PROFESSIONAL LEARNING COMMUNITIES AND THEIR FACILITATION FOR
ADVANCING AMBITIOUS TEACHING PRACTICES

by

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Date May 16, 2018

Submitted in partial fulfillment of the requirements for the degree of Doctor of Education in Teachers College, Columbia University

2018
ABSTRACT

PROFESSIONAL LEARNING COMMUNITIES AND THEIR FACILITATION FOR ADVANCING AMBITIOUS TEACHING PRACTICES

John Lawson Russell

Next Generation Science Standards and the Framework for K-12 Science Education encourage teachers to not only change the content of their teaching, but also the way that they deliver it. In order to promote these modern teaching practices, professional development (PD) experiences for teachers need to develop new approaches that enhance the transfer of the PD context into the teachers’ classroom practice. In this research study, professional learning communities (PLCs), defined as collaborative groups of teachers who make their practice visible within their professional learning, are analyzed in a formally instituted series of teacher professional education offerings. Moreover, the setting included a professional learning community composed of teacher-facilitators who were actively engaged as facilitators of other PLCs. The goal of this design experiment was to both explore PLCs as PD models within science education as well as to begin to develop tools for PD that allow teachers to work from within the context of their own classroom. The sources of evidence used in this study included...
teacher and student produced artifacts and interviews, and written transcripts of the sessions were also examined. All data were primarily explored using methodology taken from grounded theory. This approach facilitated identification of emergent themes that particularly addressed some of the ways that researchers and teacher leaders can work together in the future to make certain that PD and the teachers’ classroom practices are more coherently connected. The following themes were identified: refining the focus of professional learning communities to allow for investigations of student learning in the classroom, especially with an eye towards supporting transparency of practice through artifacts, and the usefulness of cycles of inquiry as a construct for planning professional learning communities. Furthermore, it became clear that there is a need for explicit norms to frame the classroom around what constitutes acceptable explanations and justifications for productive classroom experiences. Among other findings, it is recommended that borrowing from and adapting the work of scholars in sociomathematical norms around the use of explanations can be the basis for a possible framework for improving future studies of teacher professional practice.
ACKNOWLEDGEMENTS

The author would first like to acknowledge the help of Dr. Mensah and Dr. Anderson. Their guidance throughout my time at Teachers College was immeasurable not only to this research, but to my continued growth throughout my time here.

In addition, the author’s opportunity to do research at Math for America is not without appreciation. He would especially like to thank Courtney Allison and Liz Clark-Garvey for their own expertise around teacher education and professional learning communities, their passion for our math and science teachers, and their support throughout.

Most importantly, Smita, you are my guiding light. – JR
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Chapter I

INTRODUCTION

Interest and Justification

In recent years, the introduction of *The Framework for K-12 Science Education* (National Research Council [NRC], 2011) and *Next Generation Science Standards* (Next Generation Science Standards Lead States, 2013) have charged the science education community to create classroom environments that acknowledge the development of students’ ability to collaborate, acquire and practice knowledge which is equally as important as the content itself. With new standards comes a need for a new way to assess (NRC, 2014); and with these new standards and assessments must come new ways to see ensure that the reforms are understood and applied within the teaching community (Cohen & Ball, 1990).

The ambitious, challenging and dynamic vision of science learning suggested by the Framework and the NGSS requires teachers to learn and master multiple instructional approaches, situating their students in learning that allows students to ask questions, design investigations, analyze data, and communicate among others as a community of learners (NRC, 2015). Borko (2004) recommended that the strongest method for creating a community of learners among students is to establish and maintain a parallel community of professional learning among teachers. This community is characterized by being composed of “ongoing groups of teachers who meet regularly for the purpose of increasing their own learning and that of their students” (Lieberman & Miller, 2008, p. 2). If Borko (2004) is correct, what does this professional learning among teachers look
like, and how can it be defined in a way that makes it authentic and capable for implementation on varying scales?

An issue with the landscape of professional learning is that our current understanding of the best way to enact science professional development (PD) seems to draw from consensus among science education experts too heavily, instead of seeking classroom situated, evidence-based practices with verifiable impact on teacher learning, teacher practice, and student learning (Roth et al., 2011; Wayne, Yoon, Zhu, Cronen, & Garet, 2008). Current methods of in-service professional development of teachers are particularly problematic, where the programming often is based on advice from experts who are unfamiliar with local context and too often present irrelevant work (Wilson & Berne, 1999). Indeed, most professional development programs seem to ignore the tension between working from a research base and working from within the teacher’s experience in the classroom. Teacher surveys consistently show that programs of in-service professional development are ranked among the least valuable sources of learning, being perceived as not useful for addressing any classroom problems (Smylie, 1989; Smylie, 2014; Wei, Darling-Hammond, & Adamson, 2010). Without useful professional development, how can teachers find opportunities to enact reforms that promote and demand ambitious teaching practices that shift the goal of instruction from fact-finding to the NGSS’ goals of student-centered experiences revolving around the explanation of phenomena using full engagement in scientific practices (Reiser, 2013)?

Recent work on professional learning communities, or PLCs, suggest that they are a powerful way to plan professional learning that simultaneously grounds teacher learning within practice as well as current research (Lieberman & Miller, 2016).
However, much of the research within professional learning communities is limited to a small group of teachers (e.g., Grossman, Wineburg, & Woolworth, 2001; Vescio, Ross, & Adams, 2008), and issues of scale, when discussed, seem to concentrate more on leadership and administration than on systems that can identify issues and sustain the communities as a whole (Dufour, Dufour, Eaker, & Many, 2010).

My personal interest in professional development and professional learning communities draws from ten years of teaching in New York City public schools, primarily in West Harlem. Throughout that time, I found that there was a common need among teachers to improve their practice, but the tools were often unavailable, unknown, or both. With the changes required in order to meet the goals of the Framework and NGSS, the need for high quality PD that resists teaching teachers about isolated practice and instead focuses on advancing teachers through their own practice is paramount (Ball & Cohen, 1999; Reiser, 2013; Wilson, 2013).

The purpose of this research is to both explore professional learning communities as PD models within science education and to develop tools for PD that allow teachers to work from within the context of their own classroom. As this was done by evaluating and refining the model as it progresses, a design experiment was used for this research study.

Rationale and Goals

Design experiments are used to develop theory through iterative, practice-oriented design (Prediger, Gravemeijer, & Confrey, 2015). That is, theory emerges from in-depth involvement of the researcher in the unfolding sequence of learning experiences in classrooms, particularly the iterative periodic evaluation and transformation of practices,
with the aim of eventually yielding evidence-based recommendations to improve classroom teaching. The study reported here drew from current theory and evidence in group processes in order to develop a professional learning community that in some respects was uniquely composed of teacher-facilitators who were actively serving as in-service facilitators of other science teacher professional learning communities. Among the strategies used was to develop continuing, regularly occurring, group meetings of the facilitators to discuss and solve problems of practice that they noticed within their own community of practitioners that they were serving. This design experiment fills in gaps in theory related to issues of in-service professional development as well as the scalability of professional learning communities (PLCs). The work takes a pragmatic approach and grounds itself in the real work of teachers by using multiple PLCs as sources of information while still giving time for the teacher-facilitators to work together on common issues (Figure 1.1).

Figure 1.1. Research design for in-service professional development of science teachers and teacher-facilitators.

**First Goal**

The first goal of this research is to demonstrate the ability for professional learning communities that draw upon teachers’ own practices (commonly called practice-based professional learning) to answer issues of usability in the classroom commonly
brought up as the primary problem of in-service professional development (Thompson & Zeuli, 1999). One of the central assumptions is that the intersection of theory around practice-based professional learning and communities of practice will create design choices that fit many of the goals of professional development outlined by Loucks-Horsley, Stiles, Mundry, Love, and Hewson (2009); especially the need for professional learning that is driven by an image of classroom learning and teaching as well as a need for opportunities for teachers to reflect on practice, collaborate with colleagues and develop professional expertise. It is incredibly difficult for a professional learning community to flourish independently without building an additional skillset among teacher leaders (Jolly, 2008). Moreover, examining how teachers build this skillset over time may influence future work in PD that develops what Lave and Wenger (1991) term brokers, or practitioners who are part of multiple communities (here, the professional development and teacher communities).

Content-specificity within science departments, where for instance there is only one chemistry teacher, may suggest confounding variables, which is why the PD context here was located in an out of school setting. While not unique, it is fairly rare for professional learning communities to involve content teachers working together with other teachers from multiple schools (Easton, 2011). This is in stark contrast to professional development, which often occurs in workshops out of the school context. The setting of an out of school context allows the researcher to make suggestions about PLCs that may be generalized to all PD contexts. In addition, the tool used to generate the issues of professional learning communities, a professional learning community of teachers that are themselves facilitators, is unique among professional development
models in the way that it encourages trust, and includes and empowers teachers during the research; for use of this model in the classroom and not PD research, see Stephan (2015).

