As a result of the recent increased emphasis on mathematics professional development (MPD), studies have attempted to identify a set of features that are commonly part of successful MPD programs (e.g., Yoon et al., 2007; Garet et al., 2001). While recommendations that professional development should be collaborative, sustained, and practice-based are common across all subjects, MPD is often highlighted by activities that address the specific needs of mathematics teachers (e.g., Loucks-Horsley et al., 1998).

Professional learning communities (PLC) are also considered valuable for the growth of teachers. However, PLCs only provide a general guideline for how teachers can make meaningful changes to instruction, regardless of subject. In order for PLCs to be used as a form of MPD, more work needs to be done to identify the extent to which mathematics teachers in PLCs engage in the activities that improve their content and pedagogical knowledge and, ultimately, improve student achievement. Based on literature on teacher collaboration, PLCs, and MPD initiatives, a conceptual framework was developed to describe the collaborative work of mathematics teachers. This framework was used to guide the design of this study and the analysis of data.

The study described here employed case study methodology to investigate two teams of teachers attempting to implement principles of PLCs as part of a district-wide intervention. The goal of this study was to identify both teams’ success in implementing these principles and to what extent they engage in rich, content focused activities. To do this, the teams were
observed during their set meeting time and individual teachers took part in interviews and surveys to further explicate the team dynamic as well as individual’s dispositions and values. The teams provided two distinct cases of the collaborative work of mathematics teachers. One team had strong collaborative norms yet did not engage in the activities commonly found in effective MPD programs while the other team struggled with implementing the principles of PLCs but were able to focus more on mathematical content and pedagogy. Based on the findings, the role of PLCs as the sole source of professional development for mathematics teachers is questioned. Additionally, other factors that could be attributed to a group of teachers’ inclination to engage in high-level, content focused activities are highlighted. These factors contributed to a refinement of the conceptual framework that classifies the growth of mathematics teachers in collaborative settings. From this, suggestions for future research on collaborative MPD are presented as well as how findings from such research could be used to inform the development and replication of MPD.
Mathematics Teachers and Professional Learning Communities: Understanding Professional Development in Collaborative Settings

by
Matthew Paul Campbell

A thesis submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the Degree of Master of Science in Mathematics Education

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APPROVED BY:

Dr. Hollylynne Stohl Lee
Chair of Advisory Committee

Dr. Paola Sztajn

Dr. Allison W. McCulloch

Dr. Jeffrey Thompson
DEDICATION

To my father, Paul Clayton Campbell.
BIOGRAPHY

Matthew Paul Campbell was born on September 12, 1983 in Mineola, New York. Matthew spent most of his childhood on Long Island, graduating from Patchogue-Medford High School in Medford, NY in 2001. He then enrolled at North Carolina State University, receiving the Park Scholarship, a full, four-year scholarship based on scholarship, leadership, service, and character. He graduated magna cum laude in May 2005 with Bachelor of Science degrees in mathematics education and mathematics.

Upon graduation, Matthew went on to teach at Deer Park High School in Deer Park, NY where he taught Pre-Calculus and an SAT preparation course. He also served as co-founder and co-advisor for the boys’ volleyball club. After one year in Deer Park, Matthew returned to Raleigh, NC to take a job for one year at Athens Drive High School where he taught Algebra I and Honors Algebra II and was co-advisor for the freshman class of 2010.

Matthew then returned to NC State full-time to pursue a master’s degree in mathematics education. He worked as a graduate research assistant on the “Nurturing Mathematics Dreamkeepers” project during his first year in the program. He then worked as a graduate research and teaching assistant with Dr. Paola Sztajn in the elementary education program and as a graduate research assistant with Dr. Allison McCulloch in the mathematics education program. From this work, Matthew co-authored proposals submitted to national and international conferences and publications submitted to journals.

After receiving his master’s degree, Matthew plans to pursue a Ph.D. in mathematics education at Oregon State University in Corvallis, Oregon.
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CHAPTER 1

INTRODUCTION

There is an increased demand for new strategies for teaching and learning due to an increasingly diverse student population and increased standards (McLaughlin & Talbert, 2006; Darling-Hammond, 1998). Specifically, in mathematics, today’s students need to have the ability to solve problems through a flexible and adaptable use of their knowledge and understanding (Hiebert et al., 1997). However, developing these abilities in students cannot come merely through new curricula or testing procedures (Ball & Cohen, 1999; Wilson & Berne, 1999). The classroom teacher is a key ingredient.

In this climate of changing how students develop deep understandings of subject matter and creating an environment in which students learn in meaningful contexts and engage in rich discourse, little attention has been paid to the teachers’ role in these changes and how they learn these new ways of teaching (Putnam & Borko, 2000). Teachers’ mathematical knowledge (Hill, Rowan & Ball, 2005), pedagogical content knowledge (Shulman, 1987), and their attention to student reasoning (Carpenter, Fennema, Franke, Levi, & Empson, 1999) have been linked to increases in student achievement. On the other hand, much of the difficulty in reforming practice is due to the fact that teachers are required to teach in ways that many of them have never taught or learned (Darling-Hammond & McLaughlin, 1995). These findings assert a need for the professional development of practicing teachers.

The rapid increase in the volume of literature on mathematics professional development (MPD) is due to the realization that teachers should be better prepared to be
able to improve their own instructional practices (Sowder, 2007). However, professional development, regardless of intent, is often not designed in ways that foster changes in teachers’ practice. Most of the resources for professional development in the U.S. are allocated for one-time, fragmented experiences (Ball & Cohen, 1999). These experiences, often led by an external expert, are often not considered professionally rewarding by teachers (Wilson & Berne, 1999; Putnam & Borko, 2000; Stein, Silver, & Smith, 1998; Hawley & Valli, 1999).

As a result, recent studies have attempted to identify effective MPD initiatives with the goal of establishing a set of features that are commonly part of programs that are valued by teachers and have an impact on teacher practice and student achievement (e.g., Yoon, Duncan, Lee, Scarloss, & Shapley, 2007; Garet, Porter, Desimone, Birman, & Yoon, 2001). This search has led to findings that professional development experiences that are sustained (Garet et al., 2001), practice-based (Ball & Cohen, 1999), and allow for teacher involvement in the decision making process (Yoon et al., 2007) are successful. Additionally, studies have shown that the opportunity for collaboration is both valued by teachers (Garet et al., 2001; Arbaugh, 2003) and plays a role in supporting teachers’ inquiry and problem solving (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Given the recent focus on professional development, especially in collaborative settings, it is important to define the work of teachers in groups in order to identify what influences teacher learning and aid in the design of effective MPD.
Importance of Collaborative Opportunities for Teachers’ Growth

Professional learning communities (PLC) provide both an organizational framework and a set of requisite dispositions and activities for teacher learning. As defined in practice-based literature, PLCs are sustained collaborative opportunities where teachers focus on student learning and critically reflect on their shared practice (e.g., McLaughlin & Talbert, 2006; DuFour & Eaker, 1998). In such communities, teachers are empowered to make changes to their practice by inquiring into the best methods of instruction and developing and testing new hypotheses (Louis, Marks, & Kruse, 1996). Additionally, the decisions to make changes are based on data from the classroom to determine new and appropriate teaching strategies (DuFour & Eaker, 1998). This definition of PLCs is commonly used in widespread interventions where teachers are encouraged to collaborate and assume more responsibility for student learning. Studies have shown positive changes in the practice of teachers (i.e., student-centered instruction, high expectations for student learning) whom are engaged in PLCs (Vescio, Ross, & Adams, 2008; Little, 2002; McLaughlin & Talbert, 2001; Louis & Marks, 1998; Hord, 2004). For the purposes of this paper, the term “PLC” refers to a group of teachers that embodies these characteristics, meaning there are not “good PLCs” or “bad PLCs”. Other terminology will be used throughout the paper to describe groups that are not classified as PLCs.

Not all collaborative groups of teachers engage in the type of examination of practice found with PLCs. Research studies have shown communities of teachers that avoid the conflicts that can arise during the critical reflection on practice (e.g., Wells & Feun, 2007; Visscher & Witziers, 2004). As a result, teachers tend to stick with the teacher-centered,
traditional methods that are prevalent in schools (McLaughlin & Talbert, 2001). While structural changes such as the availability of meeting time for teachers are important for the work of a collaborative team (Louis et al., 1996), such changes are relatively easy and are less effective in impacting instructional practices. On the other hand, teachers in PLCs make the more meaningful shifts in their beliefs and values, which can have a positive impact on their instructional practices.

Many MPD interventions claim to rely on collaboration, specifically the shared values and norms for critical reflection that are part of PLCs (e.g., Borko, Jacobs, Eiteljorg, & Pittman, 2008; Lachance & Confrey, 2003; Arbaugh, 2003; Kazemi & Franke, 2004). However, a team’s inclination to engage in critical reflection is not the only component of most collaborative MPD interventions. Many programs aim to promote the use of instructional practices such as cognitively demanding tasks (e.g., Stein, Smith, Henningsen, & Silver, 2000; Borko et al., 2008; Arbaugh, 2003), mathematical technology (e.g., Lachance & Confrey, 2003; Kynigos & Argyris, 2004), and Standards-based curricula (e.g., Ross & Bruce, 2007; Borasi, Fonzi, Smith, & Rose, 1999; Loucks-Horsley et al., 1998). As a result, certain features are commonly incorporated into collaborative MPD such as video study, task analysis, student work analysis, and engaging with mathematical content and technology. These activities are important, as Kennedy (1998) found that a strong content focus in professional development programs had a positive impact on student learning. Ultimately, mathematics teachers are faced with unique challenges that must be addressed with specific forms of professional development activities.
Statement of the Problem

PLCs only provide a general guideline for the organization, activities, and individual and group dispositions necessary to make meaningful change to instruction, regardless of subject. Additionally, there is little documentation of the nature of work that teachers do while working in PLCs (Vescio et al., 2008). In order for PLCs to serve as an effective form of MPD, more work needs to be done to identify the extent to which mathematics teachers in PLCs engage in the activities that improve their content and pedagogical knowledge and, ultimately, improve student achievement.

The study described here investigates two teams of high school mathematics teachers attempting to implement principles of PLCs as part of a district-wide intervention. The goal of this study is to identify both teams’ success in implementing these principles, and to what extent features that are commonly found in effective MPD are evident in their work. From those findings, the author questions the role of PLCs in the professional development of mathematics teachers and highlights other factors that could be attributed to a group of teachers’ inclination to engage in high-level, content focused activities. As a result, the author offers suggestions for future research on collaborative MPD and how findings from such research could be used to inform the design and replication of MPD. The specific research questions investigated in this study, as well as the framework with which teachers’ work is analyzed, are stated at the end of Chapter 2.

Organization of Paper

Chapter 2 will provide a review of existing literature in order to illustrate the need for professional development for mathematics teachers, highlight agreement in the field on what
constitutes effective professional development, and define various types of teacher collaboration as seen in research. This review will provide a case for the need for the study reported in this thesis and serve as the basis for the conceptual framework considered by the author.

Chapter 3 will describe the methodology used for this study, including the context, the participants, the sources of data, and how that data was analyzed in order to answer the research questions. Chapter 4 will present the results of the investigation and Chapter 5 will use those results to answer the research questions. The author will also state the implications of this study regarding teacher collaboration and professional development, as well as recommendations for future research and design.
CHAPTER 2
REVIEW OF LITERATURE

As indicated in Chapter 1, teachers are central to the success of reform in schools and the classroom. As a result, teachers need to engage in effective professional development, which has been defined in research as learner-centered, collaborative opportunities set in the context of teachers’ own classrooms and students. Professional learning communities serve as one model of this view of professional development that can be implemented across grades, subjects, and schools.

However, research on collaborative mathematics professional development provides more useful examples of activities in which teachers should engage in order to more effectively plan and implement practices such as cognitively demanding mathematical tasks and the use of technology, which are traditionally difficult for teachers to incorporate into their practices. It is clear that worthwhile professional development, when implemented and sustained, is attributed to substantial changes in teachers’ practices and, in turn, increases in student achievement in mathematics. In this chapter, literature related to these ideas will be examined.

The literature review begins by establishing the need for the professional development of practicing mathematics teachers by highlighting some recommendations for mathematics instruction and the difficulties that teachers face in attempts to implement such practices. Next, the review will explore the body of work and suggestions of research on effective professional development for teachers. The author will then describe three types of collaborative environments for teachers gathered from research. This review will inform the
development of a conceptual framework regarding teachers’ collaborative work, which was designed for and used in this study. The specific research questions that were investigated in the present study will be stated at the end of this chapter.

The Need for Professional Development

Today’s schools face an increased demand for new strategies for teaching and learning due to an increasingly diverse student population, both academically and culturally (McLaughlin & Talbert, 2006; Darling-Hammond, 1998; McLaughlin & Talbert, 2001). Specific to mathematics, societal demands require today’s students to have the ability to solve problems through flexibility with or ability to adapt existing knowledge and understanding (Hiebert et al., 1997). The mathematics classroom is the perfect forum to allow students to develop such skills.

However, research has shown that much of the work done by students in mathematics classrooms merely has students state memorized facts or reproduce previously seen procedures (Doyle, 1988; Stein et al., 2000). This is due, in part, to the instilled belief that mathematics is a static subject that needs to be absorbed by students (Burton, 1984). As a result, students work toward proficiency and efficiency and are unable to utilize their classroom experience with mathematics in new settings (Clayden, Desforges, Mills, & Rawson, 1994). While understanding procedures is key to mathematical proficiency, mathematics is learned through authentic opportunities where students actually “do” mathematics (Stein, Grover, & Henningsen, 1996; Clayden et al., 1994; Burton, 1984). This process includes addressing problems, looking for patterns, developing hypotheses, and justifying solutions in circumstances that are truly problematic for students.
The National Council of Teachers of Mathematics (NCTM) supports this view in their *Principles and Standards for School Mathematics* (NCTM, 2000), stating that “students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge” (p. 20). Understanding in mathematics allows for students to make flexible use of knowledge and skills in order to build connections toward new ideas (Hiebert et al., 1997). Across research, there is much agreement that in order to build such understanding, students must engage in authentic, cognitively demanding activities and tasks (Stein & Lane, 1996; Newmann, Marks, & Gamoran, 1996). Hiebert et al. (1997) even partially based their characterization of a classroom’s support of students’ mathematical understanding by analyzing the nature of the tasks used throughout the class. By engaging in authentic and cognitively demanding tasks students become intrigued about doing mathematics and are invited to explore and investigate (NCTM, 2000; Stein & Lane, 1996). Electronic technologies such as calculators and computers also enhance student learning through better understanding thanks to efficiency and accuracy and the fostering of conjecture and investigation (Ben-Zvi, 2000; Heid, 1997; NCTM, 2000). Engaging in conjecturing and investigations can develop students’ understanding of what mathematics work entails (Doyle, 1983; NCTM, 1991).

Hiebert et al. (1997) also utilize the role of the teacher as a variable in characterizing a classroom’s support of students’ understanding. Ultimately, teachers are expected to make difficult shifts in practice toward reform-based, student-centered instruction and the use of cognitively demanding tasks. However, these shifts are difficult as teachers have typically not taught or even learned in such an environment (Wang, 2002; Ertmer, 1999; Darling-
Hammond & McLaughlin, 1995). As a result, teachers are unfamiliar with the changed climate and pace of a class using technology or authentic tasks and often succumb to forces that lead to decreasing cognitive demand or abandoning certain practices altogether (Henningsen & Stein, 1997; Stein et al., 1996; Herbst, 2003; Doyle, 1988; Stein & Smith, 1998; Ertmer, 2005; Norton, McRobbie, & Cooper, 2000) and, in doing so, taking away any meaningful investigation of the mathematics (Henningsen & Stein, 1997; Stein & Smith, 1998).

In order to confront these conflicts, teachers must take on the role of a facilitator, a role that is far different than the traditional view of the teacher as the source of knowledge and correctness (Hiebert et al., 1997). This role leaves teachers to walk the fine line between offering too much input that routinizes a problem and being too “hands off” and allowing the possibility that students will conduct their investigations in ways that are not meaningful. Hiebert et al. (1997) have recommended that teachers can share relevant information regarding formal terminology or alternative methods that students should not be expected to discover on their own. However, if too much input is given, teachers run the risk of creating an environment where students will abandon their own strategies and methods to follow the teacher’s offerings, regardless of any lack of understanding or connections to meaning.

Effective teaching also involves the appropriate selection of tasks and technological tools for use in the classroom (NCTM, 1991, 2000; Hiebert et al., 1997). In order to make those appropriate decisions, teachers must understand the big ideas of mathematics and also be able to put that information in a form that students can understand (NCTM, 1991, 2000). However, teachers are often put in a position to translate existing curricula into sequences of
classroom tasks and incorporate technological tools, requiring knowledge and a point of view that many teachers have not developed (Doyle & Carter, 1984).

Not only must teachers select tasks and tools that help with students’ development of problem-solving and connection-building skills but those tools must also provide teachers with a window into their students’ understanding (NCTM, 1991). This knowledge of the value of rich tasks aids in the development of appropriate plans in the future and emphasizes the importance of classroom discourse and the diverse format of settings and assessments used in the classroom. Stein and Smith (1998) have stated that while teachers will reflect on their classroom experiences informally, the habit of mind to focus and reflect on students’ learning must be developed.

So, how are these skills developed in teachers? If teachers do not experience learning in a mathematics classroom where cognitively-demanding tasks and instructional technologies are commonplace, and they do not fully develop a grasp of the requisite skills in preservice teacher education programs, how will teachers develop the skills to implement the type of practice that is proposed by NCTM (1991, 2000) and other research? Teachers must continue to engage in professional development beyond their teacher education program. Furthermore, such professional development must be effective in terms of the value that teachers place on the experience, the changes the experience foster in a teachers’ instructional practices, and, in turn, the experience’s impact on student learning and achievement. The next section will highlight research on professional development and the suggestions from this work for the design of effective programs.
Effective Professional Development

Underlying the efforts of reform is the need for a shift in practice (Ball & Cohen, 1999; Darling-Hammond & McLaughlin, 1995; Loucks-Horsley et al., 1998; McLaughlin & Talbert, 2006). Changes to practice are difficult since they are more fundamental and affect the culture of a school (Fullan, 1991; McLaughlin & Talbert, 2006). Essential to these changes are the professionals, namely the teachers, in the school (DuFour & Eaker, 1998). In this climate of changing how students develop deep understandings of subject matter, and creating an environment in which students learn in meaningful contexts and engage in rich discourse, little attention has been paid to the teachers’ role in these changes and how they learn these new ways of teaching (Putnam & Borko, 2000).

Ball and Cohen (1999) found that while a great deal of financial support for staff development exists in the United States, most of the resources are put toward fragmented experiences. Typically, one-time workshops and sessions where teachers receive new ideas from an expert from outside of the school are not considered to be professionally rewarding by teachers (Wilson & Berne, 1999; Putnam & Borko, 2000; Stein et al., 1998; Hawley & Valli, 1999). Through such experiences, teachers are merely updated on issues of curriculum and learning, receiving handouts that are often soon discarded for the newest wave of ideas. McLaughlin and Talbert (2006) found that externally developed workshops rarely address the needs of teachers and are often short lived, likening the addition of current and fashionable reforms in a school to decorating a Christmas tree.

