discourse patterns with her students, and set goals to change to involve students more in mathematical discussions. Inside activities (e.g., collaborating with colleagues to plan, implement, and reflect on lessons) provided ideas directly connected to the teacher's daily practice and supported daily decision making that became foundational to the inquiry process.

Although all of these activities were important to the teachers with whom I worked, it seemed that the collaborative PD group's inquiry-focused culture provided the catalyst for change to occur. The collaborative culture was important in establishing a productive, focused, and improvement-oriented climate for change to produce ideas and approaches that we immediately tested and refined as part of the inquiry process. Conducting the work inside the classroom created a working laboratory for investigating practice by identifying key teaching and learning moments in lessons, reflecting on learning outcomes, suggesting teaching options, and planning for future lessons. For instance, for the teacher focused on discourse, the group encouraged questioning of practices, risk-taking to identify areas for improvement and try different strategies, and using evidence from practice to guide analysis, reflection, and design of new approaches. The PD group maintained a collaborative stance and a shared vision of teaching and learning mathematics to promote deep learning about mathematics discourse and the development of discourse practices.

In these experiences, teachers regularly commented that they needed their colleagues' help to identify the key moments and to suggest alternatives and reflect on outcomes. In addition, the teachers reported that they benefited from my perspectives as a university mathematics educator. They commented that I posed questions about teaching and learning that they might not otherwise consider, offered research findings that informed aspects of their work, and shared understandings and about teaching and learning in other grades. Operating in isolation does not provide as many opportunities to become aware of other perspectives and alternative approaches as collaborative PD produced.

Considerations and Challenges in Incorporating Collaborative Professional Development as Part of the Infrastructure of Teaching

Although SCTI offers promise as an effective approach to PD, many other collaborative structures can be considered. Approaches such as lesson study (Fernandez, 2005), video clubs (Sherin, 2004), professional learning communities (Little, 2003; Little et al., 2003) and coaching (West & Staub, 2003) could each, or in combination, serve as structures to provide this collaborative support from inside the classroom. Outside influences may continue to inform learning as well. For example, as ideas are refined, teachers could review relevant literature or enroll in workshops to pursue alternative teaching approaches and/or gain more in-depth insights on students' learning. Indeed, in my experience the teachers' commitment to and interest in a specific approach (or a blend of approaches) is most important in designing PD. However, merely adopting a professional learning structure is not sufficient for catalyzing the inquiry process. The culture of the group (e.g., Does the group have a shared vision and collaborative stance?), the context of the work (e.g., Is the group taking on important and relevant questions for their practice and to improve students' learning?), and overcoming potential obstacles to productive work (as discussed below) also should be considered.

Many challenges exist to incorporating collaborative PD into the infrastructure of teaching. These challenges include but are not limited to:

- a school day that typically does not include time and structures for collaborative interactions (Stigler & Hiebert, 1999);
- a culture in the profession that does not necessarily encourage opening up one's teaching practice for critical analysis and reflection, coupled with a tradition of teachers working in relative isolation (Stigler & Hiebert, 1999);
- many teachers (especially elementary teachers) teach in more than one subject area and each of these areas may need focused attention for PD (adding to the need for time and possibly impeding teachers' focus on mathematics);
- many teachers need opportunities to better understand mathematics for teaching in addition to pedagogical issues (Hill, Rowan, & Ball, 2005);
- teachers, administrators, parents and community members need to work from a common vision of effective instruction (Gamoran et al., 2003; Weiss & Pasley, 2009) and be mutually accountable for enacting this vision (Cobb,

2009) for PD to be sustainable; yet establishing and enacting this common vision is not easy or straight-forward;

- some teachers are reluctant or even resistant to participate in PD and reaching these teachers can present additional challenges (Weiss & Pasley, 2009);
- school-based personnel with expertise in facilitating PD are needed "to push teachers' thinking and to effectively guide the discussion" (Weiss & Pasely, p. 43), and to meet this need mathematics professional developers are needed in large numbers. Thus, implementing collaborative PD in all schools requires more opportunities to develop professional developers.

In sum collaborative PD needs to become an expectation for teachers; however adequate support in the design and implementation of PD is not readily available in many schools today. Easy and uniform solutions for these challenges do not exist. However, in my experience the best driver for implementing and sustaining high quality PD is an "existence proof" within teachers' immediate context (e.g., school or district). When teachers witness or experience high-quality PD that is relevant to and serves needs for their practices and for their students, PD efforts become generative. In other words, when teachers see that PD can work for their teaching and for their students' learning, they begin to see that it is worth their time, that it can alleviate the need for some individual planning (and so it can save time), and that it rejuvenates their practices. Having these experiences results in teachers calling for and initiating more opportunities. However, creating openings for these initial experiences is challenging and requires commitments on all levels (e.g., principals, district administrators, policy makers, etc.). The openings must be created and on-going support needs to be instituted for teaching and learning to improve.

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