**Second Goal**

Based on the out of school context typical of professional development, the second goal of this research is to outline the use of boundary objects as central artifacts that teachers can use to guide professional development that carry over into the classroom. Boundary objects are artifacts, symbols, or other representations (sometimes actual objects), that have meaning for the participants in a community. That is, the objects are context-specific, as defined in the literature on communities of practice (Lave & Wenger, 1991). Common examples of a ‘boundary object’ are symbols such as a cross, which may have a variety of meanings depending on whether you are adding in the mathematics classroom, looking at a compass rose in the geography classroom, or studying the crucifixion in religious studies. Kazemi and Hubbard (2008) theorize that many school artifacts such as student work should be treated as boundary objects because they are context-specific and represent a way for professional development and classroom experiences to be in a cycle of coevolution, where the work in one area continually informs the work of the other. PD that is coevolutionary not only takes the classroom context into account, but also the change that occurs in classroom contexts as teachers experiment with the ideas that they are learning in PD. Building off of this work, as the researcher, I identify, through the work of multiple professional learning communities, aspects of boundary objects and their integration into professional
development by facilitators that may or may not drive this coevolutionary cycle and thus provide recommendations for professional development in the future.

**Third Goal**

The third goal of this research is to use the PD model as a way to navigate the common issue of horizons of observation that often plague teacher-led collaborative PD (Little, 2003; Vescio et al., 2008). Horizons of observation are an obstacle commonly found in teacher-led collaborative groups where the community is limited by visions of teaching and learning that privilege their own voices at the expense of experimentation and community-developed, divergent thinking. Horizons of observation cause teacher communities to become insular, focusing only on making explicit the practical wisdom teachers already possess about teaching, and not addressing current evidence-based, and new professional knowledge. Moreover, these less reflective approaches often neglect adequate attention to the needs of students as well. Some methods for expanding this horizon of observation have included PD models that explicitly draw upon prior outside research (Keeley, 2005). However, they may do it at the expense of grounding the work in the practice of teachers. By having teachers as both learners and facilitators, horizons can be expanded, without experiencing the usual useless sense of doing work that does not tie into the classroom.
Research Questions

Based on the foregoing rationale and objectives of this study on PLCs, the following research questions are addressed:

1. What problems of practice typify professional learning communities as they are discussed in the professional learning community of teacher facilitators, and what are the challenges in using boundary objects such as formative assessments or student work as professional development tools?

2. How can teacher leaders navigate those issues in order to lead successful PD?

3. How do teacher leaders, as brokers in professional development, become more comfortable in facilitating other teachers, as evident in participation shifts that occur between the teacher leader and participants as well as between the teachers themselves?

The first research question acknowledges that the professional learning community of teacher leaders is a generative model for theory that gives a voice to some of the principal stakeholders in professional development – the teachers that lead it. While teachers often work as collaborators and may even occasionally be the principal operators of design in curriculum work (Joseph, 2004; Stephan, 2015), this role in professional learning is unique. In addition, the role of the researcher changes to support the coevolutionary context sought in PD, by changing the role of the PD leader from ‘developer’ to ‘supporter’ of professional learning. It addresses also the disconnect that can be found between the knowledge gained in professional development and its application in the classroom, which is often attributed to differences of context. For instance, it is a common practice during PD for teachers to analyze student work to detect
the range of student strategies used in mathematical professional development, but in the classroom, teachers typically use student work purely for evaluative purposes (Kazemi & Hubbard, 2008). Unless facilitators of professional development attend to the varied meanings of boundary objects, teachers may gain and demonstrate knowledge that in no way informs their instructional practice.

The second research question reflects the need for a design experiment to “do real work” (Cobb, Confrey, Lehrer & Schauble, 2003, p. 11). For the teacher leaders, it is not enough to surface problems of practice as well as challenges in leading professional learning communities, but the PD model should give a place for the teacher leaders to experiment with solutions to these issues and suggest future work in this context. This orientation towards practice is one of the common characteristics Prediger et al. (2015) state that all design experiments should have.

The final research question takes a participation view of practice, holding that activity is the primary unit of analysis, acknowledging that as teachers experiment in the classroom, the nature of their conversations in professional development change, which can then influence future classroom practice. Here, there are multiple shifts in participation that can be measured; between the teacher leaders and the researcher, between the individual teachers in the professional learning communities, between the teachers and the teacher leaders, etc. Because the focus of the other three questions are on the work of the teacher leaders, the focus of the researcher is on their conversation shifts over time.

The overall goal for this research, mirroring Borko’s call (2004) for a parallel community of learners among teachers, inspiring the same sense of community among
their students, is that teacher learning happens when teaching becomes a collaborative, knowledge-generating activity where teachers place the formation of student ideas as a guide for their own instructional decision-making. In order to do so, the researcher believes that a model for excellent professional development supports teachers in using boundary objects as tools to generate ideas about how their students understood a scientific practice, allows teachers to enact change based on this work in their classroom, and then gives them the opportunity to share within their professional learning community to inform future work. The best leaders of this work with teachers are teachers themselves, but the supports necessary from researchers to help with this collaborative work are unknown. In order to find out how to give teacher leaders additional support, the professional learning community of teacher leaders will enable them to raise, share, experiment with and resolve various problems of practice.
Chapter II

LITERATURE REVIEW

This literature review is intended to lay the foundations for a theoretical framework to guide the development of the design experiment, the planning of the intervention, and a lens of the work around collaborative studies that can build ambitious science teaching practices.

In summarizing the prior state of research on teacher learning, and where it needs to go, Putnam and Borko (2000) outlined the goal to move beyond behaviorist perspectives in order to understand how context-specific learning occurs. This literature review starts by introducing the behaviorist perspective, its issues and how these issues are even more apparent in professional learning, then it moves through constructivism to current aspects of situated learning and communities of practice that drive a great deal of current research. In doing so, different aspects of current ideas about learning theory that influence the design of the professional development are addressed, culminating in a survey of the current vision of practice-based professional education.

After this, further background is provided on how communities of practice have led to the creation and study of professional learning communities, and especially the role boundary objects have within communities of practice, as well as their challenges. While teacher leaders have been a part of professional learning communities and professional development as a whole, the limited research that exists on teacher leader education is also discussed here.
A great deal of the literature on professional learning communities exists outside of science education, so the literature review also frames the lens of ambitious teaching and how it has been translated into science education, and especially how it has affected the work of NGSS, and the vision of student learning that is expected in translating those standards into the classroom.

Finally, because a design methodology was used in this study, a review of literature outlining components of this field of educational research are studied in order to give a proper background for the methodology section.

**Behaviorism and the Beginning of the Learning Sciences**

As psychologists started to study how we learn, they wanted a scientific approach that would allow them to observe and record data in order to come to logical conclusions. Because of the impossibility of carrying out experiments that measured acts of thought as they were occurring in the brain, the approach that seemed most appropriate was to define learning in terms of observable behaviors. Using this method, psychologists and other scientists could set up controlled experiments with variables that they could easily measure. Ivan Pavlov’s work in classical conditioning (1927) is perhaps the best example of this, where dogs’ saliva was a measured response to a bell ringing when food normally appeared.

As behavioral psychology was applied to human learning, psychologists such as Edward Thorndike and B.F Skinner stressed the importance of the environment in providing the stimuli that caused or aroused behavioral responses, as well as the
importance of operant behaviors, where behavior may be reinforced by positive events in the environment (Sternberg, 1999).

Learning, then, is largely explained as reactions to reinforcing feedback from environment. Teaching becomes an issue of finding the best stimuli and set of reinforcements that cause students to have the appropriate response. The largest success story of behaviorism has probably been within the work of applied behavior analysis, which is the process of systematically applying interventions to improve behavior to a meaningful degree, and to demonstrate that the interventions employed are responsible for improvements in behavior. This is typically done by quantitatively defining behavior in a way where interventions become far easier to reliably measure and evaluate (Sulzer-Azaroff & Mayer, 1991).¹ This work is most often done in the treatment of autism spectrum disorder, where socially significant behaviors can be focal points for study and support. While a successful approach in certain endeavors within education, decades of subsequent work in cognitive psychology have shown that the behaviorist approach cannot explain certain phenomenon which play a central role in professional learning, especially around context-dependence, misconceptions, and social learning.

Numerous studies show that even simple acts of learning like memory and recall are plastic, that is, they cannot be measured reliably because the context and environment of testing is as important as the environment at the time of the stimuli. For instance, Godden and Baddeley (1975) tested the memory of divers for events witnessed underwater in two different environments, finding that their memory was better when

¹ As a minor aside, the researcher’s first formal training within education as an undergraduate was in applied behavior analysis, as he tutored children in the St. Louis area with autism.
they were tested underwater in a context that matched the original event. Context-dependent memory has not only been shown as a consequence of environment, but also congruence of mood (Lewis & Critchley, 2003), of noise level (Grant et al., 1998) and even of drugs such as nicotine and alcohol (Goodwin, Powell, Bremeer, Hoine, & Stern, 1969; Peters & McGee, 1982).