Ultimately, researchers agree that, in order for teachers to develop the knowledge and skills expected by reformers, support that allows teachers to learn about practice, content, and
the students in their classroom must be provided. Research on the professional development of practicing teachers is a booming, yet relatively new, body of literature (Sowder, 2007). Attempts have been made to identify and characterize effective professional development (e.g., Yoon et al., 2007; Garet et al., 2001). This section will summarize those characteristics in contrast with the characteristics of more traditional professional development.

*Teachers’ Engagement in Professional Development*

Teachers should be provided with the opportunity to enhance their expertise in content and teaching strategies as well as current research on teaching and learning (Hawley & Valli, 1999; DuFour & Eaker, 1998). Often in traditional sessions and workshops, teachers passively receive new information. Despite this approach, one of the difficulties of change is that teachers cannot simply be told how to change their instruction or be expected to use methods that they have not used before, as a teacher or a learner. Darling-Hammond and McLaughlin (1995) posit that, in order to remedy teachers’ lack of experience in certain learning environments, effective professional development has teachers in the role of both teacher and learner. More specifically, Ball and Cohen (1999) assert that professional learning must be situated in the same type of environment that reformers encourage for the classroom. For example, in a professional development experience presented by Wilson and Berne (1999), teachers became learners in the environment that their students will learn though the content was appropriate for their own learning and did not simply include the content that students will learn.

One way to describe the environment that reformers encourage is through the idea of active learning. Kyriacou (1992) defines active learning as activities where students are
given a degree of ownership and control in an open-ended experience. As a result, many effective professional development experiences are participant-driven, giving ownership to teachers to address their specific needs (DuFour & Eaker, 1998; Darling-Hammond & McLaughlin, 1995). In this setting, teachers can engage in meaningful analysis of teaching and learning (Garet et al., 2001). This approach is in contrast to the widespread, top-down approach that comes with the solutions provided at externally developed professional development, which often lead to negative reaction from teachers (Wilson & Berne, 1999; Putnam & Borko, 2000; Stein et al., 1998).

To ensure the meaning and authenticity of teacher learning, Ball and Cohen (1999) promote a practice-based curriculum, allowing teachers’ own practice, learning, and students to become the source of professional development experiences. There is a growing consensus that values opportunities for teachers to reflect on and improve their practice within the context of their everyday teaching (Wilson & Berne, 1999; Putnam & Borko, 2000; Hawley & Valli, 1999). In addition, professional development efforts should be connected to other aspects of school change, sometimes dubbed “coherence” (Garet et al., 2001). Coherence involves not only aligning experiences to teachers’ goals but also to state standards, assessments, and other interventions at the school or district level. Along with an experience being practice-based, coherence makes an experience relevant to teachers (Darling-Hammond & McLaughlin, 1995). Hawley and Valli (1999) suggest that change as a result of professional development should be a gradual process and part of a continuous commitment to change.
Focus on Students’ Thinking

Using concrete results, such as student work, videotapes of classroom lessons, and curriculum materials, teachers can investigate what students are doing and thinking and how to change their practice to improve students’ learning (Ball & Cohen, 1999; Darling-Hammond, 1998; Loucks-Horsley et al., 1998). This requires a shift toward a focus on student understanding, which proves to be difficult for teachers. Researchers have observed instances of professional development where teachers drift away from a focus on students’ thinking (Cwikla, 2002) and instead concern themselves with issues of student discipline and parental involvement (DuFour & Eaker, 1998). These concerns lead to arguments that the roadblocks to student learning are outside of teachers’ control.

To ensure the meaningful use of concrete results with a sustained focus on student learning, teachers must take on what is sometimes called a “researcher’s lens” (Fernandez, Cannon, & Chokshi, 2003), by conducting empirical examinations around question-asking and designing classroom experiments (Fernandez et al., 2003; Ball & Cohen, 1999; Darling-Hammond & McLaughlin, 1995). According to Ball and Cohen (1999), in order for teachers to teach in the ways in which reformers think they should, teachers need to ask the following questions: “What is working? What is not working? For whom are certain things working or not working?” (p. 10). As teachers work with artifacts of practice, they can answer those questions, focus on teaching and learning, and develop new ideas based on evidence.

Importance of Collaboration

Taking a critical look at one’s practice and making changes to that practice is difficult as an individual task. However, schools are often set up in a way that leaves teachers to do
such work alone (Darling-Hammond & McLaughlin, 1995). As such, opportunities to work collaboratively with colleagues are valued by teachers (Stein et al., 1998; Garet et al., 2001; Arbaugh, 2003). In line with the idea of practice-based professional development, these collaborative teams should be formed among teachers from the same school or district since they will have similar issues and concerns to address as well as the same curricular and assessment requirements (Garet et al., 2001). The use of collaborative teams can allow teachers to address issues in their own classrooms using the process of inquiry and problem solving (Loucks-Horsley et al., 1998; Hawley & Valli, 1999; Arbaugh, 2003).

Sustained Efforts in Professional Development

In addition to problems with workshops and sessions being perceived as out of context and not allowing for collaboration, traditional professional development programs are often short-lived, fragmented experiences for teachers. When considering the duration of a professional development activity, one must consider both the number of contact hours (in one session and overall) and the span of time over which an activity takes place (Garet et al., 2001). Research on effective professional development mainly offers suggestions on the latter consideration of duration. Sustained professional development allows for ongoing support, continuous growth, and the ability to set, and meet, both short- and long-term goals (Darling-Hammond & McLaughlin, 1995). In this case, long-term refers to years, not months or weeks. This requires major changes in how schools are structured and how professional development is delivered (Hawley & Valli, 1999). Reform-inspired professional development experiences, such as study groups, have been shown to span longer time and involve more contact hours (Garet et al., 2001). Increased time has also been shown to
positively impact the amount of content incorporated into a professional development experience (Garet et al., 2001), which can lead to increases in student achievement (Kennedy, 1998). As a result, sufficient time must be provided in order for teachers to engage in effective professional development.

*Summary of Characteristics*

In sum, research proposes that effective professional development provides the same learning environment for teachers that they are expected to construct in their own classrooms. Teacher learning experiences should be practice-based, allowing participants to examine issues relating to their own learning, classrooms, and students. As a result, teachers must adopt a “researcher’s lens” – defining a need, formulating questions and methods, collecting data, analyzing results, and proposing new practices. This process is best completed in collaborative settings amongst colleagues with shared norms and values. Teachers must have the time and support to engage in effective professional development, working over the course of years to meet goals. Ultimately, a professional development experience should be aligned with the goals of the teachers as well as the mission of the school in order for the experience to be perceived as relevant.

In line with these suggestions, Darling-Hammond and McLaughlin (1995) offer questions that could be asked to determine is a professional development policy corresponds to teachers’ learning and change (p. 603):

- “Does the policy reduce the isolation of teachers, or does it perpetuate the experience of working alone?”
- “Does the policy encourage teachers to assume the role of learner, or does it reward traditional ‘teacher as expert’ approaches to teacher/student relations?”
• “Does the policy provide a rich, diverse menu of opportunities for teacher to learn, or does it focus primarily on episodic, narrow “training” activities?”
• “Does the policy link professional development opportunities to meaningful content and change efforts, or does it construct generic inservice occasions?”
• “Does the policy establish an environment of professional trust and encourage problem solving, or does it exacerbate the risks involved in serious reflection and change and thus encourage problem hiding?”
• “Does the policy make possible the restructuring of time, space, and scale within schools, or does it expect new forms of teaching and learning to emerge within conventional structures?”
• “Does the policy focus on learner-centered outcomes that give priority to learning how and why, or does it emphasize the memorization of facts and the acquisition of rote skills?”

These questions address the various characteristics of effective professional development outlined above. Given the context of the study reported on in this paper, the next section will take a closer look at one of those characteristics (collaboration) in order to better illustrate the benefits and possible roadblocks when teachers work together.

**Teacher Collaboration**

Professional developers value the support that is offered through collaboration as it is often incorporated into interventions that have been shown to be effective (Elmore, 2002; Hawley & Valli, 1999; Garet et al., 2001; Yoon et al., 2007). The opportunity for collaboration is both valued by teachers (Garet et al., 2001; Arbaugh, 2003) and plays a role in supporting inquiry and problem solving (Loucks-Horsley et al., 1998; Hawley & Valli, 1999; Arbaugh, 2003). This section describes three types of collaborative work and their differences in terms of the activities teachers do, their content focus, and what teachers ultimately take away from the experience.
Professional Communities

Collaboration allows teachers to question, investigate, and change their practice (Ball & Cohen, 1999). However, not all collaborative groups of teachers engage in the type of examination of practice that allows for such growth. McLaughlin and Talbert (2001) have defined communities of practice that possess a culture where teachers share values and set expectations for their work with students but have still been found to perpetuate teacher-centered, traditional methods.

The agreement among teachers in this type of community comes on issues such as behavior and course placement. Often teachers’ practice remains unchanged even in collaborative settings to avoid the conflicts that can arise during a critical reflection on practice (Visscher & Witziers, 2004; Wells & Feun, 2007). These groups are often found to function more as efficient units, dealing with day-to-day, logistical issues but avoiding issues of beliefs and practice (Visscher & Witziers, 2004). Further, Ball and Cohen (1999) assert that collaboration could also perpetuate the conservative practices of a culture setup by teachers, administrators, and parents.

Regardless of the type of instructional practice that is promoted within a professional community, in order to build the relationships, support, and shared values that make a professional community, teachers must feel that working in collaborative groups is more beneficial than working independently (Louis et al., 1996). Additionally, certain structural changes must be made such as the availability of meeting time for teachers (Louis et al., 1996; Loucks-Horsley et al., 1998). The emphasis on structural changes rather than changes
to the fundamental beliefs of individuals around the school make professional communities easier to develop but less effective in impacting instructional practices.

**Professional Learning Communities**

Another type of teacher collaboration is professional learning communities. Work in PLCs has been found to have more of an impact on teachers’ beliefs and instructional practices than the type of collaboration highlighted in the previous section (e.g., Vescio et al., 2008; Little, 2002). Both an organizational framework and a set of requisite dispositions and activities for teacher learning have been provided in literature on PLCs (e.g., DuFour & Eaker, 1998; McLaughlin & Talbert, 2006; Hord, 2004; Louis et al., 1996). These sources are being highlighted in this review as they are commonly drawn from in the widespread implementation of the concept of PLCs, including the teams of teachers involved in the study reported in this paper.

While the idea of PLCs or communities of practice spans many fields, in the field of education and teacher professional development PLCs are defined as sustained collaborative opportunities where teachers decide on the context and content of their work (McLaughlin & Talbert, 2006). In doing so, teachers in PLCs focus on student learning and critically reflect on their shared practice (McLaughlin & Talbert, 2006; DuFour & Eaker, 1998; Hord, 2004). This often requires teachers to focus, and later reflect, on what students are doing throughout a lesson to ensure that their experiences are meaningful and authentic. According to DuFour, Eaker, and DuFour (2005), teachers in communities with a focus on student learning ask the following questions:
• “What is it we want all students to learn?”
• “How will we know when each student has mastered the essential learning?”
• “How will we respond when a student experiences initial difficulty in learning?”
• “How will we deepen the learning for students who have already mastered essential knowledge and skills?”

(p. 15)

DuFour (2004) adds that teachers in PLCs should not ask questions or develop goals concerning issues of behavior, attendance, or other factors outside of classroom instruction and not relevant to student learning. By asking questions like the ones stated above, schools break from the traditional assumptions that, if the teacher input is properly executed, student learning will occur. Instead, teachers in a PLC work collaboratively to take responsibility for student learning using information from research to address the issues within the context of their own classrooms.

In PLCs, teachers make changes to their practice by inquiring into the best methods of instruction and developing and testing new hypotheses (Louis et al., 1996; DuFour & Eaker, 1998; Hord, 2004). Teachers in PLCs question and challenge existing teaching methods and their own assumptions and beliefs in order to reinvent their practice based on the needs of and their goals for their students (McLaughlin & Talbert, 2006; DuFour & Eaker, 1998). Not only are teachers expected to come up with new methods but are also encouraged to test those methods and reflect on their results (DuFour & Eaker, 1998). This intolerance for inaction leads to a culture of continuous improvement within a PLC where even failure is considered part of the learning process (DuFour & Eaker, 1998).
Meeting the needs of all students and making changes in response to high expectations requires questioning the status quo. As part of a teacher learning community, teachers can stay current in their discipline and remain professionally active (DuFour & Eaker, 1998; McLaughlin & Talbert, 2006). In order to effectively implement research-based strategies in the classroom, teachers must work together to gather, synthesize, and reflect on new information.

Finally, in assessing the impact of developed curriculum, tasks, and assessments, teachers in PLCs must have a results orientation (DuFour & Eaker, 1998). Teachers with a results orientation do not allow their goals and intentions to serve as evidence of success and instead use data to determine their successes and failures. From these conclusions, teachers should then determine new and appropriate strategies for their classroom and their students. Teachers need to be open with their results within their PLC team in order to identify areas for concern and formulate possible solutions. This again requires norms for critique and reflection within collaborative groups.

DuFour (2004) warns that the term professional learning communities, “has been used so ubiquitously that it is in danger of losing all meaning” (p. 6). The term PLC has become more and more popular and has been used to describe grade-level teams, committees, high school departments, and entire school districts. However, DuFour et al. (2005) have found many schools claiming to be PLCs without evidence of the implementation of the core principles of a PLC.

In fact, to truly implement a PLC is a difficult process--a clear point given the lack of communities that can truly be defined as PLCs across research. However, in cases where the
successful implementation of a PLC has occurred, certain structural and environmental factors are apparent. One factor is the availability of scheduled planning time (Louis et al., 1996; McLaughlin & Talbert, 2001). With the need for shared values and norms, opportunities for collaboration, and supportive conditions comes the need for the availability of meeting time for teachers in a PLC. An example of this need can be found in the description of a professional development experiences from Borko et al. (2008). In their description of a professional development experience, a summer institute and early workshops were devoted to the establishment of a professional learning community. With this focus, participants and facilitators were “comfortable engaging in critical dialogue and reflection” (p. 423). On the other hand, McLaughlin and Talbert (2006) attribute difficulties in implementing PLCs to a lack of meeting time.

While structural changes are often easier to make than more fundamental changes to a school’s culture, setting aside time for teachers in a PLC to meet has been found to be difficult itself. In a study of a high school implementing PLC principles, Wells and Feun (2007) found that time built into the school day faced opposition from a teachers’ union. This forced enthusiastic staff members to independently meet in small groups. Teachers were also found to take issue with organized meeting time claiming that it takes away from their planning time during the school day. Issues such as these make clear the assertion that, while scheduled time is a valuable asset to the development of a PLC, it alone will not guarantee successful implementation.

Louis et al. (1996) attributed the development of PLCs to what they referred to as “teacher empowerment” and “openness to innovation” (p. 762-763). McLaughlin and
Talbert (2001) also identified positive changes in communities where teachers were supported to investigate classroom-based challenges and develop responses to those challenges. This idea is followed up in their definition of learning communities, stating that teachers should have influence over the content and context of their investigations (McLaughlin & Talbert, 2006).

The affordance of such authority to teachers requires changes in both the culture of a school and the habits of teachers (Vescio et al., 2008). However, teachers who are not granted the ability to have an input into school-based decisions will begin to question the purpose of PLCs, as Wells and Feun (2007) observed in their analysis of the top-down implementation of PLC principles at the high school level. Teachers may also feel constrained by the nature of the content they teach. Louis et al. (1996) found that professional communities are more difficult to implement in high schools because of both the diversity of goals from department to department and the perceived lack of empowerment on behalf of the teachers due to subject objectives and testing requirements. As a result, teachers were less inclined to test innovative methods. It is not clear though if these teachers were granted the power to make curricular decisions or if there is an inherent roadblock in the later grades.

Teachers are often found to be participating in PLCs that are being implemented school-wide (DuFour & Eaker, 1998; Louis et al., 1996; Bezzina, 2006; Wells & Feun, 2007). Across research, PLCs are implemented as a way to make fundamental changes throughout a school, to set high standards for all students, and promote student-centered learning environments. Studies have shown positive changes in the practice of teachers in
PLCs and, in turn, their students’ achievement (Vescio et al., 2008; Little, 2002; McLaughlin & Talbert, 2001; Louis & Marks, 1998; Hord, 2004).

Louis et al. (1996) found that involvement in PLCs results in increased responsibility for student learning on behalf of teacher, administration, and staff. In a case study of a professional community within a mathematics department, McLaughlin and Talbert (2001) described how the department organized around a strong commitment to the belief that all students could succeed. As a result, teachers retooled their practice to accommodate students, all without watering down the material. In reviewing research on PLCs to determine their impact on student learning, Vescio et al. (2008) found that, in many cases, the practices of teachers participating in PLCs became more student-centered over time. Teachers have also been found to be more willing to incorporate authentic pedagogy and more cognitively demanding work (Louis & Marks, 1998; Hord, 2004). In all, due to teacher collaboration and a focus on meeting the needs of all students, student achievement has been reported to improve (Vescio et al., 2008).

Despite these findings, work that empirically looks at the benefits of PLCs specifically on teachers’ practices and, thus, student learning is not abundant (Vescio et al., 2008). Furthermore, while DuFour and Eaker (1998) propose that implementing the team concept based on grade level or subject will provide teachers with shared objectives and problems, little work has been done to evaluate subsets of a school (departments or small groups) and their implementation of the principles of PLCs (e.g., McLaughlin & Talbert, 2001; Borko et al., 2008).
Overall, PLCs serve as a way for teachers to critically reflect on their practice and make improvements to meet the rapidly changing demands from students and standards. However, as the idea of PLCs is not discipline-specific, the responsibility is put on the teacher to incorporate a content focus. Other professional development programs rely on collaboration but are rooted in the content area on which teachers aim to focus.

*Collaborative Mathematics Professional Development*

Many examples of MPD experiences have teachers working collaboratively. This appears as PLCs (Borko et al., 2008; Stein et al., 1998), lesson study groups (Fernandez et al., 2003; Stigler & Hiebert, 1999), and other study groups (Arbaugh, 2003; Kazemi & Franke, 2004; Loucks-Horsley et al., 1998). Many MPD interventions claim to rely on the shared values and norms for critical reflection that are part of PLCs. However, a team’s inclination to critical reflection is not the only component of most MPD interventions.

Based on observations from the Third International Mathematics and Science Study, Stigler and Hiebert (1999) found that mathematics teachers need ways to learn about teaching and, most importantly, student learning using the recommendations of reform. As such, the success of an MPD program is determined by changes in teachers’ practice toward the development of student-centered instruction, the use of authentic mathematical tasks, and the appropriate use of classroom technology in order to positively impact student achievement. Incorporating rich activities and materials that focus on mathematical content and pedagogy into the collaborative experience fosters these changes.