In addition, because behaviorist models ignore cognitive processes from within individuals, they do a particularly poor job of dealing with learning around misconceptions, preconceptions, and their hindering effects when they are not addressed in the classroom. The environment alone cannot provide stimuli that appropriate the correct response from participants because the environment does not know what the participant does and does not already know and the manner in which they hold those ideas. Indeed, this response to behaviorism is just one sample argument against pure behaviorism based on Piaget’s theory of constructivism and developmental learning writ large (Piaget, 1967).

Finally, the behaviorist model suggests interventions that divorce themselves from the role of peers in learning. Bandura (1977) emphasized the importance of observing other people’s behavior as a way to safely acquire complex behaviors, and Lave and Wenger (1991) furthered this idea by making the relationships among communities of practice far more reciprocal. Mastery within learning comes not from a single intervention, but from structures that stress practice, communication and experimentation between individuals of varying abilities.
Instead of the behavioral model, the central theory that has guided a great deal of work within the learning sciences within the last 20 years has been that of situated cognition, also known as situated learning or shortened to the situative perspective (Brown, Collins, & Dugoid, 1989; Lave & Wenger, 1991; Putnam & Borko, 2000). Theorists of situated cognition acknowledge that conceptual ideas are intricately situated and progressively developed through activity. It may be most useful to consider knowledge as, instead of an abstract concept, a tool that can only be fully understood through continued use (Brown et al., 1989). The way that this tool is learned is dependent not only on the method in which it is introduced and practiced, but also on the relationships that the participant has with other individuals and their place in society as well. Much of the early work of situated cognition was demonstrating that the culture of learning as it happens in school is principally responsible for the failure of transfer to out of school settings (A. Brown, 1992), because of how inauthentic it is in comparison to actual use in the field. One pertinent example within science education has been the work of Hofstein and Kind (2012) who show how the laboratory, as it is used in the typical school science classroom, enforces recipe-book procedures leading to rote knowledge instead of its use in real life as a tool to ask questions and generate new knowledge, often by working collaboratively with a team of other researchers.

The situative perspective is more appropriate for explaining many of the issues, previously unexplained through behaviorism, by demonstrating that knowledge transfer is rife with variables to consider other than the kind of intervention; learning and knowing are situated in a way that depends on the nature of the activity in comparison to how the
knowledge would be used in other circumstances as well as the relationship that learners have within their learning community (Greeno, Collins, & Resnick, 1996; Putnam & Borko, 2000).

This perspective has informed much of current work not only in professional development, but curriculum development and reform as well; for instance, the inclusion of Scientific Practices in the Next Generation Science Standards is a nod to the fact that scientific literacy involves doing science in a context that allows better transfer from the classroom to the outside world. In the most recent NRC report on designing assessment for NGSS, the authors outline that most high-stakes assessments, by their focus on rote knowledge, are not nearly sufficient to measure scientific knowledge; they merely demonstrate scientific knowledge in a classroom context (NRC, 2014). This is mirrored by reports on teacher learning that show a continued need for professional development that gives teachers tools to allow their students to learn in a more authentic environment (NRC, 2016). Similarly to how we ask for learning for our students to be situated in authentic contexts, good professional development should do as much as possible to situate the learning within the teacher’s classroom.

**Professional Learning with Context in Mind**

Although the flaws of the behaviorist perspective have been known for decades, the idea of professional development as an intervention that enacts change in teacher behavior seems to be pervasive within professional learning (Putnam & Borko, 2000). In-service professional development typically treats teachers as passive learners where a
lecture-style format introduces strategies outside of the context of the classroom (Varela, 2012). Teachers’ expertise is typically not honored and supported.

In their article on policies that support professional development, Darling-Hammond and McLaughlin write that the response to this behaviorist perspective in professional learning is by proposing a “reform agenda [that] requires most teachers to rethink their own practice, to construct new classroom roles and expectations about student outcomes, and to teach in ways they have never taught before” (1995, p. 597). In order to fulfill this vision, professional development would need to be designed in a manner that draws upon theories on the relationship between practice and professional learning to influence a design framework. Professional development should also be based on a way for teachers to share student outcomes with other teachers, and it should form a community of teachers that encourages experimentation and reflection. Each of these components has theoretical relevancy that is discussed below.

**Practice-Based Professional Education (PBPE)**

Practice-Based Professional Education (PBPE), also known as analysis-of-practice PD, first developed by Ball and Cohen (1999) for organizing professional education for math teachers, is a vision for informing design that has teachers study records of practice, typically student work (e.g., Cobb, Zhao, & Dean, 2009), lesson plans (Lewis, Perry, Hurd, & O’Connell, 2006), high-level cognitive tasks and/or video clips (e.g., Borko, Jacobs, Eiteljorg, & Pittman, 2008). Much of this work is making its way into science education (e.g., Roth et al., 2011), but with NGSS, many researchers outline that there is an ever-stronger need for work like PBPE that encourages experimentation in
the classroom and collaboration among teachers to decipher this work (Reiser, 2013; Wilson, 2013). PBPE comes from the situated perspective of learning by emphasizing that good professional development should be embedded in subject matter (Garet, Porter, Desimone, Birman, & Yoon, 2001), involve active learning and be deeply connected to issues of teachers’ own practice (Ball & Cohen, 1996; Borko, 2004; Lampert, 2009).

A recent experimental study demonstrating the importance of the theoretical construct of PBPE in professional learning was found by Heller, Daehler, Wong, Shinohara and Miratrix (2012). In their experiment, 700 teachers were engaged in one of three professional development programs (or were a part of the control). All three programs focused on electrical circuits and the content knowledge that they could bring into their classrooms. However, two of the programs had an extra intervention that connected to teachers’ practice; one of these used case studies of how the work translated to the classroom, and the other asked teachers to analyze examples of their students’ work in electrical circuits while they were teaching the content. While all three PD programs showed an effect on teacher performance, only the two PD programs that included work on the teachers’ practice had a lasting impact on student performance.

**Boundary Objects**

One key component of PBPE that bears additional review is the importance of boundary objects, which are tools that are recognized across several communities. Boundary objects may or may not be subtly or extensively different depending on the context (Star & Griesemer, 1989).
Boundary objects are a foundational part of professional development because the PD context and the classroom context are often vastly different. As an example of a boundary object that may be used in the design of PD, a state’s standards documents may hold very different meanings for the department leader who must mentor beginning teachers, the assistant principal who must use these documents in their observations, and the classroom teacher responsible for their student’s performance on an assessment at the end of the year; attending to these meanings is a very important part of communication across practitioners that should be a salient part of practice-based professional education. Cobb and colleagues (2003) write about how the meaning of a pacing guide they were using in professional development among teachers changed over time, from a document outlining procedural knowledge to one that showed a natural progression of students’ conceptual depth that made more sense to teachers as they understood the meaning behind it.

Boundary objects such as student work, lesson plans, assessments or even classroom video are foundational aspects of practice-based professional education because they allow the teacher to bring something of their practice into the PD context. However, the challenge for the facilitator is to navigate the difference in meaning that may occur when the context changes.

**Boundary Objects within Professional Learning**

Professional development involving boundary objects must imagine a bidirectional interplay and coevolution between teachers’ use of the object in professional development sessions as well as within the classroom (Cobb et al., 2009; Kazemi &
Hubbard, 2008). For instance, if student work is being used as a central artifact for the professional learning, the facilitators must pay heed to the fact that, as time goes on, the professional development must adapt to meet the needs of the teachers as they notice different nuances in their work. This interplay between the two contexts is the most meaningful departure from typical professional development, as it suggests a need to relate the teachers’ collective learning trajectory within the PD context to their individual learning trajectories inside the classroom.

There are multiple ways to attend to this interplay. One way is to use depictions of the classroom, or video cases and case studies that are done before the beginning of PD and brought into the PD context, that allow professional developers to be purposeful in their design in a way that elicits teacher conversations around their individual classrooms. Sherin and Van Es’ (2002) use of video cases at the beginning of their Learning to Notice PD allows math teachers to talk about cognitive level in the classroom and also makes them more open to videotaping and sharing from within their own classroom. By starting with depictions and moving to teachers’ own videocases, the Learning to Notice PD allows coevolution that quickly uses the teachers’ classroom in the work of the professional development. This work has been recently converted with success from mathematics classrooms into a way for science educators to notice places where they were integrating science content with scientific practices (Kisa & Stein, 2015).

Instead of using depictions, some professional development venues employ strategies where imaginary examples of actual routines and enactments are used as boundary objects that can transition between the PD and classroom contexts. In this context, defined routine instructional activities are used in PD as a way for teachers to
practice moments that they have trouble with (e.g., limiting a content conversation, doing whole group discussions, or having students revise their answers in a way that is not leading) in a safe space before they experiment with the same practice in the classroom (Lampert, Beasley, Ghouseini, Kazemi, & Franke, 2010; Lampert & Graziani, 2009). After applying these routines in the classroom, participants come back, review and revise in order to best fit their needs, extending the interplay between contexts.

Primary artifacts may also play a central role as boundary objects. Primary artifacts within education are those that originate in instructional practice – for instance, student work, lesson plans, tasks and curriculum materials. These artifacts can take on different meaning when taken out of the classroom context, and especially when used as driving forces for professional development. Kazemi and Hubbard (2008) use student work as the best example of difference in context, by pointing out that:

In PD, teachers may sit together to analyze a pile of student work they have preselected to illustrate the range of strategies students used in their classroom. They may spend extended time debating what the students understand, generating questions they might ask to better understand the students’ thinking or considering which strategies they would choose to highlight in a whole class discussion. In contrast, in their classrooms, teachers may have only a few minutes to survey students’ written work to make assessments and instructional decisions. (p. 437)

However, analysis-of-practice using student work has been shown to be tremendously useful as a PD tool to use with teachers studying cognitive levels (Franke, Kazemi, Shih, Biagetti, & Battey, 2005), nature of science among teachers and their students (Burton,
This last point is fairly crucial to the researcher because it suggests that the issue for PD is not with the student work, but with designing PD that is adaptive. Namely, finding an approach that continually and dynamically merges evidence from student work and the context where that work was generated. Video is powerful because it places the teacher back in the context of the classroom, but it is not the most common artifact used in PD. In relating to the first research questions, I hold the opinion that this distance between the classroom and the PD context provides meaningful answers that allow greater teacher learning.

**Face and Transparency of Practice**

An additional layer to the act of analyzing boundary objects and how they are being used within professional development is in the way that they construct and represent the practices that are being explored. This is especially important as teaching is, dichotomously, a public and a private act, being done to students but often with no other adults around (any teacher recognizes this in the surprise they feel whenever adults come

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2 For ease, the third research question is as follows:

- What problems of practice typify professional learning communities as they are discussed in the professional learning community of teacher facilitators, and what are the challenges in using boundary objects such as formative assessments or student work as professional development tools?
.. into their classroom). Judith Little terms this double-edged sword as the “persistence of privacy, [which] has its roots in the organization of the work of teaching itself, and in the immediacy and fluidity of classroom experience” (1990, p. 526). In this way, representations of practice typically encourage story-telling as all of the complex actions a teacher takes in a typical day must be simplified in order to talk about what they did, but it also discourages investigation, as teachers hold on to norms of privacy within their work. In the current era of teacher accountability, norms of privacy are even more tightly held as investigations may feel evaluative and focus on the teacher instead of the act of teaching (Hiebert & Stigler, 2017; Podolsky, Kini, Bishop, & Darling-Hammond, 2017).

In order to talk more fully about this, it is useful to look at the way that researchers have investigated the conversations that teachers have about the ways that they represent their teaching practices, with and without boundary objects. Little (2002) identified two aspects of teacher talk that could be used to identify productive representations of classroom practice. They are the face and transparency of practice. The face of practice is the aspect of teaching shared by the teachers, while the transparency of practice relates to the completeness of the representation and how much detail they provide in their interactions around their teaching practice. In recent work with multiple teacher communities, the face and transparency of practice seemed to have a direct effect on how well teachers attended to investigating problems of practice in their classrooms (Heredia, Furtak, Morrison, & Renga, 2016), and they may seem like useful constructs to keep in mind for PD leaders to avoid the act of teachers talking unproductively past each other (Ball & Cohen, 1990). However, tools to help enable PD leaders to increase the
transparency of practice in PD were not cited and seemed to be an additional area of research around boundary objects (Kazemi & Hubbard, 2008).

**Professional Learning Communities**

Professional learning communities are a construct owed mostly to the work of two organizational theories: Donald Schön and Etienne Wenger (Lieberman & Miller, 2016). Schön (1987) analyzed professional work in design and theorized the idea of reflective practice. In reflective practice, continual learning occurs because a practitioner allows a thought experiment from within their experience that generates a new understanding of phenomenon. Wenger’s work on communities of practice (1998) gave a blueprint for how practitioners such as teachers could extend Schön’s work to come together to develop shared tools to use to reflect. While many researchers have defined professional learning communities, they all share the following characteristics: shared values and norms, a consistent focus on student learning, reflective dialogue, deprivatized practice and a focus on collaboration (Cobb et al., 2009; DuFour, 2004; Hord, 1997; Newman, 1996).

In reviewing the impact of PLCs, Vescio, Ross and Adams (2008) show that well-developed professional learning communities, defined as having a shared ownership of problems of practice, have positive impact on both teaching practice and student achievement. This impact is based on the move from “knowledge FOR practice” to “knowledge OF practice” by legitimizing and honoring the work that teachers are already doing in their classroom (Cochran-Smith & Lytle, 1999).
A great deal of work has already been done using professional learning communities to combat the isolated structure of classrooms (Darling-Hammond, Mullmaster, & Cobb, 1995; Easton, 2011; Grossman et al., 2001; Stoll, Bolam, McMahon, Wallace, & Thomas, 2006). However, even in these communities, problems of isolation may lead to limited “horizons of observation”, creating professional learning communities that are “insular, focused only on making explicit the practical wisdom teachers already possess about teaching” (Vescio et al., 2008, p. 89). Even within professional learning communities, structures should be put in place that give a voice to outside perspectives and research.

A Professional Learning Community for Teacher Leaders

Having a deep understanding of how effective PD should be planned and what it should look like is only part of the equation. Having well-prepared teacher-facilitators to ensure PD’s effectiveness is an often-overlooked variable (Borko, Koellner, & Jacobs, 2014; Stein, Smith, & Silver, 1999). As research suggests what effective PD should look like, it must also investigate how to guide and support facilitators along the way. In addition, having strong teacher-facilitators is particularly important, as it lends itself to leadership development within schools that allows teachers to continue to stay in the classroom and also shape the work of their department and school (Dempsey, 1992; Howe, & Stubbs, 2003). In the absence of strong leadership, professional learning communities are often unable to promote either teacher or student learning (McLaughlin & Talbert, 2006).
Many mechanisms for training and supporting PD facilitators do not establish themselves until issues of scale occur, where the primary researcher can no longer lead all of the facets of the professional development. In working with novice mathematics teacher-facilitators over three years who were adapting video-based PD in different local settings, Borko, Koellner and Jacobs (2014) surveyed and interviewed the participants of the PD in order to find what strengths the teacher-facilitators had as well as where they could support teacher-facilitators in the future. They found that their teacher leaders excelled even early on at creating a climate of trust in their workshops, where teachers were able and excited to work collaboratively with each other. However, they also found that teacher leaders struggled with being able to support deep analysis in regard to student reasoning and instructional practices, and suggested further investigations around establishing learning community knowledge and language.

In similar work to train mathematics teacher leaders in supporting teachers’ mathematical reasoning, researchers found themselves building a series of norms for what good discussion should look like (social norms) as well as what good discussion of the mathematical tasks should look like (sociomathematical norms) (Kazemi et al., 2009). In this way, the researchers were able to build a curriculum at scale for training teacher leaders, while also giving lens for investigation that teacher leaders could use when working together on their own problems of practice. It could also be noted that there are no similar studies within science education of teacher leaders.

Forming a professional learning community of teacher leaders to surface and attempt to solve the issues teachers may come across as they lead professional learning and become more adept at leading other teachers is the focus of the first two research
questions. In thinking of supports for teacher leaders as they lead professional learning communities, imagining how they talk about the face and transparency of practice, and imagining what norms should be noticed during their planning and interactions with other teachers are incredibly important to think about as ways to look at the issues that the teacher leaders encountered while leading their own professional learning communities. If professional learning communities are becoming a primary framework for professional learning, then it seems apt for the people leading them to also be involved in a community where they can reflect on their work as well.

**Ambitious Teaching Practices**

In providing a lens for reflective dialogue and deprivatized practice, two of the tenets for a professional learning community (Cobb et al., 2009; DuFour, 2004; Hord, 1997; Newman, 1996), it is useful to think about whether the focus for teacher education should be on the plans and actions of teachers, the ways that students learn, or the interplay between the two. This question was of particular importance to preservice teacher educators, as they were attempting to rebuild their programs from traditional teacher education, done in the absence of students, to a more progressive vision that

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3Those questions were:
- What problems of practice typify professional learning communities as they are discussed in the professional learning community of teacher facilitators, and what are the challenges in using boundary objects such as formative assessments or student work as professional development tools?
- How can teacher leaders navigate those issues in order to lead successful PD?
created teachers that were adaptive to students’ needs. From within these circles came the idea of ambitious teaching practice (McDonald, Kazemi, & Kavanagh, 2013).