In order for teachers to embrace the ideas of mathematics reform, they themselves must possess deep understanding of content and pedagogical knowledge (Hill et al., 2005;
Stein et al., 1998). Many professional development experiences reported in research have incorporated elements that address both of these needs. This occurs when teachers work through tasks that will be used in the classroom, work with appropriately challenging mathematics, or stay current with research on mathematics content and pedagogy.

Stein et al. (2000) described situations when teachers would collaborative reflect on accounts of classroom instruction, commonly referred to as case study (Stein et al., 2000; Loucks-Horsley et al., 1998). When working with cases, Stein et al. (2000) urge that teachers should work through the tasks that were used in the classroom to develop a richer understanding of the mathematics being discussed. Similarly, Borko et al. (2008) highlighted a Problem-Solving Cycle, which started with teachers working through tasks that they planned to teach in class. Activities such as these allow teachers to focus on the content knowledge necessary to plan a given task.

Other professional development experiences have teachers working with challenging mathematics in environments similar to that which they are encouraged to set up in their own classrooms. During their summer algebra institute, teachers involved with the “Supporting the Transition from Arithmetic to Algebraic Reasoning” (STAAR) Project worked through mathematical problems in a reform-oriented setting (Borko et al., 2005). Teachers involved in a professional development course, highlighted by Lachance and Confrey (2003), worked in small groups with multimedia pre-calculus materials on authentic problems to help teachers become acquainted with learning and teaching from a constructivist perspective. Other professional development experiences described in research (e.g., Peressini & Knuth, 1998; Borasi et al., 1999; Lewis, Perry, & Murata, 2006) also engaged teachers in problem
solving activities to support their development of content knowledge and address pedagogical issues associated with reformed practice.

Teachers have also developed pedagogical understanding through studying, analyzing, and evaluating current literature on theory and practice. In describing a process called “lesson study”, Stigler and Hiebert (1999) stated that, when planning lessons, Japanese teachers would search for books and articles on problems and topics similar to the ones that they are addressing. One of the major activities during the STAAR summer institute (Borko et al., 2005) was to read and discuss current literature. Teachers involved in a study group facilitated by Arbaugh (2003) read literature on the Mathematical Tasks Framework (Stein et al., 2000) and had a discussion as part of their first meeting.

Another important part of many effective professional development experiences for mathematics teachers involves how teachers assess student learning. While DuFour and Eaker (1998) urge that teachers in PLCs should have a results orientation, much of the emphasis in their description of results refers to assessments, specifically data yielded from multiple-choice assessments. However, there are other sources of results that can be obtained from the classroom. Two of the professional development strategies highlighted by Loucks-Horsley et al. (1998) involved examining student work and student thinking and case discussions.

Many of the professional development experiences already highlighted in this review incorporated artifacts from the classroom in various forms. Some artifacts simply provide a window into the classroom. This could come in the form of written cases and reflections (Stein et al., 2000), video recordings (Borko et al., 2008), or live observations (Fernandez et
al., 2003; Stigler & Hiebert, 1999; Arbaugh, 2003). While video and written case materials exist commercially, the work of students in classrooms is most meaningful if it is from participants’ own classrooms. This requires the norms for inquiry and reflection that let teachers feel comfortable when opening up their classroom to a group of peers.

Each form of classroom record provides its own benefits. According to Lewis et al. (2006), live lessons allow observers to make note of relevant conditions that may not be noticed on video or by the classroom teacher. Live lessons also afford observers the opportunity to circulate throughout the room to observe the work that students are doing more closely (Stigler & Hiebert, 1999). Video recorded and written accounts of classroom events provide teachers with the opportunity to take a closer look at the lesson and the learners’ experiences (Lewis et al., 2006). These methods also allow teachers to revisit a lesson several times with the intent to focus on specific aspects of a lesson (Borko et al., 2008; Stigler & Hiebert, 1999). Overall, Borko et al. (2008) found that teachers value the experience of video study as it allowed them to investigate their own students’ capacity for reasoning.

The students themselves produce other useful artifacts that can be used during the analysis of a lesson. While live observations provide the freedom to observe what students are doing as they work, samples of student work or written accounts of their verbal discussions have also been used as part of professional development experiences for mathematics teachers. In the workgroups described by Kazemi and Franke (2004), teachers collectively examined student work thus shifting teachers’ focus to their own students’ thinking. This sort of investigation allowed teachers to realize the mathematical
understandings (or misconceptions) that their student have. Teachers involved in the MPD program described by Borko et al. (2008) devoted entire workshops to a focus on students’ thinking and solution methods. Of course, to be able to obtain this rich information, teachers must reconsider the work they do in the classroom. In order to obtain meaningful work from students, teachers must engage their students in discussions about their thinking instead of simply collecting work that was done at home (Kazemi & Franke, 2004). Teachers must also select tasks that elicit verbal and written responses from students to provide teachers with a lens into their understanding (Lewis et al., 2006).

While these activities are important in strengthening the content focus of MPD programs, what is less clear about these interventions (and their eventual success) is the significance of the role of PLC-type collaborative norms versus other potential factors. As part of these MPD interventions, teachers work with facilitators, have varying levels of input into the design of an intervention, take part in other forms of professional development or graduate coursework, and are motivated by factors such as the implementation of a reform curriculum. Often, teachers themselves do not implement the aforementioned activities and materials. Given that there is little documentation of the nature of the work that teachers to while working in PLCs, it is unknown if teachers, if given the chance, would implement these practices themselves.

Framework

When comparing the literature on professional communities, PLCs, and collaborative MPD, there are differences in terms of the activities teachers do, the quality of their content focus, and what teachers ultimately take away from the experience. Further, some types of
collaborative settings rely on many of the characteristics of another type. For instance, PLCs rely on a focus on student learning, experimentation, and inquiry but also rely on the shared values that comprise more traditional collaborative groups. Collaborative MPD interventions often consist of specific activities that focus teachers’ attention to students’ mathematical thinking. However, the productive use of these types of classroom artifacts relies on the shared practice, results orientation, and comfort with critical reflection, traits which are attributed to PLCs.

To help coordinate the strengths of PLCs and MPD, a conceptual framework has been developed to illustrate both the hierarchy and the links among different types of collaborative work (see Figure 1). The framework refers to three stages: Collaboration, Teacher Learning, and Specialized Growth. By using the term stages, it is implied that the features of each type of collaborative setting serve as a necessary foundation for subsequent types of work.

![Figure 1. Conceptual framework: Stages of collaborative work of mathematics teacher teams.](image-url)
To better describe the attributes and features of these three stages, elements have been identified for each. The Collaboration stage consists of three elements that are attributes of teacher collaboration. First are a teacher’s beliefs on collaboration. This consists of the value that a teacher places on the benefits of collaboration as well as their comfort with collaborating with other teachers. Next, shared values and goals, no matter how traditional, are important when teachers collaborate (Louis et al., 1996; McLaughlin & Talbert, 2001). Finally, teachers who collaborative have a shared role both in their verbal participation and their responsibilities with group work.

The Teacher Learning stage consists of three elements in addition to those in the previous stage. These elements come from literature that has defined the work of PLCs. First, teachers at this stage engage in collective inquiry by utilizing and testing a shared practice derived from recommendations from current literature (Hord, 2004; McLaughlin & Talbert, 2006; Louis et al., 1996). Teachers at this stage also have results orientation, described earlier as an inclination toward using data as evidence for success and making changes to practice based on those conclusions (DuFour & Eaker, 1998). Finally, the work of teachers should focus on student learning by developing goals for student achievement and focusing on issues of curriculum, instruction, and assessment (DuFour & Eaker, 1998; McLaughlin & Talbert, 2006; Hord, 2004).

Finally, the Specialized Growth stage has three elements derived from research on effective MPD programs. Teachers working at this stage focus on mathematical content, regarding both their own knowledge and how to teach (Hill et al., 2005; Stein et al., 1998). In addition to assessment data, teachers at this stage use of artifacts of practice when
reflecting on instruction and student learning (Ball & Cohen, 1999). Finally, teachers must also show evidence of planning and implementing reform-inspired instructional practices, as this is often a goal of MPD initiatives (Ross & Bruce, 2007; Borasi et al., 1999; Loucks-Horsley et al., 1998). Table 1 summarizes each of the three stages and their respective elements. Additionally, the explanation of each element found above is summed up with what are called “descriptors”.

Each stage also refers to the type of growth that teachers experience at each stage. At the Collaboration stage, teachers worry about logistical and other non-instructional issues, resulting in unchanged practice. However, by working collaboratively and setting goals for their work with each other and their students, teachers at this stage experience organizational growth. Teachers at the Teacher Learning stage function as a PLC and, in turn, focus on issues of curriculum, instruction, and assessment resulting in a general pedagogical growth. At the Specialized Growth stage, teachers are focused not only on teaching but are also focused on content, fostering specialized growth in both mathematics content and pedagogy.

Previous work has documented the factors attributed to fostering a group of teachers’ movement toward becoming a PLC (stage one to stage two). While structural features such as the availability of meeting time are beneficial toward the growth of a group, other factors such as the empowerment of teachers to be involved in the decision-making process (Louis et al., 1996), a focus on issues of curriculum and instruction instead of issues of behavior and policy (McLaughlin & Talbert, 2006), and the use of classroom data to drive decision-making (DuFour & Eaker, 1998) help develop a group of teachers into a PLC.
Table 1. Conceptual framework: Stages, elements, and descriptors of mathematics teachers’ collaborative work

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<th>Stage</th>
<th>Elements</th>
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<td>1.2. Shared values and goals</td>
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<td>1.3. Shared role</td>
<td>1.3.1. Participation</td>
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<td>1.3.2. Shared responsibilities</td>
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<td>2. Teacher Learning</td>
<td>2.1. Collective inquiry</td>
<td>2.1.1. Remaining active in the profession</td>
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<td></td>
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<td>2.1.2. Collaborative planning</td>
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<td>2.1.3. Experimentation</td>
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<td>2.2. Results orientation</td>
<td>2.2.1. Analysis of classroom data</td>
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<td>2.2.2. Drawing conclusions from classroom data</td>
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<td>2.2.3. Refining classroom materials from conclusions</td>
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<td>2.2.4. Refining instructional practice from conclusions</td>
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<td>2.3. Focus on student learning</td>
<td>2.3.1. Focus on goals for student learning</td>
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<td>2.3.2. Focus on issues of curriculum, instruction, and assessment</td>
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<td>3. Specialized Growth</td>
<td>3.1. Content focus</td>
<td>3.1.1. Use of research on mathematical content and pedagogy</td>
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<td></td>
<td>3.1.2. Engaging with mathematical content</td>
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<td>3.1.3. Focus on mathematical concepts</td>
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<td></td>
<td>3.2. Use of artifacts of practice</td>
<td>3.2.1. Use of classroom artifacts such as video and observation</td>
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<td></td>
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<td>3.2.2. Use of student work</td>
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<td>3.2.3. Drawing conclusions from artifacts of practice</td>
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<td>3.3. Implementation of reform-inspired...</td>
<td>3.3.1. Planning and use of mathematical tasks</td>
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<td>instructional practices</td>
<td>3.3.2. Planning and use of technology</td>
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The transition of a PLC consisting of mathematics teachers to a group engaging in the type of activities found in effective MPD (stage two to stage three) is not as clear. While many MPD interventions claim to value and rely on collaboration and the traits of PLCs, researchers or facilitators drive many of the decisions for activities and content. In order for PLCs to serve as a source of professional development for mathematics teachers, the role that they play in the specialized growth of teachers must be better defined.

Research Questions

In order for PLCs to serve as an effective form of MPD, more work needs to be done to identify the extent to which mathematics teachers in PLCs engage in the activities that improve their content and pedagogical knowledge and, ultimately, improve student achievement. To evaluate PLCs as an effective form of MPD, the study described here investigated two teams of teachers attempting to implement principles of PLCs as part of a district-wide intervention. The goal of this study is to identify both teams’ success in implementing these principles and to what extent the presence of features that are commonly found in effective MPD is evident in their work.

The specific research questions are as follows:

1) Considering the model that their school district is promoting, how well are these two teams of teachers operating as a PLC (stage one and two)?

2) What factors are associated with each team being able to exist (or not) as a PLC?

3) To what extent are the teachers in each team collaboratively engaged in the type of activities that are commonly found in effective MPD (stage three)?
4) What factors are associated with each team’s success or struggle to make a transition from stages one and two to stage three and engage in high-level, content focused activities?

By answering these questions, the author will highlight the role of PLCs in the professional development of mathematics teachers, as well as other factors that could be attributed to a group of teachers’ inclination to engage in high-level, content focused activities. As a result, the author will offer suggestions for future research on collaborative MPD and how findings from such research could be used to inform the design and replication of MPD.
CHAPTER 3
METHODOLOGY

The researcher chose to study two teams of high school mathematics teachers attempting to implement the principles of professional learning communities as part of a district-wide intervention to determine both their success in implementing those principles and the extent to which they engage in the type of activities found in effective mathematics professional development. The purpose of this chapter is to justify the choice of methodology used for investigating the questions, describe the context of the study, the participants involved in the study, and the methods used in the data collection and analysis.

Justification for Methodology

In order to answer the research questions stated at the end of the previous chapter, a case study methodology was used (Stake, 1995; Yin, 2008; Merriam, 1998). For this study, a case is defined as a team of mathematics teachers attempting to implement the principles of PLCs as set forth by their district. Specifically, two cases were investigated as part of this study. As stated by Stake (1995), case study allows the researcher to study the complexities of a single case and understand, “its activity within important circumstances” (p. xi). Further, case study methodology allows for the study of multiple teams of teachers at different locations within the same program, in this case the district’s implementation of PLCs (Stake, 2006). For this study, survey data or students’ and teachers’ test scores would not sufficiently explain the collaborative work of a group of teachers or the factors influencing their work.
As such, the primary level of analysis consisted of a record of each team’s interactions. Supplemental data from individuals were also taken to further explain each group’s interactions and also examine any conflicting or agreeing perspectives amongst the team members. This triangulation of data (Stake, 1995; Merriam, 1998) provides a more convincing and consistent picture of each group.

Context of the Study

The study took place in a large, urban school district in the southeastern United States which is one of the largest in the country. The district was one of many school systems involved in a school and business consortium with the goal of improving high school graduation rates. As a result of their involvement with this partnership, as well as a mission to stay current with movements in the field of education, the district adopted the idea of PLCs to be implemented throughout its schools. At the time of this study, PLCs had been implemented in the district for two years. To help the researcher understand the context of the use of PLCs in this district, an interview was conducted with a district administrator that was integral in the implementation of the PLCs. The information that follows was gained from that interview.

The district made a decision to promote the principles for PLCs described by DuFour and his colleagues (DuFour & Eaker, 1998; DuFour et al., 2005; DuFour, 2004) as the result of an existing relationship between the district and DuFour’s group. Despite promoting this particular set of practices, literature, and training, administrators in the district are also cognizant of the broader work on PLCs having done their own research on collaboration in
schools and business. Based on this work, district administrators value the power of coming together and sharing conversations in the reflective practice of teachers.

Workshops and large group presentations to introduce the principles of collaborative learning were held and attended by hundreds of teachers from the district. At the secondary level, teachers were informed to work in subject-specific teams, planning common lessons, investigating current issues in their field, and evaluating their practice using assessment data. One main goal of this work was to increase student achievement on the end-of-year state exams. As the district contends that teachers are not developing the requisite collaborative skills in their teacher education programs, work is being done to ensure that teachers are given adequate time to work collaboratively as they develop the skills to function as members of a PLC. Ultimately, district administrators hope that this format can help with the professional development of teachers, both as a time to administer professional development and as a form of professional development itself.

Participants

For this study, the collaborative practices of two teams of teachers were investigated during the first semester (Fall) of the 2008-09 school year. The North Carolina State University Institutional Review Board approved all methods and instruments used in this study. The approval letter (IRB# 205-08-5) can be found in Appendix I. Both teams’ involvement in the study was the result of a positive response from each team’s members after the researcher gauged interest from several schools across the district. Their positive response to participate and their comfort with the researcher was important given the researcher’s role as a non-participant observer.
In choosing the teams, in addition to their interest in participating, the course on which the teams focused and the schools at which they were based were also taken into consideration. Both teams were focusing on their Algebra I classes, which provided some control in the event of any comparison. The two teams were housed at different schools in the same district, Brantley High School and Elmwood High School (both pseudonyms). Both schools each housed more than 2000 students. The student population at each school consisted of students from across the district, including a large percentage of students from the urban center of the district. Additionally, each school’s mathematics department was comprised of more than 15 mathematics teachers. Both schools offered similar programs, especially for advanced students.

*Brantley High School*

The team that participated in the study from Brantley High School consisted of five teachers who were focusing on their Algebra I classes. Students attend their Algebra I class every day for approximately 90 minutes each day. Of the five teachers, three were female (Hillary, Kate, and Samantha) and two were male (Luke and Vincent). Four of the teachers (Hillary, Kate, Samantha, and Luke) had five or fewer years of teaching experience and all five teachers had between two and four years of experience teaching Algebra I. Two of the teachers (Luke and Vincent) worked in other professions before starting their teaching career.

The implementation of PLC principles at Brantley High School began at the start of the school year prior to this study. Kate and Luke were designated as co-leaders of the team by group consensus and the fact that Kate was actively involved in the introduction of these principles at the school level as the department co-chair. Samantha was also a participant of
the original Algebra I team. Hillary and Vincent were new to the team for the year of this study. There are three other Algebra I teachers who are not on this team. At Brantley, there are only teams for Algebra I, Geometry, and Algebra II, all of which are courses that culminate in end-of-year state exams. For teachers who teach more than one of those classes, they were placed on one of the teams based on prior test scores or experience. The department co-chairs made these decisions with input from the teachers themselves.

During the year of this study, Samantha took on the role of team leader. However, Luke continued to attend the district-wide Algebra I team leader meetings. Every Tuesday, students at Brantley High School have a late start as teachers have built in time in the morning to meet with their teams. This serves as the vast majority of the meeting time for this Algebra I team.

*Elmwood High School*

The team that participated in this study from Elmwood High School consists of four teachers teaching an Algebra I course targeted for students who have previously taken and failed the course. Like at Brantley High School, students in these Algebra I classes meet for about 90 minutes each day. All students will end the year with the state test for Algebra I. There are two other teams at the school composed of teachers who teach other versions of Algebra I: one is a course for students who took Algebra I as accelerated eighth graders and are retaking the course and the other is for a more “traditional” Algebra I course.