The idea of ambitious teaching practices, or ambitious teaching, originally comes from preservice mathematics and literacy education and focuses on the identification of teaching practices that represent rigorous and equitable teaching for all students (Cohen, 1993). Within typical classrooms, ambitious teaching involves restructuring classrooms to be student-centered, giving them opportunities to reason about key subject matter, to participate in discourse that is specific to the discipline being taught, and to solve authentic problems (Lampert & Graziani, 2009). Within science education, this has meant that students should learn to generate explanations of natural phenomena, understand how claims are justified, build ways to represent their thinking to others, critique one another’s ideas, and be given time to revise their ideas in response to those critiques.

While the origin of these practices was for preservice education, it was quickly noticed that “these forms of practice are rare, even in the classrooms of experienced teachers” (Windschitl, Thompson, & Braaten, 2011). As such, they have become a foundation for imagining how the Science and Engineering Practices of NGSS play out in the classroom.

Hallmarks of ambitious teaching practices are their adaptiveness to students’ needs and thinking, and the myriad of tools that teachers can use to elicit and then react to student thinking. For professional learning communities, they are a rich way of thinking about how to build investigations of practice.
Domain-General Knowledge: The Scientific Practices of the Framework

Within the setting of the professional learning communities that are being led by the teacher leaders, all have some mix of domain-specific content focus (e.g., biology or physics) and/or a focus on some aspect of pedagogical content knowledge (PCK), defined broadly as the domain of knowledge that teachers apply when teaching their content (Shulman, 1986). These foci must be on an aspect that is continual within the teachers’ classrooms over the course of the PD; for instance, a group of chemistry teachers will not want to spend an entire year investigating conservation of matter with other teachers if they cover the topic in the first month of teaching. For the majority of those professional learning communities, the PCK focus will use domain-general knowledge, which gives teacher leaders multiple opportunities to widen their horizons of observation by pulling from current work on, for instance, learning progressions (Furtak, Thompson, Braaten & Windschitl, 2012), informal assessment (Ruiz-Primo, & Furtak, 2007), and curriculum revision (Penuel & Fishman, 2012).

Even though the foci of many of the learning communities are not explicitly stated through the science and engineering practices of NGSS, it is still useful in thinking of future framing to imagine how they could inform future work. The science and engineering practices of NGSS and The Framework for K-12 Science Education (NRC, 2014) can be seen as a grounding for all science teachers for many reasons, the principal one being that they are fundamentally important within all realms of science education and therefore important to all realms of science teachers, from physics to earth science and elementary through college. Of the three dimensions of the Framework, they are also uniquely situated for iterative practice because all teachers use them at all times, so
teachers will not want for opportunities to bring them into their classroom. As Bybee states, “When students engage in scientific practices, activities become the basis for learning about experiments, data and evidence, social discourse, models and tools, and mathematics and for developing the ability to evaluate knowledge claims, conduct empirical investigations, and develop explanations” (2011, p. 38). From personal conversations with teachers, they have also shown to be already engaging in thought about how the processes are being used in their classroom (in part, this is because of New York State’s recent adoption of the Framework in informing their own New York State Science Learning Standards); in previous work leading a professional learning community, teachers selected the planning of investigations as a practice that they were interested in exploring with their students, mirroring some recent research showing the myriad of supports that students seem to need in experimental design (Arnold, Kremer, & Mayer, 2014).

**Design Experiments**

In the traditional sense of education research, design and experimentation were thought of as different realms – experimentation acts to build theory, typically through controlled studies that too often never become adapted in actual classroom practice; whereas, design takes theory, that is for the most part established, and applies it and evaluates it in other contexts. However, researchers were noticing that, especially within the learning sciences, they were struggling to create contexts for experimentation that could be broadly applicable to the classroom. As a consequence, they were using more and more design processes with theories that were not yet fully formed. In addition, the
role of the researcher within the learning sciences was becoming more and more interventionist, just as it is with a teacher in the classroom (A. Brown, 1992). In order to create a system where the best parts of design and experimentation inform each other, where iterative work could adapt as the theory was becoming more and more fully defined, the methodology of a design experiment (also called design research, or developmental research) was born (Edelson, 2002).

Design experiments are conducted with the intention to develop theory around domain-specific learning processes. The methodology of a design experiment addresses the complexity of educational settings by acknowledging that it is composed of multiple elements of different types and focusing on function, testing and revision. Cobb and colleagues (2003) identify five crosscutting features that apply to design experiments. They have:

- a purpose of developing a class of theories about processes of learning and the means that support that learning
- a highly interventionist nature as opposed to one that is observational
- conditions that develop theory by constantly testing and reflecting upon them
- attention to evidence that leads to iterative design
- an emphasis on theoretical scopes that can influence prospective design.

By combining elements of design with elements of research, one has a set of methodological approaches where the design of the learning environment serves as the context for research, while the ongoing and retrospective analysis informs the improvement of the design (Edelson, 2002; Gravemeijer, 1994; Schoenfield, 2006).
It should also be noted that, while there have been design experiments that have revolved around the development of a professional learning community (Lehrer & Schauble, 2000; Stein, Silver, & Smith, 1999), its use here with teacher leaders who are themselves setting up professional learning communities borrows from these traits while still needing a unique framework around domains of teacher (and not student) learning.

**Summary of the Literature Review – Informing a Framework**

Professional development has been slow to integrate many of the same practices that it advocates for in the classroom, especially the move from a transmission model that informs itself from the behavioral perspective, to models that understand that there is a need to situate the learning that occurs within the classroom context. I understand that this is far easier said than done, as the community of practice in a classroom is different than that of the PD context, and so there is a need to “border-cross”, especially when dealing with objects that are useful in both communities of practice, which are called boundary objects. Boundary objects come with their own caveats, as they require understanding that different people will see those boundary objects differently, depending on the context.

Professional learning communities start to shape this work, by focusing on teacher practices, student learning, and the link between the two, typically through the act of deprivatizing the practice of the teacher, in order that it may be investigated. Research on PLCs is limited but positive, and they seem to work as long as they encourage transparency of practice among the participants. Teachers are often leaders of PLCs, but the little research into the work of training teacher leaders has suggested that they excel
in framing the classroom context, but still need supports to frame and push the thinking of other teachers.

A design experiment is an appropriate methodology for this work because it is highly interventionist, suggests an environment where theory can be constantly tested and revised, and suggests that the adaptations in design that occur from future iterations are also important in informing the work. In framing the work of the professional learning communities, the researcher has suggested a lens of ambitious teaching practices, because they advocate for an environment where teachers must elicit and react to student thinking, which should allow for collaborative investigations by other teachers.
Chapter III

METHODOLOGY

Research Design

Central to answering the research questions was the formation of the teacher leader professional learning community to surface and question the difficulties that arise with the work of the individual professional learning communities as well as the skills needed for teacher leaders to facilitate professional learning in their local context. To this end, design research and its use of adaptive professional development, which acknowledges a coevolution within professional development that adapts to the needs of the participants as they come up, was the most appropriate methodology because they treat the design and underlying research as interdependent, where the design of the learning environment serves as the context for research and ongoing analysis of the facilitator professional learning community can be used to reflect on and refine not only the teachers’ own PD, but future implementations of support for teacher leaders as well (Cobb et al., 2009; Joseph, 2004; Hoadley, 2004; Kazemi & Franke, 2004).

Design experiments have a few common central characteristics (Cobb et al., 2003; Predige et al., 2015). The intent of design experiments is to create an environment to study the phenomenon, acknowledging not only that this is interventionist in nature, but that the role of the researcher is often tied to this intervention. In a sense, the collection of data is even more important in this work than in others because one of the duties of the researcher is to critically examine their own work as well as the work of the participants. In doing this, the deeper goal of design experiments are to put theory in harm’s way –
that is, to inform the design of the work, to continually reflect on its use, and to generate new ideas (Reinking & Bradley, 2008).