Of the four teachers, three were female (Jackie, Sabrina, and Pam) and one was male (Doug). There was generally more teaching experience on this team than on the team at Brantley High School, with three of the four teachers (Jackie, Sabrina, and Doug) having
taught for at least ten years. Two of the teachers (Jackie and Doug) had taught Algebra I for 13 years each but the other teachers were in their first year of teaching the course. Additionally, those teachers (Sabrina and Pam) were in their first year at Elmwood High School. As a result, the team had a far different look than it did in the year prior to this study. Jackie served as the team leader and was also in the process of completing her administrative internship as part of a graduate program. Jackie also attends the district-wide Algebra I team leader meetings. Like at Brantley High School, teams at Elmwood meet on Tuesday mornings as part of a scheduled late start for students. This serves as the vast majority of the meeting time for this team.

Sources of Data

Data was collected for this study using three sources: team meeting observations, individual surveys, and individual interviews. As previously stated, observations of team meetings served as the primary source of data as it provided a record of each group’s collaborative interactions. Based on the framework used for the study (namely the descriptors), the researcher developed appropriate questions for the surveys and interviews that would ensure the opportunity to observe or explore aspects of each stage of the framework. As previously stated, using these three data sources allowed for triangulation of data to ensure the consistency of observed phenomena across different environments.

For each PLC team, the researcher observed four of the Tuesday morning team meetings, usually lasting 45 minutes each. Field notes were taken by the researcher on attendance, seating arrangement, general flow of the meeting, and any observations that may be relevant to the study. The meetings were also audio-recorded for recall purposes.
The teachers participating in the study were given two surveys, one at the start of data collection and one at the end. The first survey (see Appendix A) consisted of demographic information such as age and teaching experience as well as information on their involvement in professional development experiences. The second survey (see Appendix B) consisted of written response questions on the teachers’ and teams’ goals for their collaborative interactions. Both surveys included identical Likert scale questions regarding teachers’ experiences with their team and the activities in which they engage with their teams. The Likert scale questions used in the survey were adapted from two existing surveys (McLaughlin & Talbert, 2001; Wells & Feun, 2007) as they highlighted aspects of the Collaboration and the Teacher Learning stages. The additional questions that required a written response addressed aspects of the framework that were not addressed by the Likert scale questions. The teachers completed both surveys during the data collection period, one at the start in the early weeks of the school year and one at the end of data collection. This was to ensure consistency in responses and account for the lack of experience of new team members at the beginning of the PLCs work as a team. Due to the relatively short duration of data collection, there was not a goal to compare the data from the two surveys as a possible measure of growth over time.

The teachers also participated individually in two semi-structured interviews over the course of data collection. The first interview (see protocol in Appendix C) was designed to allow teachers to elaborate on their experiences with their team as well as other forms of professional development. The interview also painted a picture of each teacher’s classroom by having teachers explain their “ideal mathematics lesson”. The second interview (see
protocol in Appendix D) was designed for a far different goal. For this interview, teachers were presented with three tasks of varying cognitive demand based on a similar story and asked to analyze and rate each task in their own opinion. The teachers were also presented with sample student work for each problem and asked to analyze each student’s understanding based on the presented work. This interview was designed to explicate teachers’ dispositions when analyzing tasks and student work as well as their willingness to use high-level mathematical tasks. This information helped in the analysis of a group’s work with demanding tasks or explaining why the group did not engage in such work.

Methods and Analysis of Data

All team meetings and interviews were fully transcribed. For both team meetings and individual interviews, coding sheets were developed to pair positive indicators of effective group interactions and professional development with a corresponding element or stage. Individual codes were determined prior to data collection and analysis and were based on expectations for how certain interactions and behaviors would appear within team meetings and individual interviews. Examples of codes can be found in Table 2. Full versions of the coding guides for team meetings and individual interviews are found in Appendices E and F, respectively.

Analysis of Team Meeting Audio Recordings

For the analysis of the data collected in this study, the audio recordings of team meetings, along with the researcher’s field notes, were analyzed first as they were the most representative source of what the teams of teachers did with their meeting time. The analysis of team meetings consisted of three phases: annotation, coding, and summary. During the
Table 2. Examples of codes used in analysis of team meetings and individual interviews

<table>
<thead>
<tr>
<th>Stage</th>
<th>Element</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collaboration</td>
<td>1.2. Shared values and goals</td>
<td>B1 – Redirection</td>
</tr>
<tr>
<td>2. Teacher Learning</td>
<td>2.1. Collective inquiry</td>
<td>D3 – Mention of common plans, activities, or assessments</td>
</tr>
<tr>
<td>3. Specialized Growth</td>
<td>3.2. Use of artifacts of practice</td>
<td>H2 – Looking at student work beyond answers as part of results analysis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Examples of Codes for Individual Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage</td>
</tr>
<tr>
<td>1. Collaboration</td>
</tr>
<tr>
<td>2. Teacher Learning</td>
</tr>
<tr>
<td>3. Specialized Growth</td>
</tr>
</tbody>
</table>

annotation phase, the audio recordings were segmented into two-minute intervals. Within each interval, a record was kept of the events of the meeting including any notable quotes.

Each interval was then revisited and coded with all applicable codes based on the events and focus of the team meeting at that time. Examples of coded instances can be found in Table 3. The researcher also made note of any “distracters”, or aspects of the meetings that took away from positive growth as defined by the framework, for potential use in the overall analysis of the data. The intervals served as a way to segment the team meeting into more manageable pieces but also provided a way to offer a rough estimate of the amount of meeting time that was devoted to certain topics or activities. For example, as seen in the Brantley Team Meeting Coding Sheet in Appendix G, during the 09/09/08 meeting, five
Table 3. Examples of coded instances during team meetings

<table>
<thead>
<tr>
<th>Code</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 – Redirection</td>
<td>Instance where discussion of one or more teachers is interrupted to change topics, typically to get “on topic” according to the agenda/goals of the team</td>
</tr>
<tr>
<td>D3 – Mention of common plans, activities, or assessments</td>
<td>Instance where team discusses or even mentions lesson plans, activities, or assessments that are being used by all teachers on the team. Discussions can involve formal or informal evaluation of success. (Note: The development of these materials are another code within the same element)</td>
</tr>
<tr>
<td>H2 – Looking at student work beyond answers as part of results analysis</td>
<td>Instance where team is analyzing data from the classroom and references student work beyond answers or multiple-choice responses. This type of analysis provides a deeper insight into the understanding of students.</td>
</tr>
</tbody>
</table>

intervals were coded with “Analyzing classroom data”. As a result, we can roughly say that ten minutes were spent on this activity, which is approximately 22 percent of the meeting time for that day. This also allowed for a rough estimate of the amount of meeting time spent on activities and discussions that were deemed productive as part of the framework. Coding sheets from both Brantley and Elmwood team meetings can be found in Appendices G and H, respectively.

After all of the team meetings were annotated and coded, the data was summarized. Since this study aimed to determine both the effectiveness of implementation and the extent of the inclusion of certain activities, each team was rated within each element and, thus, each stage. Ratings were based on the frequency and consistency of observable indicators and
other evidence of incorporating the elements of each stage found during the four team
meetings. While these ratings measured the quantity of codes, the quantity of codes at
different stages of the framework indicates quality as well. Within one element, a team was
rated as “High” if there were consistent and multiple observed indicators across data sources
and individuals. A team was rated as “Moderate” for an element for either slightly less
frequency or less consistency. A rating of “Low” was assigned to an element if there was
only occasional evidence of indicators with much less consistency. Finally, a team received
a rating of “None” for an element if there was negligible or no evidence of positive indicators
for a given element. Complete ratings and explanations can be found in the next chapter.

Analysis of Individual Teacher Interviews

Individual interviews were analyzed in a similar fashion to the team meeting audio
recordings, going through three phases: transcription, coding, and summary. The researcher
transcribed each interview using the audio recordings that were taken. Each transcript,
including any work done by each teacher during the second interview, was then coded using
the codes developed for this source of data. Examples of coded instances can be found in
Table 4. Like with the team meeting coding, the researcher also made note of any distracters
for potential use in the overall analysis of the data.

Once the interviews were coded, the data was summarized. Here, the researcher
looked for consistency both across all teachers from one team and from the team meeting
analysis to the interview analysis. As planned, consistencies across multiple data sources
would serve as a way to verify observations from the team meetings.
Table 4. Examples of coded instances during individual interviews

<table>
<thead>
<tr>
<th>Code</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4</td>
<td>Evidence or mention of being comfortable sharing new ideas with team</td>
</tr>
<tr>
<td></td>
<td>Teacher explicitly mentions his/her comfort with sharing new ideas with the team or describes instances where he/she shared new ideas with the team</td>
</tr>
<tr>
<td>F4</td>
<td>Mention of goals for student achievement</td>
</tr>
<tr>
<td></td>
<td>Teacher explicitly mentions the team’s goals for student achievement</td>
</tr>
<tr>
<td>I7</td>
<td>Mention of incorporating new practices such as use of technology and high-level tasks</td>
</tr>
<tr>
<td></td>
<td>Teacher mentions the use of practices such as the use of technology and high-level tasks</td>
</tr>
</tbody>
</table>

Analysis of Individual Teacher Surveys

Survey questions were regrouped within the stages and elements of the framework in order to further identify any trends or inconsistencies across data sources or individuals. Within each question, the average and median rating was taken across all team members. Further, the average score of each team member within an element was calculated. Additionally, while growth across pre- and post-study surveys was not investigated, changes in individual responses between surveys were noted for potential use in the overall analysis of the data. For written responses on the surveys, responses were compared across each team and any consistencies or inconsistencies were noted.

Overall Analysis of the Data

By then combining the results across all data sources, consistencies could be noted in order to identify the strengths and weaknesses of a team at each element and stage of the framework. Any strengths of each team were further analyzed using information from the team meetings, individual responses, and even teachers’ demographic information. Similarly, weaknesses of each team were analyzed using the collected data. Any inconsistencies across
the three data sources were also further examined for possible factors associated with fostering or inhibiting collaborative growth and teacher learning in mathematics. From all of this information, a narrative was developed for each team describing their effectiveness at each element, and stage of the framework and the reasons for their successes or struggles as a collaborative team. The researcher also used cross-case analysis as another way to identify factors associated with the successes and struggles of each team’s collaborative and individual growth. These narratives are presented in Chapter 4, followed by the conclusions and discussions in Chapter 5.
CHAPTER 4

RESULTS

This chapter presents the findings of the data analysis. The results from each team will be presented separately. Using data collected from the data sources described in Chapter 3, each case will describe the team’s strengths and weaknesses at each element and, in turn, stage in order to evaluate the collaborative work of those mathematics teachers. Additionally, any observed or perceived factors involved in a team’s strengths or weaknesses will be highlighted within each case.

In doing so, this study seeks to answer the following questions, previously stated in Chapter 2:

1) Considering the model that their district is promoting, how well are these two teams of teachers operating as a PLC (stage one and two)?

2) What factors are associated with each team being able to exist (or not) as a PLC?

3) To what extent are the teachers in each team collaboratively engaged in the type of activities that are commonly found in effective MPD (stage three)?

4) What factors are associated with each team’s success or struggle to make a transition from stages one and two to stage three and engage in high-level, content focused activities?

Results from Brantley High School

The team that participated in the study from Brantley High School consisted of five teachers: Hillary, Kate, Samantha, Luke, and Vincent. Four of the teachers (Hillary, Kate, Samantha, and Luke) had five or fewer years of teaching experience and all five teachers had
between two and four years of experience teaching Algebra I. Two of the teachers (Luke and Vincent) worked in other professions before starting their teaching career. Luke, Kate, and Samantha worked together in the year prior to this study on an Algebra I team. Hillary and Vincent were new to the team during the year of the study. Samantha served in the role of team leader.

The following section describes the nature of the collaborative work of the Algebra I team at Brantley High School. This narrative serves as a description of a team that has been successful at implementing the principles of PLCs yet was not effective in implementing the type of activities that are commonly found in effective MPD interventions. Additionally, special attention will be paid to the factors that influenced this team’s success at stages one and two and their struggles transitioning to stage three. A description of the team’s work will be given for each element of the framework as well as a rating. A summary of these ratings can be found in Table 5.

Stage 1: Collaboration

The Collaboration stage consists of three elements: beliefs on collaboration, shared values and goals, and shared role. In order to evaluate this team as a professional community, the three elements must be explored. This section will describe the team through the lens of each of these elements in order to describe their performance.

1.1. Beliefs on collaboration. Within the framework used for this study, two descriptors were used to qualify the beliefs of the individuals on a team regarding collaboration: value of collaboration and comfort with collaboration. As with all of the results reported in this chapter, a team’s strength or weakness within a given element is based
Table 5. Summary of Ratings for Brantley High School with Explanations

<table>
<thead>
<tr>
<th>Stage</th>
<th>Element</th>
<th>Rating</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collaboration</td>
<td>1.1. Beliefs on collaboration</td>
<td>High</td>
<td>Maximum use of meeting time; Good attendance; Preferring collaboration over isolation; Comfort with and openness to sharing ideas with team</td>
</tr>
<tr>
<td></td>
<td>1.2. Shared values and goals</td>
<td>Moderate</td>
<td>Common goal to share classroom materials in order to ease burden; Varied reasons for why teachers want to share materials and how to go about doing that</td>
</tr>
<tr>
<td></td>
<td>1.3. Shared role</td>
<td>Moderate</td>
<td>Very uneven participation and distribution of responsibilities; However, teachers in agreement over role</td>
</tr>
<tr>
<td>2. Teacher Learning</td>
<td>2.1. Collective inquiry</td>
<td>Moderate</td>
<td>Teachers active in profession through professional development, though not extensive; Team engages in a shared practice; Team experiments some with curriculum and “spiraling”</td>
</tr>
<tr>
<td></td>
<td>2.2. Results orientation</td>
<td>High</td>
<td>Frequent analysis of assessment data; Refinement of assessments and classroom materials based on conclusions drawn from data</td>
</tr>
<tr>
<td></td>
<td>2.3. Focus on student learning</td>
<td>High</td>
<td>Common goal for student achievement; Much of collaborative time is focused on issues of curriculum, instruction, and assessment</td>
</tr>
<tr>
<td>3. Specialized Growth</td>
<td>3.1. Content focus</td>
<td>None</td>
<td>No evidence of mathematical content focus</td>
</tr>
<tr>
<td></td>
<td>3.2. Use of artifacts of practice</td>
<td>None</td>
<td>No evidence of use of artifacts of practice such as classroom video or student work</td>
</tr>
<tr>
<td></td>
<td>3.3. Implementation of reform-inspired</td>
<td>None</td>
<td>No evidence of the planning or use of reform-inspired instructional practices such as cognitively demanding tasks or technology</td>
</tr>
<tr>
<td></td>
<td>instructional practices</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

52
on observations from team meetings as well as responses to interview and survey questions. More detailed explanations of the data sources can be found in Chapter 3.

For the team at Brantley, it was evident that there was a high value placed on collaboration by the teachers. One indicator of this was the fact that the team used the full extent of the meeting time made available to them. As part of a scheduling change to accommodate the implementation of PLC principles across the district, Brantley High School conducted a late-start on Tuesdays giving teachers time to meet for 45 minutes on Tuesday mornings. For this particular team, meetings started on time and lasted for the duration of the 45 minutes. In general, the meetings were well attended. One teacher (Kate) missed two meetings because of obligations at the school-level. While perpetual absences would be problematic, this was not a concern across the team nor did it seem to reflect any negative opinions to collaboration from Kate. Not only does the team’s use of meeting time reflect the high value that members of this team place on collaboration but also the individual teachers’ responses to interview and survey questions. Data from individual teachers further support this finding. The teachers commented on their preference regarding collaboration in their interviews and responded with “agree” or “strongly agree” to the statement, “The teachers on my team and I are in agreement about the need to collaborate.” Additionally, teachers shared instances of when the team or subsets of the team will collaborate outside of the assigned meeting time.

The teachers on this team also showed a comfort with collaborating. During team meetings, there were instances where individuals would share ideas or encourage others to share ideas. Additionally, four of the team members (Kate, Samantha, Luke, and Hillary)
were involved with the creation of materials (e.g., test, review sheets, printed notes, etc.) for the team to use as a whole. Each of the team members also made available their students’ test data for analysis. Further, all of the team members stated that they were comfortable sharing ideas with their team, citing examples of such times. As a result of these teachers’ comfort with collaboration and the value they place on those interactions, this team was rated “High” for element 1.1.

1.2. Shared values and goals. In the case of a professional community, the teachers who work together share values and goals for their work together. This can be considered in two ways: goals for their own work and goals for their students’ work. As a focus on student learning is an element of PLCs (Stage 2, Element 2.3), here the focus will be on the teachers’ goals and values regarding their own work, as an individual and as a team.

For this team it was clear that the goal for working together was to share materials and ideas, cutting down on the burden on any one teacher. In a way, this could also be considered a value as teachers placed importance on the freedom that shared responsibility gave to each of them. While these goals were not often explicitly stated in team meetings, interview and survey data showed that the team shared this goal.

However, there was more variability on how the team would reach those goals and the motives behind those goals. During some team meetings there was a need for redirection, or a change in focus back to the stated goals of the meeting, illustrating that there are differing opinions on how meeting time should be spent. Additionally, three of the teachers on the team (Vincent, Luke, and Kate) disagreed with the statement, “The teachers on my team and I are in agreement about what should be happening within our learning
community,” on their second survey. Teachers also gave varying responses as to why they wanted to share materials and plan collaboratively, ranging from giving order and control to the curriculum, providing additional time to improve one’s practice, and, for new teachers, get caught up to speed with planning and assessments. While the teachers on this team shared goals for their work together, the methods with which they could reach those goals differed. Due to these inconsistencies, this team was rated as “Moderate” for element 1.2.

1.3. Shared role. When considering the role of the members of a collaborative group, the researcher looked at both the participation of each teacher and the responsibilities that each held. For the team at Brantley, the roles were very uneven. It is worth repeating that two of the team members (Hillary and Vincent) were new to the team. In team meetings, Luke, Samantha, and Kate dominated much of the meeting time with Hillary and Vincent (the new members) expressing only a few ideas over the course of all the meetings.

The responsibilities, which this team attempted to share, were very unevenly distributed among the team members. Outside of providing assessment data to share, Vincent, who was new to the team and teaching Algebra I for the first time in years, had no direct input into any of the materials that the team collectively used. Hillary, another new team member, was only responsible for co-creating chapter review sheets alongside Samantha. Samantha, the team leader, created the agenda for each meeting based on notes from the previous meeting, co-created review sheets, and provided printed notes at the start of each chapter. She also served as the unofficial facilitator to make sure that the team got through all of the important points on the agenda. Kate, outside of her role as department chair, took an active role alongside Luke in creating the chapter tests. She also provided
quizzes that could be given throughout a unit. Luke had the most responsibility serving as co-creator on tests, creator of pre-assessments that the teachers used, and the point person for data collection and analysis. He even continued to attend the district-wide Algebra I team leader meetings even though Samantha is the team leader.

This uneven balance is apparent during team meetings as well as responses to interview and survey questions. What was surprising, however, is that despite such differences, each teacher knows their role as well as the role of others. Additionally, there was no evidence that teachers were dissatisfied with their role or the roles of others. The teachers on this team do not have an equal role but, after a closer look, that may be the collectively agreed upon structure. It is fair to expect that less experienced team members would have a lower amount of responsibility. As a result, this team was rated as “Moderate” for element 1.3.

Stage 2: Teacher Learning

The Teacher Learning stage consists of three elements: collective inquiry, results orientation, and focus on student learning. In order to evaluate this team as a PLC, the three elements must be explored. This section will describe the team through the lens of each of these elements in order to rate their performance.

2.1. Collective inquiry. Within the framework used for this study, two aspects of inquiry were considered: remaining active in the profession (i.e., utilizing research) and experimentation. During team meetings at Brantley, there was no explicit evidence that the teachers on the team referenced research as part of their work. However, through individual interviews and surveys, it was clear that the teachers on this team did remain active in the
profession. Luke, Kate, Hillary, and Samantha each cited examples of current or recent professional development including all four having attended a PLC workshop offered by the district. Additionally, teachers attended IB training and Samantha was in the process of applying for her National Board Certification. None of the teachers had a graduate degree in education, though Luke had a master’s degree in chemical engineering and had taken graduate coursework as part of his licensure program.

Regarding experimentation, the team utilized different methods of assessment based on their analysis of data. The teachers discussed the use of pre-assessments and post-assessments. They also would “spiral” (phrase used by teachers) frequently missed questions onto future tests and monitor their students’ progress. Further, the teachers on this team gave favorable responses on the survey to the statement, “Within my team, I am encouraged to experiment with my teaching.”

In a PLC, teachers inquire collaboratively using a shared practice. The team at Brantley engaged in a shared practice, collectively using materials that were developed by team members. These materials, mainly assessments, were frequently referenced during team meetings and interviews. Given their goals as a team, it is clear that this team shared their practice. While they did engage in some inquiry, it was not a frequent occurrence. As a result, this team was rated as “Moderate” for element 2.1.

2.2. Results orientation. In PLCs, teachers make decisions and assess results on the basis of data. From these results, conclusions can be drawn and changes can be made to classroom materials and, even, instructional practices. The team at Brantley had made data analysis a fixture in their team meeting time. As part of their common chapter tests, the team
chose to analyze the results on the first ten multiple-choice questions across all of the students. This requires a shared comfort with collaboration in order for teachers to be open with what could be considered sensitive information. In surveys, teachers responded “almost always” or “most of the time” to the statement, “The extent to which you and your PLC examine and compare student learning results.”

With this data, the team drew conclusions on student learning. This often referred to the type of problems that students missed, their content, and whether or not such a problem would appear on the cumulative state exam. Changes were then made to future tests assuring that students would again see frequently missed problems. Teachers would also claim to address these problems in class. However, there was no evidence that these results changed teachers’ instructional practices. One could contend, however, that the team has used different practices in assessment in response to the call for a results orientation. Given the team’s focus on analyzing assessment data, this team rated as “High” for element 2.2.

2.3. Focus on student learning. By focusing on student learning, teachers in PLCs set goals for student achievement. For the team at Brantley, as well as many teams in their district, the goal was to have students succeed on the cumulative state exam at the end of the year. This was a goal that was referred to in team meetings and also mentioned by teachers individually in interviews and surveys. In fact, all five teachers strongly agreed that their team works together to achieve a common goal for student learning. Major changes were made to the implemented curriculum by this team, deviating from both the district’s pacing guide and their textbook.
The goal of these changes was two-fold. One, the team saw the need for a more challenging curriculum especially in the beginning of the year. So, instead of reviewing old material in the fall, the teachers came in with new material such as matrices. Secondly, the team noticed significant shifts in the state’s end-of-year exam without corresponding shift occurring in the curriculum. As a result, their curriculum changes address concepts differently in hopes of improving student achievement. Based on survey responses, the team was happy with these changes as they all disagreed with the statement, “The teachers on my team and I have very different ideas about what we should emphasize in the curriculum”.

Another aspect of this element is the focus on issues of curriculum, instruction, and assessment. The team at Brantley spends a good amount of their meeting time on these issues. During observations, about half of the time spent in meetings could be considered focused on issues of curriculum, instruction, and assessment. This time does not include discussions regarding logistical issues, student behavior, or school policy. Those topics would be expected to be the focus of groups of teachers, especially when new teachers are introduced to a group. In individual surveys, statements regarding time spent on curriculum and assessment received mainly ratings of “most of the time” and “almost always”. Based on the team’s emphasis on goals for student achievement and focus on issues of curriculum, instruction, and assessment, this team was rated as “High” for element 2.3.

Stage 3: Specialized Growth

The Specialized Growth stage consists of three elements: content focus, use of artifacts of practice, and implementation of reform-inspired instructional practices. In order to evaluate this team’s ability to incorporate aspects of effective MPD, the three elements
must be explored. This section will describe the team through the lens of each of these elements in order to rate their performance.

3.1. Content focus. According to Kennedy (1998), programs with a stronger content focus have positive impacts on student learning. By focusing on mathematical content, the researcher has identified three aspects: using research on mathematical content and pedagogy, engaging with mathematics, and discussing mathematical concepts. Despite the team at Brantley’s success in implementing the principles of PLCs, there was little to no evidence of any of those descriptors in their team meetings or individual responses.

While research was mentioned occasionally, it was literature with a general content focus such as PLC literature or books on classroom management. The team did not reference any mathematical resources to better inform their instruction. Additionally, the teachers did not engage with mathematics, either that they were going to use in class or for their own enrichment. Only occasionally would the team focus on mathematical concepts. These topics arose due to discussions on their changed curriculum. There was no evidence of any sort of content focus in teachers’ interview or survey responses either. Other than the fact that this team consisted of mathematics teachers, there was no content focus in their collaborative interactions, giving them a rating of “None” for element 3.1.

3.2. Use of artifacts of practice. While PLCs will make decisions on the basis of results, the data for such analysis often comes from tests or other assessments, primarily multiple-choice data. MPD interventions often incorporate other classroom data, or artifacts of practice. These include classroom video, observations, written accounts, and students’
verbal responses and written work. Even with this more qualitative approach, conclusions can be drawn regarding practice.

Despite this team’s focus on analyzing classroom data, they did not incorporate any artifacts of practice beyond test data, such as the ones described above. Aside from an occasional and informal account of instruction from individual teachers, the team from Brantley used nothing but multiple-choice test data to assess their instruction and their students’ mathematical understanding. In turn, no further conclusions could be drawn without the collection and critique of other artifacts. As a result, this team was rated as “None” for element 3.2.

3.3 Implementation of reform-inspired instructional practices. Finally, a goal for many collaborative MPD interventions is to foster the reform of teachers’ instructional practices through the inclusion of cognitively demanding mathematical tasks and technology. For the team from Brantley, this type of reform did not occur as a result of their collaborative interactions. It should be noted that, given the methods of this study, it is not completely known what teachers did in their individual classrooms. However, during team meetings there was not a single mention of tasks or technology. Furthermore, in surveys and interviews, there was no evidence that the use of such practices was being planned or implemented. In fact only one teacher (Samantha) even mentioned the use of technology and that was in reference to another professional development experience. While the team at Brantley may have reformed their assessment strategies based on the type of data they wanted to collect, there was no evidence of the teachers attending to reforming their practice
during their collaborative interactions. As a result, the team at Brantley received a rating of “None” for element 3.3.

Summary of Brantley High School

Across the three stages, there is a distinct contrast between what this team has succeeded at collaboratively and what still needs work. A summary of the ratings for the team from Brantley High School can be found in Table 2. As a collaborative group, this team has been successful. The teachers on the team value the time to collaborate with colleagues and they have a shared mission for their work together. Despite the uneven roles across the team, there seems to be an agreement in terms of the responsibilities that everyone has and what each person can offer the team.

The team at Brantley has also been successful implementing the practices of PLCs. In fact, the team’s success has even been used as a model for other teams in their school attempting to implement the same PLC principles. The teachers have contributed to and implemented a shared practice using materials and assessments that they evaluate on the basis of student achievement. The group agrees on their goals for student achievement and focuses much of their time on issues of curriculum, instruction, and assessment.

However, the level of the content focus of this team was low. There was little to no evidence that the teachers on this team participated in the type of activities that teachers have been found to partake in successful MPD programs.

Results from Elmwood High School

The team that participated in this study from Elmwood High School consists of four teachers (Jackie, Sabrina, Pam, and Doug) teaching an Algebra I course targeted for students
who have previously taken and failed the course. There was generally more teaching experience on this team than on the team at Brantley High School, with three of the four teachers (Jackie, Sabrina, and Doug) having taught for at least ten years. Two of the teachers (Jackie and Doug) had taught Algebra I for 13 years each but the other teachers (Sabrina and Pam) were in their first year of teaching the course as well as their first year of teaching at Elmwood High School. Jackie served as the team leader during the year of this study.

The following section describes the nature of the collaborative work of the Algebra I team at Elmwood High School. This narrative serves as a description of a team that has struggled implementing the principles of PLCs but has shown some evidence of engaging in the type of activities commonly found in effective MPD interventions. Special attention will be paid to the factors that influenced this team’s struggles at stages one and two and their signs of success at stage three. A description of the team’s work will be given for each element of the framework as well as a rating. A summary of these ratings can be found in Table 6.

Stage 1: Collaboration

As with the previous case, in order to evaluate this team as a professional community, the three elements of the Collaboration stage must be explored. This section will describe the team through the lens of each of these elements in order to rate their performance.

1.1. Beliefs on collaboration. The team at Elmwood High School was in their first year together, including two new teachers to the school (Sabrina and Pam). The team was also in their first year of using meeting time prior to the start of the school day, once a week. However, the team did not fully take advantage of this scheduled time, ending two of their
Table 6. Summary of Ratings for Elmwood High School with Explanations

<table>
<thead>
<tr>
<th>Stage</th>
<th>Element</th>
<th>Rating</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collaboration</td>
<td>1.1. Beliefs on collaboration</td>
<td>Low</td>
<td>Did not maximize use of meeting time; Good attendance; Limited interactions outside of set meeting time; Teachers have a reluctance to share their experience from this year</td>
</tr>
<tr>
<td></td>
<td>1.2. Shared values and goals</td>
<td>Moderate</td>
<td>Common goal to share classroom materials and learn new methods of teaching; Unfocused discussions, though group seems to agree with direction of group</td>
</tr>
<tr>
<td></td>
<td>1.3. Shared role</td>
<td>High</td>
<td>Even participation and responsibilities; Expectation that all teachers share and participate</td>
</tr>
<tr>
<td>2. Teacher Learning</td>
<td>2.1. Collective inquiry</td>
<td>Low</td>
<td>Teachers’ professional development comes mainly through graduate coursework; Team does not engage in shared practice often and does not test new ideas as a group</td>
</tr>
<tr>
<td></td>
<td>2.2. Results orientation</td>
<td>Low</td>
<td>Attempts to compare data from common assessments but teachers often failed to provide data to share with group; No evidence that results altered instructional decisions</td>
</tr>
<tr>
<td></td>
<td>2.3. Focus on student learning</td>
<td>Low</td>
<td>Common goal for student achievement; However, little collaborative time focused on issues of curriculum, instruction, and assessment</td>
</tr>
<tr>
<td>3. Specialized Growth</td>
<td>3.1. Content focus</td>
<td>Low</td>
<td>Teachers would work through mathematical problems and activities and reference literature on mathematical content and pedagogy</td>
</tr>
<tr>
<td></td>
<td>3.2. Use of artifacts of practice</td>
<td>None</td>
<td>No evidence of use of artifacts of practice such as classroom video or student work</td>
</tr>
<tr>
<td></td>
<td>3.3. Implementation of reform-inspired</td>
<td>Low</td>
<td>Occasional evidence of the planning or use of reform-inspired instructional practices such as tasks and graphing calculators</td>
</tr>
</tbody>
</table>
four observed meetings at least ten minutes early. While the team often would stay and discuss things that the teachers felt were off-topic for PLC-type meetings, Pam, the appointed facilitator, would adjourn the official meeting in this event. Additionally, Doug missed one meeting and was late to a second meeting of the sessions observed by the researcher.

While teachers responded with “agree” or “strongly agree” to the statement, “The teachers on my team and I are in agreement about the need to collaborate,” the teachers did not discuss the value they place on collaboration during their individual interviews. Further, the teachers did not acknowledge that they met with their teams outside of the set meeting time.

Regarding teachers’ comfort with collaborating, every teacher expressed a willingness to share ideas with their team and also welcomed the sharing of ideas for their own benefit. However, three of the teachers (Doug, Pam, and Sabrina) also expressed that they did not feel as though they had much to offer to the team. Teachers expressed frustration with their current classes, a lack of time to work on innovative ideas, or a difficulty with their students as reasons for why they refrained from sharing ideas with the group. These ideas took away greatly from the collaborative discussions of the team, as Jackie was often the only team member who would regularly bring activities and other ideas to share. Also, Jackie was the most open to share accounts from her own classroom, something that the others seemed hesitant to do. As a result of the team’s limited interactions and some teachers’ discomfort with sharing ideas with the group, this team was rated as “Low” for element 1.1.
1.2. Shared values and goals. While some teachers seemed to refrain from sharing their own accounts or ideas with the group, the members of the team at Elmwood all wanted to learn new ideas and strategies from the group. This was a common response from teachers in individual interviews or surveys, as teachers responded “agree” or “strongly agree” to the statement, “The teacher on my team and I are in agreement about what should be happening within our learning community.” However, it was not clear during team meetings how they were attempting to address those goals. Despite the fact that they had a difficult goal to attain since there was more receiving than sharing, there was an expectation that by working together the teachers could learn from each other and serve as a support network. As a result, there was an expectation that everyone participate in group discussions in order to address the problems that they were facing with this Algebra I course.

Pam, serving as the facilitator of the group, would occasionally have to redirect the team’s discussions in order to stick to the agenda. She, along with other teachers, felt that the team may go off topic occasionally and may deviate from the agenda but that all of their conversations are “relevant” and “necessary”. Often, discussions would degrade into complaints over the structure of the class, class size, the format of the two-period class, and other logistical and policy concerns. While these may not be valued discussions in the context of a PLC, it was clear that the team all valued these discussions. As a result of the team’s agreement, in some capacity, on the direction of the team and the appearance of sharing ideas on how to attain their goals, this team was rated as “Moderate” for element 1.2.

1.3. Shared role. As was stated above, every teacher on the team at Elmwood were expected and encouraged to share and participate with the group. Despite Jackie serving as
the official team leader by attending district-wide meetings and providing an agenda and Pam serving as a sort of facilitator for team meetings, there were no classified roles for teachers to assume. Instead, the work of this team played out more like a group discussion, with each teacher providing some sort of input regarding most of the topics of discussion over the course of their meeting time.

While in interviews some teachers expressed that they question the value of what they have to offer to the team because of how their classes were performing during the year of this study, every teacher on the team did share ideas and some activities with the team. Jackie would often bring in old tests she’s used and notes that she types up for her students. Sabrina would also bring in some activities from her class and offer insight into how other school districts function based on her previous teaching experience. Pam would bring books that she had read regarding classroom management or offer her opinions on some policy issues within the school. The ultimate value of some of that input against the backdrop of PLCs aside, on this team, every teacher provided equal input to team discussions, warranting a rating of “High” for element 1.3.

Stage 2: Teacher Learning

As with the previous case, in order to evaluate this team as a PLC, the three elements of the Teacher Learning stage must be explored. This section will describe the team through the lens of each of these elements in order to rate their performance.

2.1. Collective inquiry. Many of the ideas that teachers from the team from Elmwood brought to the table were from a good source as three of the teachers (Jackie, Doug, and Sabrina) held graduate degrees in education, two of which (Doug and Sabrina) were in
mathematics education. Further, at the time of this study, Doug was in the process of pursuing a Ph.D. in mathematics education. However, other forms of professional development were not as plentiful across the team. During individual interviews, the teachers gave varied responses regarding professional development and what they felt they took away from those experiences.

Despite the fact that each team member contributed equally to group discussions, there was little evidence that the team from Elmwood engaged in a shared practice. Ideas that were offered were used more as suggestions and little was used on a more widespread basis. Further, the team agreed to do one shared unit for each quarter of the school year. A shared unit would consist of a common pace, common topics, and a common test. Otherwise, the teachers worked much more independently. Part of this was out of necessity as Pam and Sabrina worked out of different textbooks from each other and from Doug and Jackie. Additionally, Doug and Jackie were the only two on the team working out of the textbook that was adopted by the school district and the basis for the district-wide Algebra I pacing guide. While it was not a frequent occurrence that the team collaborated on designing classroom materials, during the time of this study the team did design a chapter test using an old version from Jackie as an initial guideline. This provided an opportunity for each team member to provide feedback and have a product that was developed collaboratively.

There was also very little experimentation from the team. Jackie was the only team member to exhibit an inclination toward experimentation, as she would bring new ideas for the use of graphing calculators to the table to share with the group. The teachers on the team also gave mixed responses on survey statements regarding experimentation and testing new
methods. Given these teachers’ limited involvement with other forms of professional
development, limited engagement in a shared practice, and limited experimentation with new
teacher methods, this team was rated as “Low” for element 2.1.

2.2. Results orientation. Due to the fact that the team at Elmwood did not frequently
engage in a shared practice, it was difficult for the teachers on the team to meaningfully
compare their students’ results. As a proxy for common activities and tests, the team made
use of assessments made available throughout the district. Eventually, the district plans on
using these types of assessments to provide feedback and data for comparison throughout the
year.

During the time of this study, the team tried to administer and analyze one of these
assessments. However, the analysis of the resulting data was never observed and was often
deterred by team members not having administered the assessment at the time of a meeting
or not providing their data to share with the group. This could have been the result of the
lack of a shared practice or the lack of value placed on collaboration by the teachers.
Without the analysis of student results, this team did not draw any conclusions regarding the
performance of their students nor did they make any changes or decisions based on such
conclusions. As a result, this team was rated as “Low” for element 2.2.

2.3. Focus on student learning. The teachers on the team from Elmwood shared a
common goal for student learning regarding the cumulative state exam at the end of the year.
For two years, goals had been set to have a certain percentage of students pass the exam. As
a result, much of the classroom focus of the team regarded preparing students for the end-of-

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year exam, including the aforementioned district-provided assessments, which consisted of practice multiple-choice questions similar to the questions seen on the state exam.

In order to focus on student learning, teachers must focus on issues pertaining to curriculum, instruction, and assessment. During Elmwood team meetings, a relatively small amount of time was devoted to these issues. In fact, only about one-third of the team’s time in meetings was devoted to meaningful topics. Additionally, the time spent away from discussing these issues were instead spent on discussions on class size and student behavior.

Other observations also indicated a lack of a focus on student learning from the team from Elmwood. During the second interview when presented with high-level mathematical tasks, the teachers gave varied responses over the appropriateness of such tasks or their expectations for students’ performance on such tasks. By focusing on issues relating to behavior and policies, teachers are not focusing on students’ achievement and learning. This would also be indicated by a focus on the implementation of a planned curriculum rather than the results of such a curriculum. Despite this team’s common goal for student achievement, their lack of focus in group discussions warranted a rating of “Low” for element 2.3.