In design, this study employed Putnam and Borko’s theory (2000) that teacher learning occurs when it is thoughtfully planned and situated in a community that has shared discourse. In looking at this from a communities of practice perspective, situating the community of teacher leaders in their own work with their teacher participants is incredibly important, and builds off of work in domains of learning, especially those theorized by Cohen and Ball (2000) in math and Short (2006) in science. This can be done through a professional learning community that engages in practice based professional education through the use of primary artifacts as boundary objects (treating the teacher leaders as brokers, and emphasizing the importance of boundary objects when crossing between communities). To be most useful, the researcher holds that there are ways that teacher facilitators can support discourse that focuses on teaching and instructional dilemmas (Little & Horn, 2007), allowing teachers to refine and apply them as they learn more about their students. The exploration of how to use primary artifacts in PD were a basis of the work of the professional learning community of teacher leaders. In this way, the professional development at each level becomes multidirectional, where the professional learning community of teacher leaders, the PD they lead, and the classroom context of the participants influence each other (Kazemi & Hubbard, 2008). Moreover, by making primary artifacts one of the central foci of the work of the professional community of teacher leaders, the connection of the PD to actual classroom experiences and the professional practices of the teachers was made more manifest.
Setting

Math for America New York City

Math for America is an organization that supports public school mathematics and science teachers across New York City. By providing fellowships and opportunities for professional learning to teachers, they serve a mission of building a community of accomplished mathematics and science teachers who make a lasting impact in their schools and communities and hope to serve as a model for how districts around the nation can elevate the career of teaching. Currently there are just over one thousand teachers who are a part of Math for America, representing nearly ten percent of public school mathematics and science teachers in New York City.

The principle way that the community of teachers within Math for America interact is by choosing from a catalog of various professional learning opportunities, the majority of which happen at a central location in Manhattan. While some of these courses are run by outside facilitators, the majority of the courses are facilitated by teachers and all of the courses are offered as course suggestions by teachers as well as internal surveys where they set their professional learning goals for the following year. There is an expectation that teachers come to a specific number of workshops within each academic year; however, that expectation is typically exceeded by teachers.

Within the courses at Math for America, all occur in the evening on school nights (typically from Monday through Thursday). Each course meets for two hours at a time, and the number of times a course meets depends upon what type of course it is, but the course can range from a single time to eight.
One of the most common course types are Professional Learning Teams (PLTs), which are specialized professional learning communities, drawing from teachers around the city instead of one school. In this way, these PLCs, typically composed of five to 12 teachers, can focus within content and pedagogy in ways that a department cannot (for instance, a Physics teacher can focus on a problem of practice within the lens of Physics, instead of through a general lens of science as they would within a department meeting at their school). These courses, through which the design experiment was built to be a part of and support, are completely teacher facilitated and, as with all other courses at Math for America, their participants have autonomously chosen to be a part of them.

The researcher also serves as a Program Officer within Math for America and has been heavily involved in the creation and occasional facilitation of professional learning opportunities specific to the organization for two years at the time of the experiment.

The research that was undergone for this dissertation was done under a memorandum of understanding between the researcher and Math for America, allowing the intervention and resulting work done by the researcher specific to this dissertation to be done under the knowledge of and in collaboration with the leadership at Math for America.

Participants

The cohort of 11 PD teacher leaders chosen for this design experiment were primarily selected using purposeful sampling, where the researcher selects individuals for study because they purposefully inform an understanding of the research problem (Creswell, 2007). As the research problems revolved around finding general supports for
teacher leaders, it was important to select teachers who were across a continuum of experience leading others, came from a background of school settings, and were currently facilitating professional learning communities.

For this experiment, all the teacher leaders were chosen based upon the fact that they were all science teachers, they were going to be leading Professional Learning Teams at Math for America, they had a range of experiences and backgrounds as teachers and as teacher leaders, and that they were willing participants in the research. The schools that they came from represented a range of urban middle and high schools across four of the five boroughs of New York City (Staten Island excluded), including consortia schools that are exempt from end-of-year assessments, charter schools, as well as specialized high schools. The teachers came in with varying amounts of experience facilitating professional learning communities in and outside of their classrooms, where some had led professional development outside of and/or within the setting of Math for America for many years, while others were novice facilitators leading PD for the first time.

The 11 teacher leaders were not only participants in the design experiment’s professional learning community (explained in the next section), but they also facilitated five professional learning communities that are a part of a larger PD program at Math for America. Using Penner and Klahr’s categorizations of scientific reasoning within science education (1996), some of these professional learning communities were domain-specific, focusing on content knowledge as it is taught within a curriculum (e.g., AP Chemistry), some were domain-general, focusing on skills that occur in all science classrooms (e.g., Discussions in the Classroom), and some combined the two. In the interest of preserving confidentiality and because the courses at Math for America are
public knowledge, anything that could explicitly allow readers to ascertain the identity of a participant (including the name of the course that they facilitated) has been altered from transcripts, artifacts and surveys, and pseudonyms were used as necessary. The participants, some notes on the professional learning community that they facilitated, and their experience facilitating, are all listed in the Table 3.1.

Due to the nature of the selection, the teacher leaders had already started designing their Professional Learning Teams before the design experiment began; while this meant that I could not help with certain design choices such as finding a rich problem of practice to explore, it did mean that reflections of teachers on these decisions could be explored thoughtfully in the data.

Data Collection

Permission to conduct this research was obtained by a review board from a college of education in the Northeast United States. The main data sources for this design experiment are qualitative, including video recordings of the teacher leader professional learning community, interviews with the teacher leaders, researcher field notes as well as artifacts from the teacher leaders’ own professional learning communities (session plans, student work, etc.). In addition, many of the in-person observations were aligned using an observation protocol well known for measuring various facets of professional learning among teachers (Professional Development Observation Protocol, Banilower & Schimkus, 2004).
Table 3.1. Participant List for Design Experiment and the nature of the PLTs (specialized PLCs at Math for America)

<table>
<thead>
<tr>
<th>Teacher Leader’s Name</th>
<th>Nature of the PLT</th>
<th>Experience Facilitating and Participating in PLTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amanda</td>
<td>Established, but has been trying to move from domain-specific content knowledge to focal in domain-general skills for the participants’ students.</td>
<td>Extremely experienced, having led department meetings at her school as well as PLTs at Math for America.</td>
</tr>
<tr>
<td>Heather</td>
<td>Novice facilitator, but an experienced member of this PLT, which had run continuously for past three years.</td>
<td>Novice facilitator, but an experienced member of multiple PLTs in the past.</td>
</tr>
<tr>
<td>Amy</td>
<td>First time for this PLT, which was focusing on domain-general inquiry skills while grounding itself in the investigation of artifacts</td>
<td>Novice facilitator of a professional learning community, but an experienced teacher leader as both a coach and a curriculum designer in her district.</td>
</tr>
<tr>
<td>Samantha</td>
<td>Starting to become established, loosely based on one of the scientific practices of NGSS, had happened before but was surprisingly under registered (which comes through in transcripts)</td>
<td>Had facilitated this PLT in the past, as well as other professional development on the topic.</td>
</tr>
<tr>
<td>David</td>
<td>Had facilitated this PLT in the past.</td>
<td>Had facilitated this PLT in the past.</td>
</tr>
<tr>
<td>Isabelle</td>
<td>Starting to become established, based on a domain-general skill (to science and other teachers) as it played out in one specific content area.</td>
<td>Facilitated this PLT the one time that it occurred in the past.</td>
</tr>
<tr>
<td>Lisa</td>
<td>Facilitated this PLT the one time that it occurred in the past.</td>
<td>Had experience facilitating in the past, but little experience outside of Math for America.</td>
</tr>
<tr>
<td>Elizabeth</td>
<td>First time for this PLT, which was based on one of the scientific practices as it played out in one content area.</td>
<td>Extremely experienced as a facilitator, both inside and outside of Math for America.</td>
</tr>
<tr>
<td>Kevin</td>
<td>Experience facilitator at her school and in her network, but a novice facilitator of PLTs</td>
<td></td>
</tr>
<tr>
<td>Melissa</td>
<td></td>
<td></td>
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</table>
In order to answer the research questions, evidence from one source was continually revisited with the information gathered from other sources, using triangulation as a measure of internal validity (Merriam, 2009). The central question for methods of data gathering in most research of this kind will always be to answer the simple question regarding grounded theory – “What’s happening here?” (Glaser, 1978).

**Planning**

For each of the sessions of the professional learning community, the researcher, in their role as the group’s facilitator, used a modified journal club approach, where participants read a piece of research on teacher education, discussed the article and/or engaged in a group learning routine, and then were given time to apply the work to the planning of their own PLCs. This choice was based off of the work of Vescio et al. (2008), who state that a tenet of productive professional learning communities is that of continuous teacher learning that is adaptive to teachers’ needs. It was also based off of what Lieberman and Miller (2016) call the horizon of observation, where they noticed that, without using research within the professional learning community, the work becomes limited in scope.

One of the goals of planning was to make sure that the sessions produced not only rich discussion, but also rich documentation of the thoughts of the participants. To this end, methods for group learning such as graphic organizers, discussion questions and quote walls were used in order to elicit the active thoughts from all participants, which then became artifacts that the researcher could also use to uncover the thoughts of the participants, even when they were not speaking. Pictures and scanned copies of these
artifacts were organized and coded principally using Process Coding (Saldaña, 2015), in order to permit situating the thoughts of the participants in the actions that the participants thought they were trying to accomplish.