Stage 3: Specialized Growth

As with the previous case, in order to evaluate this team as a PLC, the three elements of the Specialized Growth stage must be explored. This section will describe the team through the lens of each of these elements in order to rate their performance.

3.1. Content focus. Even though much of the team’s time was unfocused, when the team did discuss issues of curriculum and instruction, the conversations were sometimes centered on mathematical content. During team meetings, teachers worked through
mathematical tasks that teachers were going to use in class. One example is the sharing of methods of teaching different topics such as when Doug showed the team a method for solving equation using an “unstacking” method using an abbreviated way of how he would show his students (see Figure 2). Jackie provided worksheets of graphing calculator activities that they all attempted before trying to use it in their own classrooms. Teachers on this team would also work through test problems as they planned or discussed common assessments.

![Diagram of Doug’s “unstacking” method for solving equations](image)

Figure 2. Diagram of Doug’s “unstacking” method for solving equations

The team also referenced curricular resources and other literature on mathematics content and pedagogy. Doug would offer suggestions and examples from books and articles that he had read as part of his graduate studies. The team would also occasionally discuss mathematical concepts and big ideas that they hoped to address in class. While all of these
activities are productive and a common aspect of effective MPD programs, this team was rated “Low” for element 3.1 due to the overall lack of time spent on such activities.

3.2. Use of artifacts of practice. The team from Elmwood struggled to engage in a shared practice, which affected their ability to compare and analyze classroom data. While, in PLCs, such analysis often comes from tests or other assessments, the team also did not use other classroom data such as video, observations, written accounts, and students’ work. Jackie did try to encourage the group to observe other teachers but this was more a gesture toward the newer teachers in the group than a move toward classroom analysis within their team discussions.

Aside from an occasional and informal account of instruction from individual teachers, the team from Elmwood used nothing but multiple-choice test data to assess their instruction and their students’ mathematical understanding. In turn, the teachers on the team could make no further conclusions regarding their instruction. As a result, this team was rated as “None” for element 3.2.

3.3 Implementation of reform-inspired instructional practices. The teachers on the team from Elmwood frequently expressed a desire to use new teaching practices. During the second interview the teachers expressed an interest in higher-level mathematical tasks, though they questioned how their Algebra I students would respond to them. However, this interest plus their openness to sharing ideas led to a few occasions where teachers would share and discuss activities and problems for their students.

The team would also focus on the use of technology, namely the use of graphing calculators. It should be noted that Jackie was concurrently part of another research study.
regarding graphing calculator use. However, it is also worth noting that this study
investigated her existing use of the graphing calculator. Jackie would bring activities for the
team to work through together. Other teachers on the team would discuss their successes and
failures using the graphing calculator in their Algebra I classrooms. While the discussion
would often focus on the number of calculators that can be found in each classroom, by
talking about graphing calculator use and looking at possible activities, the team at Elmwood
is engaging in discussions that are had in collaborative MPD experiences. As a result of the
team’s discussions regarding technology and tasks, though seldom, the team received a rating
of “Low” for element 3.3.

Summary of Elmwood High School

The team from Elmwood was not successful in implementing PLC principles but
began to show aspects of features of MPD programs at the time of this study. A summary of
the ratings for this team can be found in Table 3. In essence, the team at Elmwood High
School was functioning as a traditional collaborative team by sharing values and materials
but not taking a critical look at their instructional practice.

The teachers on this team shared goals for their collaborative work and goals for
student achievement. However, they did not have the collaborative norms to address these
issues as a team. While sharing was encouraged, some team members refrained from
discussions because of their impression of their own work with struggling students. The
team also did not engage in a shared practice, making it difficult to test new ideas and
compare and analyze data. Finally, the team spent little time focusing on issues of
curriculum, instruction, and assessment instead discussing issues of behavior and policy.
However, when the team did focus on meaningful issues of student learning, there were aspects of successful MPD programs evident in their work. By working through tasks, referencing literature on mathematical content and pedagogy, and discussing the use of reform-inspired instructional practices such as tasks and technology, the team from Elmwood engaged in forms of activities that have been shown to impact mathematics teachers’ content and pedagogical knowledge.
CHAPTER 5
DISCUSSION

The purpose of this study is to investigate two teams of teachers attempting to implement principles of professional learning communities in order to identify both teams’ success in implementing these principles and to what extent the presence of features that are commonly found in effective mathematics professional development was evident in their work. The participants in this study were working under the context of a goal to create PLCs. However, the goal of this study was to observe teams of teachers working in that capacity and their possible transition to a professional development experience with high-level content focus.

The collaborative norms that are attributed to PLCs are claimed to be integral for some MPD interventions (e.g., Borko et al., 2008; Lachance & Confrey, 2003; Arbaugh, 2003; Kazemi & Franke, 2004). Additionally, collaborative opportunities are prevalent in professional development given findings that these experiences are both valued by teachers (Garet et al., 2001; Arbaugh, 2003) and play a role in supporting inquiry and problem solving (Loucks-Horsley et al., 1998). Since the nature of the work of teachers in PLCs is not well documented (Vescio et al., 2008), it is important to identify the role of PLCs in the specialized growth of mathematics teachers in order to aid in the design of effective and replicable MPD programs.

Chapter 5 is divided into four sections: summary, limitations, implications, and recommendations. First, a summary of the study is presented, followed by conclusions of the research questions. Then, the limitations of this study will be described. The next section
will identify the resulting implications for the design of professional development for mathematics teachers in collaborative settings. Finally, the chapter concludes with recommendations for future research.

Summary

Two teams of teachers were investigated for this study as they implemented PLC principles as part of a district-wide intervention. As part of this intervention, each school provided teams of teachers with weekly meeting time. For this study, the researcher observed four meetings for each team over the course of two months during the 2008-2009 school year. Additionally, individual teachers participated in two interviews and two surveys each. The combination of these three data sources allowed for the evaluation of each team’s ability to implement PLC principles and the extent to which each team engages in the type of activities that are commonly found in successful collaborative MPD programs. Using a conceptual framework that was developed from literature on professional communities, PLCs, and collaborative MPD literature, each team was rated in a series of elements in order to better describe their collaborative work. A more detailed description of this framework can be found in Chapter 2 and a more detailed description of the rating system that was used can be found in Chapter 3. To help in comparing the teams and answering the research questions, a summary of each team’s ratings on each element in the stages of the framework can be found in Table 7. What follows is a discussion of a response to each of the four research questions in this study.
Table 7. Summary of Ratings for Brantley and Elmwood High School

<table>
<thead>
<tr>
<th>Stage</th>
<th>Element</th>
<th>Brantley HS Rating</th>
<th>Elmwood HS Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collaboration</td>
<td>1.1. Beliefs on collaboration</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>1.2. Shared values and goals</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>1.3. Shared role</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>2. Teacher Learning</td>
<td>2.1. Collective inquiry</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>2.2. Results orientation</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>2.3. Focus on student learning</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>3. Specialized Growth</td>
<td>3.1. Content focus</td>
<td>None</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>3.2. Use of artifacts of practice</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>3.3. Implementation of reform-inspired</td>
<td>None</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>instructional practices</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Research Question 1

*Considering the model that their district is promoting, how well are these two teams of teachers operating as a PLC (stage one and two)?* The conceptual framework considered during this study defines three stages: Collaboration, Teacher Learning, and Specialized Growth. The components and attributes of each stage were gathered from literature on professional communities, PLCs, and collaborative MPD programs. While some literature on PLCs (e.g., DuFour & Eaker, 1998) define PLCs with features of both the Collaboration and Teacher Learning stage, other work (e.g., McLaughlin & Talbert, 2001, 2006) drew a distinction between the work done by traditional collaborative groups compared to that of PLCs. This is the reason for the separation between stages one and two in the conceptual
framework. However, when considering a team’s success as a PLC, one must consider how the team operates at both stage one and two since each contains attributes of a PLC. Given this, the two teams investigated for this study portrayed two very different capabilities of functioning as a PLC.

*Brantley High School.* Despite having two new members on their team from the year prior, the team at Brantley High School had effectively implemented the PLC principles promoted by their district at the time of this study. All of the teachers on the team appeared to value the benefits of collaboration and the team made maximum use of the meeting time provided to them by their school. The teachers also shared a mission for their collaborative work as each teacher looked to use their time together to share materials and lighten the workload on any one teacher. Despite these goals, there was an uneven distribution of responsibilities among the five teachers, though every teacher seemed comfortable and content with the group norms.

Given the team’s goal to share classroom materials, the team was successful at implementing a shared practice, including a common curriculum and common assessments, all of which received input from multiple teachers on the team. The team’s biggest feat was the creation of a reordered curriculum based on observations of student achievement after significant changes to the cumulative state exam. The teachers in the team also remained involved with professional development experiences including workshops offered by the county to introduce PLC principles.

These teachers also opened up their practice to the rest of the team by sharing their students’ results from chapter tests. This data was used to compare practice, monitor student
achievement, and make changes to classroom materials. Much of the team’s time was devoted to issues relating to student learning including curriculum, instruction, and assessment. In sum, due to strong collaborative norms and efforts made to make shifts in their teaching practice and improvements to student achievement, the team from Brantley was effective at implementing principles of PLCs as part of the district-wide intervention.

*Elmwood High School.* The team from Elmwood High School was in their first year together, including two teachers who were new to the school. Despite the value that teachers on this team seemed to place on the sharing of ideas and materials and learning new instructional strategies, the team did not take advantage of the time with which they were provided by their school to meet as a group. Some of the teachers on the team were also reluctant to open up their practice and share their ideas based on struggles they had with the course or their students. While much of their time as a group may not have been productive in the eyes of a PLC, all four teachers participated in group discussions equally with little interruption or need for redirection.

Despite a goal to share instructional materials and ideas, the team from Elmwood seldom engaged in a shared practice. While a “common unit” was used each quarter, the teachers were mainly on their own, administering different assessments and, sometimes, working on different topics. As a result, the team could not compare their student learning results. The team also could not make effective use of common assessments offered by the district due to individuals failing to provide their classroom data. While the team would occasionally focus on issues of curriculum, instruction, and assessment, much of their discussion distracted them from issues relating to student learning instead focusing on issues
of scheduling, behavior, and policy. The team at Elmwood High School did not have the collaborative norms to investigate and reflect on a shared practice, therefore failing to successfully implement the principles of PLCs provided to them by their district.

Research Question 2

What factors are associated with each team being able to exist (or not) as a PLC?

Based on the data collected for this study from both group and individual environments, some factors have been identified by the researcher that could be related to each team’s ability or inability to implement the principles of PLCs. By conducting a cross-case analysis, drawing connections and contrasts between the two teams offered additional insight into the possible factors involved with a team’s ability to function as a PLC.

One factor gives added confirmation to earlier findings regarding a team’s ability to become a PLC. Looking at these two teams, Brantley was a stronger professional community than Elmwood including a higher value placed on collaboration by the teachers on the team at Brantley. As was observed during this study, Brantley also had greater success at implementing the principles of PLC as part of their district’s intervention. This finding is not too surprising given previous work on professional communities and PLCs (e.g., McLaughlin & Talbert, 2001; Louis et al., 1996). This finding also falls in line with the conceptual framework used for this study, which implies that a team needs to have strong collaborative norms in order to eventually function as a PLC. A closer look at each team’s collaborative norms suggests that additional factors that relate to individual teachers’ beliefs and values could exist. For example, some teachers on the team at Elmwood questioned the benefits of collaboration or the likelihood of learning from the other teachers on their team.
during their individual interviews. Given the team at Elmwood’s struggle with working as a PLC, the findings of this study suggest that these individual values could impact the collaborative work of a team.

Another difference between the two teams was the amount of time spent collaboratively. In this case, time refers to the span of time in which collaborative interactions took place. For the team at Brantley, three of the teachers had worked together under the same context of PLCs for the same subject (Algebra I) during the previous year. The team at Elmwood had not previously worked together, and included two teachers that were new to the school altogether. While this study was conducted over a relatively short period of time, this finding would suggest that PLCs require extensive amounts of time in order to fully develop. Again, this is not a surprising finding given previous work done on PLCs and effective professional development in general (e.g., Garet et al., 2001; Darling-Hammond & McLaughlin, 1995).

Another observed factor, and a far more novel one, is the professional development that teachers from each team were involved in outside of their team interactions. For the team at Brantley, four of the five teachers on the team (including the three most vocal members of the team) participated in at least one of the workshops offered by the district to introduce the principles of PLCs that were part of the intervention. On the other hand, only one of the four teachers on the Elmwood High School team attended such a workshop. The team at Brantley explicitly engaged in activities such as collaborative planning and data analysis while the team at Elmwood was much less focused. Given the difference between
the two team’s abilities to implement these collaborative practices, this issue of professional development seems to be a practical reason for the discrepancy.

These factors should be considered in the future research and design of collaborative MPD programs, a point that will be further explained in following sections.

Research Question 3

To what extent are the teachers in each team collaboratively engaged in the type of activities that are commonly found in effective MPD (stage three)? The conceptual framework developed for this study using literature on professional communities, PLCs, and collaborative MPD programs suggests PLC-type collaborative norms help foster teachers’ engagement with rich, content-focused. However, the findings of this study seem to refute that hypothesis. The team from Elmwood showed more evidence, albeit minimal, of partaking in activities indicative of MPD than the team from Brantley, despite their inability to function effectively as a PLC at Elmwood.

Brantley High School. Despite their ability to work as what would be classified as a PLC, the team from Brantley High School showed little to no evidence of engaging in the type of activities that are commonly found in successful MPD programs. Aside from some discussion of mathematical concepts related to the curricular changes that the team had made, there was no significant presence of mathematical content in the group’s discussions and activities. While the team frequently used assessment data to reflect on and refine their practice, the team at Brantley did not use any other artifacts of practice such as classroom video or student work to assess student learning or reflect on practice. Finally, the team showed no evidence of planning or using reform-inspired instructional practices such as
high-level mathematical tasks or technology. According to the framework used in this study, the team at Brantley did not work in a way that would foster specialized growth as mathematics teachers.

*Elmwood High School.* While the team at Elmwood struggled to implement PLC principles and spent relatively little time focused on issues relating to student learning during the time of this study, they showed some evidence of engaging in the type of activities that are commonly found in MPD literature. During time when the team was focused on issues of curriculum, instruction, and assessment, the teachers would discuss mathematical concepts and work through mathematical problems to be used in the classroom. Teachers on the team also referenced literature regarding mathematical content and pedagogy. Like the team at Brantley, the team at Elmwood did not use any artifacts of practice to assess student learning. However, this is not too surprising given that the team did not even use assessment data to compare and analyze results. Finally, the team showed some evidence of planning and using reform practices, mainly incorporating the use of graphing calculators. While evidence of these practices was not substantial, the team from Elmwood showed some ability to engage in the type of activities that are common aspects of MPD programs.

**Research Question 4**

*What factors are associated with each team’s success or struggle to make a transition from stages one and two to stage three and engage in high-level, content focused activities?*

This question was in regard to a team’s transition from stages one and two to stage three. However, this is only truly applicable to the team from Brantley, as the team from Elmwood had not attained the collaborative norms attributed to stages one and two. However, as with
each team’s ability to implement PLC practices, some factors have been identified by the researcher that could be attributed to both team’s ability to engage in the type of activities that are common to successful MPD programs.

First, regarding the team from Brantley’s transition from stages one and two to stage three, some observed factors might be attributed to the team’s failure to partake in activities that include more of a content focus. The team at Brantley has focused intently on incorporating activities such as data analysis and developing a shared practice, all of which they likely learned about in the district-wide PLC professional development workshop. However, time spent on these activities could have taken their focus away from more content-oriented activities. While this is purely speculative, it would be interesting to see how this team develops further over time given that this study took place at the beginning of a school year.

While the professional development in which the teachers on this team took part may have helped in their ability to implement the practices of a PLC, it may have also hindered their ability to partake in the activities commonly found in effective MPD. On this team, most of the professional development experiences noted by these teachers related to more general topics such as classroom management and poverty. Additionally, none of the teachers on the team have a graduate degree in mathematics education or other education area. As a result, the teachers on the team from Brantley may not know the type of team activities that would help them address their mathematical content and pedagogical knowledge. Further, these teachers may have an impression of professional development that
does not include addressing their own content knowledge, utilizing student work to reflect on practice, or planning the use of high-level tasks and technology.

The team from Elmwood High School did not effectively implement PLC principles at the time of this study. However, they showed some evidence of focusing on content as part of their collaborative work. One possible factor in this could be the work done by the teachers on this team outside of their collaborative work. Three of the four teachers had graduate degrees in education; two in mathematics education, and one teacher was concurrently involved in a different research study on use of graphing calculators. Further, one teacher was in the process of working toward a Ph.D. in mathematics education. These experiences could explain teachers’ disposition toward discussing literature regarding mathematical content and pedagogy or their inclination to consider reform practices.

Additionally, individual teachers may have influenced the direction of the group to include a focus on more content-related issues. At Elmwood, one teacher often introduced ideas relating to the graphing calculator to group discussion. Another teacher was often the source of research on mathematical content and pedagogy. At Brantley, one teacher served on the school’s student support team and would introduce ideas regarding behavioral and academic interventions. Another teacher was fascinated with the capabilities of data analysis. While it is not surprising that the individual teachers that make up a group influence the group’s direction, it was clear during this study that the individual teachers’ interests and areas of expertise can play a significant role in the work of collaborative groups.
Limitations

This study only examined two teams of mathematics teachers from a large, urban school district using a case study methodology. Consequently, it was not a goal of this study to generalize the rest of the teams in this district or teams of teachers outside of this district. However, these two teams offer an illustration of the work of mathematics teachers in collaborative settings designed around a certain intervention. While generalizations cannot be made, the results from this study can certainly raise questions about other teams in similar circumstances, warranting further research.

While multiple data sources in both group and individual settings ensured the consistency of observed results, more could have been done to understand the work of the teachers involved in this study. First, the study took place over a relatively short period of time. Additionally, each team was observed only four times and for no more than two weeks in a row. Individually, while interviews and surveys provided useful data regarding teachers’ perspectives on their group interactions, more proven measures could have been taken to further understand teachers’ beliefs, attitudes, and knowledge. This will be discussed further in the recommendations section.

Implications

Collaborative opportunities are prevalent in professional development given findings that these experiences are both valued by teachers (Garet et al., 2001; Arbaugh, 2003) and play a role in supporting inquiry and problem solving (Loucks-Horsley et al., 1998). Further, the designers of collaborative MPD interventions (e.g., Borko et al., 2008; Lachance & Confrey, 2003; Arbaugh, 2003; Kazemi & Franke, 2004) claim to rely on the collaborative
norms that are attributed to PLCs. In such work, teachers benefit from the activities and dispositions that come from working as a PLC. However, facilitators, often university-affiliated mathematics educators, provide the direction for these groups toward the specialized growth that impacts mathematical instructional practices and, in turn, student achievement. The nature of the work of teachers in PLCs is not well documented (Vescio et al., 2008) making it important to identify the role of true PLCs in the specialized growth of mathematics teachers.