In later sessions, the article was carefully chosen based off of the participant interviews, and teacher leaders also brought in focus questions and artifacts from their own course, which the group heard, analyzed and investigated through modified consultancy protocols (McDonald, Mohr, Dichter, & McDonald, 2013). The articles that were used focused on a vision of practice-based professional education (Ball & Cohen, 1996), ideas of co-evolution between the classroom and PD context and the implications for classroom and PD leader practice (Kazemi & Hubbard, 2002; Heredia et al., 2016), as well as the role of a facilitator in focusing towards instructional dilemmas when participants may want to focus away from them (Little & Horn, 2007).

Each session was video recorded and transcribed for later coding, and any group and individual artifacts were photographed or scanned. Agendas for the sessions are in Appendix A at the end of this paper, and sample artifacts of each type absent the course survey (transcript, primary artifacts, interviews, and researcher memos) can be found in Appendix E.

**Data Analysis**

**Professional Learning Community Transcripts and Artifacts**

Video recordings of the teacher leader professional learning community were transcribed verbatim and coded, with a first pass translating segments of the transcript and a later phase that uses the most significant and frequent codes to find meaningful
statements that are then recoded to build the skeleton of themes (Glaser, 1992; Strauss & Corbin, 1998). The initial coding, which was primarily done through in vivo coding (Saldaña, 2015), began immediately following the first meeting, as themes that begin to emerge will not only influence theory, but will also suggest interview questions and may change the design and planning of future sessions of PD. The choice of in vivo coding was done in order to preserve the participants’ voices in the first pass of coding. However, there was also a consistent space for memo-writing in the researcher’s journal as a method for starting the analysis of the data as soon as possible (Charmaz, 2014).

**Session Interviews with Participants**

At the end of each of the four two-hour long sessions that a participant facilitated as part of their own professional learning community, they were interviewed about how the session went, and their relation to the work that was being done in the teacher leader PLC. These interviews provided additional evidence about the participants’ meanings, intentions and actions. This was the case both during the facilitator professional learning community, as well as evidence of the challenges and triumphs they had in leading their own PD; specifically, about planning around their use of boundary objects.

In order to normalize the interview process, interview questions were standardized for each participant at the end of a particular session (for instance, each participant received the same set of questions after they had just facilitated their second session). At the end of each session, participants received the interview questions on a Google Document and typed their responses. The researcher was present to clear up any confusion about the meaning of the questions (methodology suggested by F. Mensah,
personal communication, Jan. 24, 2017). Interview questions can be found in Appendix B.

First coding of the interviews was done in a similar manner as the transcripts of the professional learning community, using in vivo coding in order to preserve the voice of the participants.

**Course Survey**

At the end of the professional learning community, as is typical for all professional development at Math for America, participants received a course survey that is a mix of multiple choice and open-ended questions on the focus of the professional development and how they feel the course affected their learning. Because of the nature of the sample size of this course (n = 11) as well as the qualitative nature of this study, the multiple-choice questions were not used in this research report, but they are provided to give extra context. However, open-ended questions were included as a post-session interview and were coded using the same techniques. The multiple choice and open-ended questions as well as participant responses can be found in Appendix C.

**Observations of Participants’ Own Professional Learning Communities**

I also became a participant in each of the teacher leaders’ professional learning communities and made in-person observations of the teacher leaders in their professional learning communities. These were recorded in a research journal as a secondary source of data to provide context for the issues and statements that the teacher leaders were making in the professional learning community used in this research, and in later interviews.
These observations presented another source of data that, principally through memo-writing, allowed additional context to emerge in conjunction with the other sources of evidence.

A Methodological Look at the Research Questions

In understanding how the methodology informs the research questions and to summarize the research design, each research question is listed and a brief statement is included about how the design, planning and instrumentation is related to answering each question. This can also be found in the Design Summary Chart (Table 3.2) at the end of this section.

Research Question 1

What problems of practice typify professional learning communities as they are discussed in the professional learning community of teacher facilitators, and what are the challenges in using boundary objects such as formative assessments or student work as professional development tools?

The transcripts of the video-recordings of the professional learning community are coded for initial, and then emergent, themes in conjunction with interviews and observations of the teacher leaders’ professional learning communities. Thus, they provided rich data sources with which to answer this research question. A core element of the PD should be a focus on teaching and instructional dilemmas and not teachers (Hiebert, Gallimore, & Stigler, 2002). Primary artifacts (such as boundary objects) provide a way for teachers to open their classrooms to other teachers in order to surface
problems of practice. However, there are many challenges in order to do this, both in terms of the comfort teachers have sharing their work as well as issues of studying an artifact when it is out of its initial context. Boundary objects provide a theoretical lens that teacher leaders can use when planning, where challenges in implementing this can be found through the teacher leader professional learning community, interviews as well as observations.

**Research Question 2**

*How can teacher leaders navigate those issues in order to lead successful PD?*

As the design of PD evolves from the themes that are identified by the teacher leaders, it hopefully will yield better ways to respond to those issues of practice, and if not, can point the way for future professional development. It is understood that the nature of this approach may be tool-oriented (i.e., useful for implementation in classroom practice); if so, the researcher will use the emergent themes to come up with characteristics that may be useful in generating those tools.

**Research Question 3**

*How do teacher leaders, as brokers in professional development, become more comfortable in facilitating other teachers, as evident in participation shifts that occur?*

Building upon Lave and Wenger’s ideas of communities of practitioners (1991), the primary method of merit in measuring how effectively teachers are reflecting on their practice is by noticing the ways that they participate in their communities. For the teacher
leaders, this means noticing not only the role they are assuming in the teacher leader professional learning community, but how they interact with other teachers in their own PD as well. For this question, it was useful to look at the course surveys at the end of the course – how did participants find the work of the professional learning community, and did it help them become more comfortable in using certain practices with their own groups?

**Methods of Analysis**

The evidence for this study consisted of eight hours of videotape from the professional learning community (amounting to roughly 760 exchanges of dialogue), 22 artifacts from the sessions, 38 post-session interviews, and 11 course surveys. Evidence was organized and analyzed using the qualitative application NVivo 11 on both a Mac and a PC, operating with a collection of files that were on an external hard drive that was locked in a cabinet during hours when it was not being analyzed. NVivo 11 was chosen because of its primary use as a tool for qualitative researchers and the way that it can work to not only code the data, but to organize it within emergent schema. It is also ideal for working with multiple types of data, as it can collect codes from transcripts, pictures and scans of artifacts as well as video and organize them together.

Research using design experiments have a purpose of building and testing theory, which directly influenced the choice of coding by the researcher. According to Barab and Squire, “This focus on advancing theory grounded in naturalistic contexts sets design-based research apart” (2004, p. 5). Grounded theory has a systemic methodology, with a range of first and second level coding schema to choose from. For this set of evidence,
using a mix of in vivo and process coding for the initial codes helped to preserve the participants’ voices and thoughts, while still making some descriptions of the application of their words to the context. This was followed by axial and emergent coding to build the theory as it emerged from interviews, transcripts and artifacts.

The use of in vivo coding, which is also known as literal coding and verbatim coding, uses the participants’ own words. Saldaña has stated that “[a]s you read interview transcripts or other documents that feature participant voices, attune yourself to words and phrases that seem to call for bolding, underlining, italicizing, highlighting, or vocal emphasis if spoken aloud” (2015, p. 75). However, she warns that in vivo Coding, when used on its own, may limit the researcher’s perspective on the data, and recommends that it should be combined with another coding schema in order to contribute to more theoretical views about the process.

Process coding uses gerunds (“-ing” words) exclusively in order to connote action in the data (Charmaz, 2014). Within grounded theory, it is particularly useful for noticing not only action, but also what the consequences of action and interaction are. Considering that the research questions suggest actions on the part of teacher leaders, and those who work with them, process coding seemed most important in building a theory that informs future work.

Samples of the in vivo and process coding within sample transcripts and artifacts can be found in Appendix E.

Overall, over three hundred initial codes came out of the assorted work. A word cloud for these codes can be a useful first glance depiction of the data (Fig. 3). Considering the research questions, there already seem to be words from participants
(e.g., “work”, “practice”, “artifacts”) that can be used in building a theory for teacher leaders and how to support them in their work with other teachers.

Figure 3.1. Word cloud of initial codes, obtained using In Vivo and Process Coding of transcripts, artifacts and interviews.

While the initial coding was happening, patterns were starting to appear as suggestions of possible categories and subcategories. These categories were further extended during axial coding, where the properties and dimensions of categories are built by the assembling and reassembling of codes. In creating these categories, codes were sometimes reassigned as categories, with related codes placed underneath them. In other instances, codes were grouped and named with a new axial code. For instance, the idea of
the focus of a professional learning community kept coming up through transcripts, and eventually the word string “Focus of a PLC” was created by the researcher to become an axial code. However, within that code, one participant noted that a “narrow focus lessens complexity”, which became the basis for a sub-category on complexity, and one of the focuses of a professional learning community.