The two teams involved in this study attempted to function as PLCs under the context of a district-wide intervention. The district chose to implement the principles of PLCs in response to such movement in the field and a goal to increase high school graduation rates. District administrators aimed to utilize the forum provided by PLCs as a main form of professional development for its teachers. As a result, workshops were held to help teachers become knowledgeable of the principles of PLCs, understand the benefits of collaboration, and develop the tools necessary to function effectively in groups.

The results of this study suggest that the plan for implementation used by this district may not be effective in terms of the use of PLCs as a form of professional development that fosters specialized growth. As stated in the limitations sections, the results from these two teams can in no way be used to generalize to all of the teachers in the district. However, they do provide two illustrations of possible issues with the type of widespread implementation that we saw in this study. For the team at Elmwood High School, which had difficulty implementing the principles of PLCs in order to critically reflect on their practice, the promotion of the PLC ideas was ineffective. For the team at Brantley High School, which
was able to function as a PLC, their learning was more general and they did not engage in the
type of activities that have been shown to foster specialized growth in mathematics teaching.

While generalizations cannot be made here, it is not too unreasonable to believe that
these two illustrations can be representative of how other teams in this context function,
either in the district at the center of this study or other districts implementing such
widespread reform. Perhaps one should criticize the use of workshops, a traditional form of
professional development, to promote collaborative learning in a far more reform-based
environment. The results from this study suggest that existing forms of professional
development affect the interactions of a group. As such, teachers on these teams need to
develop both the collaborative norms necessary for critical reflection of practice and the
mathematical content and pedagogical knowledge needed to improve their instruction and, in
turn, student achievement. As the results from this study also suggest that individuals’
dispositions weigh heavily in the direction of a group, we cannot assume that by only
addressing the collaborative capabilities of a group of teachers that we are fostering
specialized growth.

With this in mind, as well as the case of the team from Elmwood High School, the
framework introduced in Chapter 2 must also be addressed. The grounds for the
development of that framework were based on literature on professional communities, PLCs,
and collaborative MPD. Gathered from this work was the idea that the shared values and
collaboration that comes with a group of teachers working together is necessary to build a
PLC. Similarly, the inclination and ability to critically reflect on practice collaboratively in
PLCs is a critical aspect of collaborative MPD programs. However, facilitators often
introduce the activities that address teachers’ mathematical content and pedagogical knowledge. The goal of this study was to better define the role of PLCs in mathematics teachers’ collaborative growth, ultimately bridging the gap between stages two and three in the framework as other work had essentially bridged the gap between stages one and two (McLaughlin & Talbert, 2001; Louis et al., 1996; DuFour & Eaker, 1998).

However, the case of Elmwood High School, a group that did not function as a PLC but was able to engage in some activities that are commonly found in collaborative MPD programs, seems to defy the idea of stages. As a result, the framework has been reconceptualized to stray away from the one-dimensional idea of stages to a two-dimensional concept consisting of two independent variables, PLCs only representing one of those dimensions (see Figure 3).

Figure 3. Conceptual framework: The role of collaborative norms and content focus on teachers’ growth
As described with the original framework in Chapter 2, each stage represented the type of growth that a teacher undergoes while engaged in certain collaborative work. At the Collaboration stage, teachers worry about logistical and other non-instructional issues, resulting in unchanged practice. However, the benefits of collaboration lead to organizational growth. Teachers at the Teacher Learning stage function as a PLC and, in turn, focus on issues of curriculum, instruction, and assessment resulting in a general pedagogical growth. At the Specialized Growth stage, teachers are focused not only on teaching but are also focused on content, fostering specialized growth in both mathematics content and pedagogy. However, as with the team from Elmwood, there can be the case where teachers are not functioning as a PLC yet focus their learning on mathematics.

This new conceptual framework (Figure 3) takes this case into account and also identifies two variables (strength of professional community and quality of mathematical content focus) influencing the learning and growth of teachers. Though the two variables are to be considered continuous, there are four categories of teacher learning and growth denoted within the framework: Organizational Growth, Idiosyncratic Growth, General Pedagogical Growth, and Specialized Growth.

As teachers begin to collaborate, traditional practices can still be perpetuated as groups can still shy away from the conflicts that can arise during a critical reflection of practice (Ball & Cohen, 1999; McLaughlin & Talbert, 2001; Visscher & Witziers, 2004; Wells & Feun, 2007). As a group of teachers becomes a PLC, however, they begin to focus on issues of curriculum, instruction, and assessment and challenge their shared practice.
Content focus also plays an important role in the effectiveness of professional development experiences (Kennedy, 1998). Additionally, teachers’ mathematical knowledge (Hill et al., 2005), pedagogical content knowledge (Shulman, 1987), and their attention to student reasoning (Carpenter et al., 1999) have been linked to increases in student achievement. Without a content focus even teachers in the strongest professional communities will only experience growth in their general knowledge and pedagogy. As a result, MPD interventions include a focus on content, involving teachers with experiences that address their content and pedagogical knowledge.

Teachers can engage in these types of activities but weak collaborative norms can impact the specialized growth of teachers. In the framework, Idiosyncratic Growth is the most variable type of growth as it is completely dependent on the individual. As a result, this framework does not suggest that teachers who independently engage in action research, curriculum evaluation, and the study of classroom artifacts could not experience specialized growth but the growth could either be less significant or consistent in its effect on the team of teachers. This is best illustrated by the case of the team from Elmwood High School. This framework does suggest that as teachers become a PLC along with focusing on content, one could expect to see the type of specialized growth that qualifies an effective MPD experience.

Based on the results of this study, the role of PLCs as the sole source of professional development of mathematics teachers should be questioned. It is clear that teachers’ collaborative norms do not affect their inclination to focus on mathematical content and pedagogy. However, it is equally important to address both of these factors in order to
ensure the specialized growth of teachers. While the results from this study cannot conclude how to foster a content focus in the collaborative work of teachers (outside of direct facilitator decision-making), it has provided a clearer view of the professional development of mathematics teachers in collaborative settings by offering a language that can be used when discussing aspects of the collaborative work of teachers and when classifying the growth of teachers in those settings.

Recommendations

Future research on mathematics teacher learning in collaborative settings can use the common language offered by the conceptual framework presented in this thesis. Future research can also address some of the limitations of this study in order to better define the growth of teachers at various levels of collaboration and content focus and also how to build collaborative norms and a focus on content.

By taking a prolonged and more intensive look at a team of teachers, one could get a better idea of the work that is done by those teachers and their growth over time. As a result, it may be more apparent as to what factors play a role in the team’s collaborative norms and their content focus. Future research should also take a more direct look at other forms of professional development that are concurrently implemented in order to better understand teachers’ dispositions when it comes to professional development. This could also include faculty and department meetings that can emphasize setting goals for teachers’ collaborative work. To replicate effective MPD programs, these factors must be taken into account as this study suggests that they play a role in the actual practice of teachers in collaborative settings.
Regarding individual teachers’ impact on the direction of a group, better-tested measures of teachers’ content knowledge, pedagogical knowledge, beliefs, and attitudes that are available in the field should be used in order to get a better picture of individual teachers and the influence they may have on a group. Future researchers should also consider comparing the work of teachers focusing on different courses (e.g., Algebra I, Algebra II, Calculus, honors classes, remedial classes) in order to determine any effect of a course or teachers’ impressions of the course and its students on the work of a group. One hypothesis would be that teams focused on upper-level courses like Pre-Calculus or Calculus may focus more of their discussion on mathematical content and pedagogy given the difficulty of the course as well as the strength of the students.

Finally, it is recommended that future research report on ways to introduce mathematics teachers to the type of activities that are commonly found in effective MPD programs in order to increase the content focus of teachers’ collaborative interactions. In order to replicate the experiences that teachers have been found to have in collaborative settings in research (e.g., Borko et al., 2008; Arbaugh, 2003; Lachance & Confrey, 2003), methods must be found to acquaint teachers with certain activities and dispositions without relying on a facilitator being directly involved with a team of teachers or, even, a PLC. In a timely article in the March 2009 issue of Mathematics Teacher, Slavit, Bornemann, and Haury (2009) describe the experiences of a group of teachers inquiring into their practice as a PLC. Further, the group analyzed and planned high-level mathematical tasks, analyzed student work and utilized other classroom data aside from assessments as evidence of progress, and observed each other’s teaching. Without a doubt, this group exemplifies strong
collaborative norms and a focus on content that would be expected to result in teachers’ specialized growth. While a mathematics educator had some, albeit limited, input on the group’s interactions, this example does a better job of bridging the gap between research and practice and could be used to provide a framework for effective and replicable collaborative MPD.

Conclusion

As collaborative professional development opportunities for teachers become more commonplace because of their observed positive effect on teachers’ practice, we must understand what makes up the work of teachers in groups. The results from this study suggest that a group of teachers could function effectively as a PLC without focusing on issues relating to mathematical content and pedagogy. At the same time, a team can focus on content without possessing the collaborative norms to address their instructional practices. These findings plus existing literature on professional communities, PLCs, and collaborative MPD programs fostered a conceptual framework that offers a common language used when describing aspects of the collaborative work of teachers and when classifying the growth of teachers in those settings. This two-dimensional framework can be used in future research on mathematics teachers collaborative interactions in order to further identify factors in the growth of teachers in these settings and to better inform the design of effective and replicable professional development.
REFERENCES


Hawley, W. D. & Valli, L. (1999). The essentials of effective professional development: A new consensus. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the*


APPENDICES
Appendix A

First Individual Teacher Survey

Directions: Thank you for your participation in this thesis research project. Below are questions on personal background and information. Complete this survey to the best of your ability. In accordance with your informed consent, this questionnaire will be immediately blinded and labeled with a code known only to the researchers.

Age: ______________ Gender (circle one): Male Female

How many years have you taught? ______________

How many years have you taught at your current school? ______________

What subjects are you teaching this semester? Include the number of years you have taught each subject: __________________________

_________________________________________________

_________________________________________________

What other subjects have you taught during your teaching career? Include the number of years you taught each subject:

_________________________________________________

_________________________________________________

List all degrees you have completed or are in the process of completing: ______________

_________________________________________________

Did you have another career prior to entering the teaching field? If so, please describe previous careers along with the number of years in each: ______________

_________________________________________________
List and briefly describe any professional development in which you have participated during the past three years that have been implemented or mandated by your school: ____________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

List and briefly describe any professional development in which you have participated during the past three years outside of school. How did you find out about those opportunities? ________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

How do you remain active in the teaching profession? ____________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

For the following questions, please use the scale provided below to indicate the extent to which you agree or disagree with each of the following statements concerning your team:

- 4 = strongly agree
- 3 = agree
- 2 = disagree
- 1 = strongly disagree

Our team works together to achieve a common goal for student learning:

1 2 3 4 Don’t Know

The teachers in team and I have very different ideas about what we should emphasize in the curriculum:

1 2 3 4 Don’t Know

Teachers in my team are constantly learning and seeking new ideas:

1 2 3 4 Don’t Know

Within my team, I am encouraged to experiment with my teaching:

1 2 3 4 Don’t Know

The teachers in my team and I are in agreement about what should be happening within our learning community:

1 2 3 4 Don’t Know

The teachers in my team and I are in agreement about the need to collaborate:

1 2 3 4 Don’t Know

The teachers in my team and I are in agreement about how to use the results of common assessments:

1 2 3 4 Don’t Know

My involvement with my team provides me continuing professional stimulation and growth:

1 2 3 4 Don’t Know
For the following questions, please use the scale provided below to indicate the extent to which each scenario occurs within your team meetings:

1 = almost never  
2 = some of the time  
3 = most of the time  
4 = almost always

The extent to which you and your team discuss what and when you want to teach various concepts in the curriculum:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>

The extent to which you and your team determine the most essential outcomes for this course:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>

The extent to which you and your team develop common assessments for this course:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>

The extent to which you and your team examine and compare student learning results:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>

The extent to which you and your team discuss instructional methods you use to teach your students:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>

The extent to which you learn something useful during team meetings:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>

The extent to which you are changing the way you teach, based on your work with teachers in your team:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>

The extent to which you and your team are seeking new teaching methods, testing those methods, and reflecting on the results:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Don’t Know</th>
</tr>
</thead>
</table>
Appendix B
Second Individual Teacher Survey

Directions: Thank you again for your participation in this thesis research project. Below are questions on your experience with professional learning communities. Complete this survey as thoroughly as possible and to the best of your ability.

What are the goals of your PLC team? ____________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

What are you looking to get out of your experience with PLCs? _____________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

What, specifically, have you learned or how has your teaching practice changed by working in PLC teams?

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

What do you feel are the benefits of collaborating with colleagues versus working individually?

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________
The remaining questions were adapted from survey questions found in the following sources:

For the following questions, please use the scale provided below to indicate the extent to which you agree or disagree with each of the following statements concerning your team:

4 = strongly agree
3 = agree
2 = disagree
1 = strongly disagree

Our team works together to achieve a common goal for student learning:

1 2 3 4 Don’t Know

The teachers in team and I have very different ideas about what we should emphasize in the curriculum:

1 2 3 4 Don’t Know

Teachers in my team are constantly learning and seeking new ideas:

1 2 3 4 Don’t Know

Within my team, I am encouraged to experiment with my teaching:

1 2 3 4 Don’t Know

The teachers in my team and I are in agreement about what should be happening within our learning community:

1 2 3 4 Don’t Know

The teachers in my team and I are in agreement about the need to collaborate:

1 2 3 4 Don’t Know

The teachers in my team and I are in agreement about how to use the results of common assessments:

1 2 3 4 Don’t Know

My involvement with my team provides me continuing professional stimulation and growth:

1 2 3 4 Don’t Know
For the following questions, please use the scale provided below to indicate the extent to which each scenario occurs within your team meetings:

4 = almost always  
3 = most of the time  
2 = some of the time  
1 = almost never

The extent to which you and your team discuss what and when you want to teach various concepts in the curriculum:

1  2  3  4  Don’t Know

The extent to which you and your team determine the most essential outcomes for this course:

1  2  3  4  Don’t Know

The extent to which you and your team develop common assessments for this course:

1  2  3  4  Don’t Know

The extent to which you and your team examine and compare student learning results:

1  2  3  4  Don’t Know

The extent to which you and your team discuss instructional methods you use to teach your students:

1  2  3  4  Don’t Know

The extent to which you learn something useful during team meetings:

1  2  3  4  Don’t Know

The extent to which you are changing the way you teach, based on your work with teachers in your team:

1  2  3  4  Don’t Know

The extent to which you and your team are seeking new teaching methods, testing those methods, and reflecting on the results:

1  2  3  4  Don’t Know
Appendix C

First Individual Teacher Interview Protocol

Thank you for your participation in my study on high school mathematics teachers’ involvement in professional learning communities and for speaking with me today. This interview is being audio recorded for recall purposes. All transcripts and files will be coded with your participant ID in accordance with the consent form that you signed at the beginning of this year.

In this interview, there are no right or wrong answers. Feel free to take time to think about each question, as this is a discussion and not a race. I would like to talk with you today about your experience with PLCs, as well as your experience with other professional development and a bit about your beliefs on teaching.

Professional Learning Communities (PLC)

As you know, professional learning communities are being implemented in schools around Wake County. The following questions will relate to your experiences with PLCs.

1) How have you learned about PLCs? Tell me about what you have learned and how that impacts your work in PLCs.

2) How were you placed with the team you currently work with?
   
   • Do you work with other PLC teams?

3) Your team meetings are on Tuesday mornings. Are there other times that the group or some members of the group get together?
   
   • Are these meetings goal related? Are they social?

4) What do you see as your role on your PLC team?

5) What is typically discussed during PLC meetings?

   • Are there prevailing issues that your team is certain to address?
   • Are there types of activities in which you often engage?

6) How does your team decide the order to the curriculum?

   • What is the reasoning for those decisions?
7) Does your team ever discuss activities or tasks that can be used in the classroom?
   • Do you spend any time working through these activities or tasks yourself or as a team?
   • Where do these ideas come from?
   • Does everyone use them in their classrooms?
   • Do you discuss how the activity fared?

8) Does your team ever work through activities or tasks for reasons other than lessons?

9) Blue Diamond assessments are used throughout Wake County. Tell me more about these tests.
   • How does your team use them?
   • How do you use the data from the Blue Diamond assessments?
   • How do the data from these tests influence other decisions that your team makes?

10) Does your team develop common assessments?
    • How do you decide on the makeup of these assessments?
    • How does your team use the results from these tests?
    • Do these tests address different goals than Blue Diamond assessments or other pre-developed materials?

11) What else, other than multiple-choice tests, do you use as evidence for student’s understanding?

12) Do you feel comfortable sharing new ideas with the other teachers in your PLC team?
    • If so, can you provide an example of a time when this happened?
    • What do you do with these new ideas?
    • Where do you get new ideas for the classroom?

13) Are there any difficulties of working with your PLC team? How do you address those issues?

14) Do you collaborate with teachers who are not in your PLC team? What do you look to get out of those interactions?
Professional Development

Part of the information you provided on the survey at the start of this year was in reference to professional development. This question will relate to your experience with professional development.

15) What have you gained from professional development experiences in which you’ve taken part? [refer to specific examples stated on the demographic survey]

16) For what reasons do you take part in professional development experiences?

Classroom Teaching and Beliefs

These last questions will attempt to paint a picture of how your classroom typically looks as well as your beliefs on best practices.

17) Describe your beliefs on how students best learn? How do those beliefs impact your teaching practice?

18) Describe, in your opinion, an ideal mathematics lesson:

   a. What are the students doing during the lesson?
   b. What are you doing during the lesson?
   c. What other indicators do you use to determine the effectiveness of a lesson?
   d. How often do you implement such lessons? Why not more frequently?

19) Do you feel you share these beliefs with the other members of your team?
Appendix D

Second Individual Teacher Interview Protocol

This interview is being audio recorded for recall purposes. All transcripts and files will be coded with your participant ID in accordance with the consent form that you signed at the beginning of this year.

In this interview, there are no right or wrong answers. Feel free to take time to think about each question. For my study, I am not only interested in PLCs, but also mathematical tasks in the classroom. As a result, this interview will be different than the last one. I will be showing you some sample tasks as well as sample student work and I am interested in your impressions of them.

For all three tasks:

This is a sample task. Please read through the problem. Feel free to write on the sheet.

1) What are your first impressions of this task?
2) What does this task require students to understand?
3) Would you use this task in your classroom?
   • How would you use it?
   • Would students work in groups? Individually? Etc.
   • How would you expect students to work through this task?
   • What kind of responses would you expect from students?

Here is a sample of student work from this task

4) What do you think this child understands or misunderstands, based on their response here?

5) Where would you go next with this student?

(Repeat for additional student work)

Once all three tasks have been shown:

6) Rank these three tasks in order of which you’d most likely use in a lesson. Explain why you chose this order.

7) Rank these tasks in order of which you’d most likely use on a test. Explain why you chose this order.

| Order for #6 | | | | Order for #7 | | | |
**Task 1:**

Alice’s walking rate is 2.5 meters per second. Her younger brother, Mack, walks 1 meter per second. Because Alice’s rate is faster than Mack’s, Alice gives Mack a 45-meter head start in a 100-meter race.

Which equation can be used to find the number of seconds it takes Alice to catch Mack?

(a) $2.5s = 45s$

(b) $2.5s = s + 45$

(c) $s + 1 = 45s + 2.5$

(d) $2.5s = s - 45$
Task 1:

Alice’s walking rate is 2.5 meters per second. Her younger brother, Mack, walks 1 meter per second. Because Alice’s rate is faster than Mack’s, Alice gives Mack a 45-meter head start in a 100-meter race.

Which equation can be used to find the number of seconds it takes Alice to catch Mack?

(a) $2.5s = 45s$

(b) $2.5s = s + 45$

(c) $s + 1 = 45s + 2.5$

(d) $2.5s = s - 45$
**Task 2:**

Alice and her younger brother, Mack, are in a 100-meter walking race. Since Alice’s walking rate is faster than Mack’s, she gives him a head start. The graph below represents the distance walked for both Alice and Mack over time.

Reference the graph above for each question. Explain your strategies for answering each question and give evidence to support your answers.

1) Which line represents Alice? Which line represents Mack?

2) How long of a head start did Alice give Mack?

3) How fast is Alice walking? How fast is Mack walking?

4) Is there a point where Alice and Mack are tied? How much time into the race are they tied? How long into the race are they tied?

5) Who wins the race?
**Task 2:**

Alice and her younger brother, Mack, are in a 100-meter walking race. Since Alice's walking rate is faster than Mack's, she gives him a head start. The graph below represents the distance walked for both Alice and Mack over time.

Reference the graph above for each question. Explain your strategies for answering each question and give evidence to support your answers.

1) Which line represents Alice? Which line represents Mack?
   - **Racer 1 is Alice**
   - **Racer 2 is Mack**

2) How long of a head start did Alice give Mack?
   - **45 m**

3) How fast is Alice walking? How fast is Mack walking?
   - **Alice is walking 2.5 m/s**
   - **Mack is walking 1 m/s**

4) Is there a point where Alice and Mack are tied? How much time into the race are they tied? How long into the race are they tied?
   - **Yes, 30 seconds into the race**

5) Who wins the race?
   - **Alice**
Task 2:

Alice and her younger brother, Mack, are in a 100-meter walking race. Since Alice’s walking rate is faster than Mack’s, she gives him a head start. The graph below represents the distance walked for both Alice and Mack over time.

Reference the graph above for each question. Explain your strategies for answering each question and give evidence to support your answers.

1) Which line represents Alice? Which line represents Mack?
   Alice is Racer 1 because she starts further back and goes faster.
2) How long of a head start did Alice give Mack?
   45 m because Mack’s line starts at 45 m
3) How fast is Alice walking? How fast is Mack walking?
   I don’t know but Alice is faster because the line is steeper.
4) Is there a point where Alice and Mack are tied? How much time into the race are they tied? How long into the race are they tied?
   They are tied after 30 seconds and 65 meters because that’s where they intersect.
5) Who wins the race?
   Alice because her line gets to 100m fastest.
Task 3:

Alice’s walking rate is 2.5 meters per second. Her younger brother, Mack, walks 1 meter per second. Because Alice’s rate is faster than Mack’s, Alice gives Mack a 45-meter head start in a 100-meter race. What happens in the race?

Explain your strategy for solving this problem and give evidence to support your answer.
Task 3:

Alice's walking rate is 2.5 meters per second. Her younger brother, Mack, walks 1 meter per second. Because Alice's rate is faster than Mack's, Alice gives Mack a 45-meter head start in a 100-meter race. What happens in the race?

Explain your strategy for solving this problem and give evidence to support your answer.

\[
\begin{align*}
\text{Alice: } & \frac{100}{2.5} = 40 \text{ seconds} \\
\text{Mack: } & \frac{100}{1} = 100 \text{ seconds} - 45 = 55 \text{ seconds}
\end{align*}
\]

Alice beats Mack by 15 seconds.
Task 3:

Alice's walking rate is 2.5 meters per second. Her younger brother, Mack, walks 1 meter per second. Because Alice's rate is faster than Mack's, Alice gives Mack a 45-meter head start in a 100-meter race. What happens in the race?

Explain your strategy for solving this problem and give evidence to support your answer.

M: 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

A: 0 1.5 10 11.5 12.5 13.5 14 14.5 15 15.5 16 16.5 17 17.5 18 18.5 19 19.5 20 21 21.5 22 22.5 23 23.5 24 24.5 25 25.5 26 26.5 27 27.5 28 28.5 29 29.5 30 30.5 31 31.5 32 32.5 33 33.5 34 34.5 35 35.5 36 36.5 37 37.5 38 38.5 39 39.5 40 40.5 41 41.5 42 42.5 43 43.5 44 44.5 45 45.5 46 46.5 47 47.5 48 48.5 49 49.5 50 50.5 51 51.5 52 52.5 53 53.5 54 54.5 55 55.5 56 56.5 57 57.5 58 58.5 59 59.5 60 60.5 61 61.5 62 62.5 63 63.5 64 64.5 65 65.5 66 66.5 67 67.5 68 68.5 69 69.5 70 70.5 71 71.5 72 72.5 73 73.5 74 74.5 75 75.5 76 76.5 77 77.5 78 78.5 79 79.5 80 80.5 81 81.5 82 82.5 83 83.5 84 84.5 85 85.5 86 86.5 87 87.5 88 88.5 89 89.5 90 90.5 91 91.5 92 92.5 93 93.5 94 94.5 95 95.5 96 96.5 97 97.5 98 98.5 99 99.5 100

Alice wins by 15 meters. They were tied at 75 meters.
Appendix E

List of Codes for Team Meeting Analysis

Stage 1: Collaboration indicators –

1.1. Beliefs on collaboration:

A1 - Length of meetings (use of meeting time)
A2 - Attendance
A3 - Instances of encouragement to share and/or having substantive conversation (who involved)

1.2. Shared values and goals:

B1 - Redirection (& who does the redirecting)
B2 – Development of team goals
B3 – Mention of team goals

1.3. Shared role:

C1 - Individual participation
C2 - Individual responsibilities

Stage 2: Teacher Learning indicators –

2.1. Collective inquiry:

D1 - Direct mention of research articles or other literature
D2 - Developing common plans, activities, or assessments
D3 - Mention of common plans, activities, or assessments
D4 - Forming hypotheses for results from the use of common plans, activities, or assessments

2.2. A results orientation:

E1 - Discussing plans to collect classroom data
E2 - Analyzing classroom data
E3 - Discussion of conclusions drawn from data
E4 - Refinement of lessons or activities based on conclusions from data
E5 - Refinement of curriculum based on conclusions from data
E6 - Refinement of assessments based on conclusions from data

2.3. Focus on student learning:

F1 - Development of goals for student achievement
F2 - Reference to goals for student achievement (including EOC/NCSCOS)
F3 - Discussion relating to curriculum, instruction, and assessment
Stage 3: Specialized Growth indicators –

3.1. Content focus:

G1 - Teachers working through tasks for use in classroom
G2 - Teachers working through mathematical content to address their own content knowledge
G3 - Direct mention of research on mathematical content or pedagogy
G4 - Discussion of algebraic concepts
G5 – Developing/Refining curriculum to address algebraic concepts or remove topics no longer in curriculum

3.2. Use of artifacts of practice:

H1 - Use of classroom artifacts such as classroom video, lesson plans, or student work
H2 - Looking at student work beyond answers as part of results analysis
H3 - Discussion of classroom observations from the observer
H4 - Discussion of teacher accounts of classroom instruction
H5 - Drawing conclusions or making changes based on observable classroom results

3.3. Implementation of reform-inspired instructional practices:

I1 - Discussion of mathematical tasks for use in the classroom
I2 – Development/Refinement of mathematical tasks for use in the classroom
I3 - Discussion of other reform-inspired instructional methods such as technology
I4 – Planning of use of other reform-inspired instructional methods
I5 - Reflecting on use of tasks or other reform-inspired instructional methods
Appendix F

List of Codes for Individual Teacher Interview Analysis

Stage 1: Collaboration indicators -

1.1. Beliefs on collaboration:

A4 - Evidence or mention of being comfortable sharing new ideas with team
A5 - Instances of group interactions outside of set meeting time
A6 - Evidence of preferring collaboration over isolation

1.2. Shared values and goals:

B4 - Defined goals for work with PLC team consistent across all members

1.3. Shared role:

C3 - Defined role and/or responsibilities on PLC team consistent to team meetings

Stage 2: Teacher Learning indicators -

2.1. Collective inquiry:

D5 - Direct mention of research articles or other literature
D6 - Evidence of remaining active in the profession (grad classes, conferences, professional memberships)
D7 - Mention of common plans, activities, or assessments

2.2. A results orientation:

E7 - Mention of analysis of classroom data
E8 - Mention of conclusions drawn from data
E9 - Mention of refinement of lessons, activities, or assessments based on conclusions
E0 - Mention of making changes to practice based on conclusions

2.3. Focus on student learning:

F4 - Mention of goals for student achievement
F5 - Evidence of high standards and expectations for students
Stage 3: Specialized Growth indicators –

3.1.Content focus:

G6 - Teachers working through task when presented with task
G7 - Mention of working through tasks or other mathematics
G8 - Mention of research on mathematical content and pedagogy
G9 - Mention of grounds for curriculum order such as student performance, better addressing algebraic concepts, or removal of old topics

3.2.Use of artifacts of practice:

H6 - Mention of use of classroom artifacts such as video, lesson plans, or student work
H7 - Mention of use of evidence of student learning other than summative assessments and multiple-choice data
H8 - Evidence of valuing students’ responses outside of just their answers

3.3. Implementation of reform-inspired instructional practices:

I6 – Evidence of willingness to incorporate new practices such as use of technology and high-level tasks
I7 - Mention of incorporating new practices such as use of technology and high-level tasks
# Appendix G

## Brantley Team Meeting Coding Sheet

<table>
<thead>
<tr>
<th>PLC1 - Brantley High School - Team Meeting Coding (maximum 23 intervals)</th>
<th>09/09/08</th>
<th>09/23/08</th>
<th>10/14/08</th>
<th>10/21/08</th>
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<tr>
<td><strong>Stage 1: Collaborative indicators</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1.1. Beliefs on collaboration</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>A1 Length of meetings (use of meeting time)</td>
<td>23/23</td>
<td>22/23</td>
<td>23/23</td>
<td>22/23</td>
</tr>
<tr>
<td>A2 Attendance</td>
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<td><strong>1.2. Shared values and goals</strong></td>
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<td>B1 Redirection</td>
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<td>B3 Mention of Team Goals</td>
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<td><strong>1.3. Shared role</strong></td>
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<td>I7-G3</td>
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<td>C2 Individual Responsibilities</td>
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<tr>
<td>I1-A9</td>
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## Stage 2: Teacher Learning indicators

### 2.1. Collective inquiry

<p>| D1 Direct mention of research articles or other literature | 0 | 0 | 0 | 0 |
| D2 Developing common plans, activities, or assessments | 0 | 0 | 5 | 0 |</p>
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<th>10/14/08</th>
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<td>D4</td>
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2.2. A results orientation

| E1 | Discussing plans to collect classroom data | 1 | 2 | 0 | 0 |
| E2 | Analyzing classroom data | 5 | 4 | 3 | 0 |
| E3 | Discussion of conclusions drawn from data | 4 | 6 | 4 | 0 |
| E4 | Refinement of lessons or activities based on conclusions from data | 0 | 0 | 0 | 0 |
| E5 | Refinement of curriculum based on conclusions from data | 0 | 3 | 0 | 0 |
| E6 | Refinement of assessments based on conclusions from data | 2 | 7 | 1 | 0 |

2.3. Focus on student learning

| F1 | Development of goals for student achievement | 0 | 0 | 0 | 0 |
| F2 | Reference to goals for student achievement | 4 | 4 | 1 | 0 |
| F3 | Discussion relating to curriculum, instruction, and assessment | 10 | 14 | 9 | 7 |

Stage 3: Specialized Growth indicators

3.1. Content focus

<p>| G1 | Teachers working through tasks for use in classroom | 0 | 0 | 0 | 0 |
| G2 | Teachers working through mathematical content to address their own content knowledge | 0 | 0 | 0 | 0 |
| G3 | Direct mention of research on mathematical content or pedagogy | 0 | 0 | 0 | 0 |
| G4 | Discussion of algebra concepts | 1 | 1 | 0 | 2 |
| G5 | Developing/refining curriculum to address algebraic concepts or remove skills/topics no longer in curriculum | 1 | 0 | 1 | 0 |</p>
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<tr>
<th>PLC1 - Brantley High School - Team Meeting Coding (maximum 23 intervals)</th>
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<th>09/23/08</th>
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<td>H3 Discussion of classroom observations from the observer</td>
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<td>H5 Drawing conclusions or making changes based on observable classroom results</td>
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<td><strong>3.3. Implementation of reform-inspired instructional practices</strong></td>
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<td>I3 Discussion of other reform-inspired instructional methods such as use of technology</td>
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<td>I4 Planning of use of other reform-inspired instructional methods</td>
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<tr>
<td>I5 Reflecting on use of tasks or other reform-inspired instructional methods</td>
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# Appendix H

## Elmwood Team Meeting Coding Sheet

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### Stage 1: Collaborative indicators

#### 1.1. Beliefs on collaboration

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<tr>
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<tr>
<td>A3</td>
<td>Instances of encouragement to share</td>
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<td>1</td>
<td>1</td>
<td>1</td>
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</tbody>
</table>

#### 1.2. Shared values and goals

| B1 | Redirection | 2 | 1 | 4 | 1 |
| B2 | Development of Team Goals | 0 | 0 | 0 | 0 |
| B3 | Mention of Team Goals | 1 | 0 | 1 | 1 |

#### 1.3. Shared role

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<td>Facilitator</td>
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</table>

### Stage 2: Teacher Learning indicators

#### 2.1. Collective inquiry

| D1 | Direct mention of research articles or other literature | 2 | 0 | 0 | 1 |
| D2 | Developing common plans, activities, or assessments | 0 | 0 | 0 | 0 |
| D3 | Mention of common plans, activities, or assessments | 5 | 1 | 4 | 3 |
| D4 | Forming hypotheses for results from the use of common plans, activities, or assessments | 0 | 0 | 0 | 0 |

#### 2.2. A results orientation

| E1 | Discussing plans to collect classroom data | 0 | 3 | 0 | 0 |
| E2 | Analyzing classroom data | 1 | 0 | 2 | 0 |
## PLC2 - Elmwood High School - Team Meeting Coding (maximum 23 intervals)

<table>
<thead>
<tr>
<th></th>
<th>09/16/08</th>
<th>09/30/08</th>
<th>10/07/08</th>
<th>10/28/08</th>
</tr>
</thead>
<tbody>
<tr>
<td>E3</td>
<td>Discussion of conclusions drawn from data</td>
<td>1</td>
<td>1</td>
<td>3</td>
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<tr>
<td>E4</td>
<td>Refinement of lessons or activities based on conclusions from data</td>
<td>0</td>
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<tr>
<td>E5</td>
<td>Refinement of curriculum based on conclusions from data</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>E6</td>
<td>Refinement of assessments based on conclusions from data</td>
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### 2.3. Focus on student learning

<table>
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<tr>
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<th>10/07/08</th>
<th>10/28/08</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Development of goals for student achievement</td>
<td>0</td>
<td>0</td>
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<tr>
<td>F2</td>
<td>Reference to goals for student achievement</td>
<td>3</td>
<td>4</td>
<td>1</td>
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<tr>
<td>F3</td>
<td>Discussion relating to curriculum, instruction, and assessment</td>
<td>11</td>
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### Stage 3: Specialized Growth indicators

#### 3.1. Content focus

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<tbody>
<tr>
<td>G1</td>
<td>Teachers working through tasks for use in classroom</td>
<td>2</td>
<td>3</td>
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<tr>
<td>G2</td>
<td>Teachers working through mathematical content to address their own content knowledge</td>
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<tr>
<td>G3</td>
<td>Direct mention of research on mathematical content or pedagogy</td>
<td>1</td>
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<tr>
<td>G4</td>
<td>Discussion of algebraic concepts</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>G5</td>
<td>Developing/refining curriculum to</td>
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#### 3.2. Use of artifacts of practice

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<th>10/28/08</th>
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</thead>
<tbody>
<tr>
<td>H1</td>
<td>Use of classroom artifacts such as classroom video, lesson plans, or student work</td>
<td>0</td>
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<tr>
<td>H2</td>
<td>Looking at student work beyond answers as part of results analysis</td>
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<tr>
<td>H3</td>
<td>Discussion of classroom observations from the observer</td>
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<tr>
<td>H4</td>
<td>Discussion of teacher accounts of classroom instruction</td>
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<td>1</td>
<td>0</td>
</tr>
<tr>
<td>H5</td>
<td>Drawing conclusions or making changes based on observable classroom results</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>09/16/08</td>
<td>09/30/08</td>
<td>10/07/08</td>
<td>10/28/08</td>
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<tr>
<td>---</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>I1</td>
<td>Discussion of mathematical tasks for use in the classroom</td>
<td>2</td>
<td>1</td>
<td>0</td>
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<tr>
<td>I2</td>
<td>Development/refinement of mathematical tasks for use in the classroom</td>
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<tr>
<td>I3</td>
<td>Discussion of other reform-inspired instructional methods such as use of technology</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>I4</td>
<td>Planning of use of other reform-inspired instructional methods</td>
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</tr>
<tr>
<td>I5</td>
<td>Reflecting on use of tasks or other reform-inspired instructional methods</td>
<td>0</td>
<td>1</td>
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</tbody>
</table>
Appendix I

IRB Approval Letter (IRB# 205-08-5)

From: Joseph Rabiega, IRB Coordinator
North Carolina State University
Institutional Review Board

Date: May 16, 2008

Project Title: Planning and Implementation of Mathematical Tasks in Secondary Mathematical Classrooms

IRB#: 205-08-5

Dear Mr. Campbell-

The research proposal named above has received administrative review and has been approved as exempt from the policy as outlined in the Code of Federal Regulations (Exemption: 46.101. b.2). Provided that the only participation of the subjects is as described in the proposal narrative, this project is exempt from further review.

NOTE:

1. This committee complies with requirements found in Title 45 part 46 of The Code of Federal Regulations. For NCSU projects, the Assurance Number is: FWA00003429.

2. Any changes to the research must be submitted and approved by the IRB prior to implementation.

3. If any unanticipated problems occur, they must be reported to the IRB office within 5 business days.

Please provide a copy of this letter to your faculty advisor.

Sincerely,

Joe Rabiega
NCSU IRB