Eventually, as axial coding progressed, the relationship between categories started to emerge, and axial coding started transitioning towards emergent coding, which is typically the culminating step toward achieving grounded theory. Using the previous example, “Focus of a PLC” did not seem to link to the other codes that were being used, and upon reflection, it appeared to the researcher that in fact, the focus that participants were talking about was the practice that was being analyzed within the professional learning communities. To this end, the axial code “Focus of a PLC” became the emergent code “Focusing on Practice.”

While coding was done for the most part as a lone researcher, it was done using the recommendations of Ezzy (2002), which include to use member checking; i.e., check your interpretations with the participants themselves, code as you transcribe your data, and to maintain a reflective journal on the research project.

**Ensuring Accuracy**

In order to have any effect on the field of education, this research must have been rigorously conducted, presenting insights and conclusions that ring true to readers considering the data. Lincoln, Lynham and Guba ask upon reading a paper, they would “feel sufficiently secure about these findings to construct social policy or legislation
based on them” (2011, p. 178). While these are lofty goals for research, that does not mean that they are not important to hold to!

In thinking about how to make sure that the work is applicable, accuracy (also explored through concepts of validity) is a concern for both quantitative and qualitative studies, but it is typically interpreted in different ways. For a quantitative study, validity is typically explored through the procedures that have been followed, as it represents best the story of the experiment. On the other hand, qualitative studies emphasize accuracy, reality, transferability and must provide readers with enough of a depiction of what happened, and tell a story that makes sense (Firestone, 1987).

There are typically two different measures of used to judge the accuracy and usability of qualitative research: internal accuracy, which deals with the question of how research findings match reality, and transferability, or the extent to which the findings of one study can be applied to other situations. We will consider each separately below.

**Internal Accuracy**

In considering the internal validity of this research, it is important to remember that all data, whether quantitative or qualitative, is being translated and interpreted by the researcher. Internal validity, then, is a goal that must be considered throughout the work, rather than a product that can be finished and moved on from and should be continually assessed in relationship to the purpose and circumstances of the research, as well as the source of the evidence that it is being analyzed (Merriam, 2009).

Within this work, because the evidence comes from multiple sources, and is in multiple forms, triangulation would be an appropriate first strategy for ensuring that the
study’s findings are internally accurate. Guba and Lincoln (1994) define triangulation as the process of using multiple measures to clarify meaning and to verify the repeatability of an observation. In the process of triangulation, categories and themes are compared across and within the various sources of evidence. In this study and with the help of NVivo, triangulation can be achieved by making sure that the themes that emerge are not dependent on one data source or one participant but are instead checked across the data types. Following comparison, if all four sources of data appear to reinforce one another, or if one source of data is reinforced through multiple participants, one can argue that the findings of the study have internal validity.

In addition to triangulation, member checking is another strategy to make sure that the study’s findings are internally valid. Member checking, also known as respondent validation, is the practice in which the researcher shares with participants their preliminary findings, thus providing each participant an opportunity to confirm, deny, or clarify the researcher’s interpretations (Merriam, 2009). Applied to this study, member checks happened throughout with email updates to the participants about where the research was, in-person chats about the preliminary findings, and checks about whether they felt like they were appropriate, considering the work of the professional learning community. Considering that many of the research participants have continued to lead professional learning communities at Math for America, it has been easy to not only do member checking, but to also have them help with the development of some of the tools that have come from the theory being posited.

Finally, and especially appropriate for this study, considering the multiple roles that I served within Math for America, reflexivity is the strategy of stating and explaining
ones’ biases, dispositions and assumptions regarding the research (Merriam, 2009).

While the role of Program Officer at Math for America and the role of researcher have in many ways mutual goals (the advancement of theory in order to support teachers as they work with other teachers), I have made earnest effort to state biases that may need to be considered as the reader interprets relevant passages in this research.

**External Transferability**

The question of generalizability is extremely important, especially in considering the setting for this work. Indeed, it is not typical for teachers from various schools with differing backgrounds to come together regularly to work on a common problem of practice, as the setting for this investigation describes. It would be possible then, to throw away all of the findings of this paper and say that it could not happen anywhere but in this type of a setting. On the other hand, one could equally make the argument that if something is true for these groups, it should true for groups of teachers at the same school, who share students and do not have to provide others with as much background in order to achieve transparency of practice. In the end, the researcher imagines that both of these interpretations have some element of truth to them.

To that end, this becomes an issue of transferability. According to Lincoln and Guba (1985), the burden is actually not on the original investigator but “with the person seeking to make an application elsewhere”, while the investigator’s responsibility, on the other hand, is to provide “sufficient descriptive data” that allows transferability to occur (p. 298). This responsibility is also known as the use of rich, thick description, which has come to be used to refer to a descriptive, detailed presentation of the setting and in
particular the findings of a study. In this manner, it is important to position the readers to assess the similarity between the position they find themselves in, the position the researcher was in, and the applicability of the findings to their own work (Merriam, 2009).

Wherever possible, I have made choices intended to increase the generalizability of this research. For instance, by recruiting participants who come from a myriad of backgrounds and experiences, I have increased the maximum variation in the sample, to allow for a great range of application of the findings.

**Role of Researcher**

The role of the researcher varied over the course of the research; at one point the role was more naturalistic and largely serving as an observer; however, when participating in teacher leaders’ PD, the role of the researcher was more dynamic when serving as a designer and facilitator in the professional learning community of teacher leaders. Throughout, decisions in regard to developing contexts, frameworks, tools and pedagogical models consistent with, and to better understand, the theories outlined above were submitted in the researcher’s journal for outside review as typically done for design experiments (Barab & Squire, 2004; Cobb, 2000). I acknowledge that I served in a dual role as a researcher and as a program officer at Math for America, a position which facilitated my role as a participant observer in the research and also provided the opportunities to finish this research study that otherwise would not have been possible with the degree of detail realized here.
Table 3.2. Design Summary Chart.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Source</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What problems of practice typify professional learning communities as they are discussed in the professional learning community of teacher facilitators, and what are the challenges in using boundary objects such as formative assessments or student work as professional development tools?</td>
<td>Transcriptions of videotapes of the teacher leader professional learning community, follow up interviews and observations of PD</td>
<td>Qualitative coding for emergent themes, memo-writing</td>
</tr>
<tr>
<td>2. How can teacher leaders navigate those issues in order to lead successful PD?</td>
<td>Design framework, transcriptions of teacher leader PLC, follow-up interviews</td>
<td>Qualitative coding for emergent themes, memo-writing, framework design and reflection</td>
</tr>
<tr>
<td>3. How do teacher leaders, as brokers in professional development, become more comfortable in facilitating other teachers, as evident in participation shifts that occur?</td>
<td>Transcriptions of videotapes of the teacher leader professional learning community, follow up interviews, course surveys</td>
<td>Qualitative coding for emergent themes, memo-writing, analysis of the course survey</td>
</tr>
</tbody>
</table>
Evidence gathered from all the sources as explained in Chapter III was analyzed to understand the work of the teacher leaders and the ways the professional learning community of teacher leaders was or was not successful in guiding future work in the preparation of new teacher leaders. Each of the research questions is addressed in presenting the findings.

**Research Question One**

*Research Question 1: What problems of practice typify professional learning communities as they are discussed in the professional learning community of teacher facilitators, and what were the challenges in using boundary objects such as formative assessments or student work as professional development tools?*

Based on the emergent coding, three core themes emerged for how teacher leaders were talking about the work of facilitating their professional learning communities and the importance of boundary objects in crossing between the classroom and PD contexts. The significant role that boundary objects served in the teacher leaders’ perceptions of how they understood the challenges of their professional obligations made these two aspects closely related. The three emergent themes are: 1) Finding a Focus within Practice, 2) Transparency of Practice, oriented through artifacts, and 3) Defining Inquiry Cycles through planning and enacting practices.
Each of these themes addressed related topics that the teacher leaders discussed and point towards future iterations of this design experiment to help construct a theory for supporting teacher leaders, which is further explained in the discussion section of this dissertation.

In writing about the findings, the researcher shares what Erickson (1986) calls “particular and general description”, which consist of interviews, quotes and specific vignettes placed alongside generalizations, in order to ground the findings within the design experiment and to “help the reader make connections between the details that are being reported and the more abstract arguments” (p. 149).

**Theme One: Finding the Focus of Professional Practice**

One of the participants, Melissa, concisely stated the essence of this theme: “lessen complexity by narrowing your focus.” Figure 4.1 diagrammatically shows the subthemes that emerged from the main theme of “focusing within teaching practice.” This figure is a radial diagram produced in NVivo 11, with the main theme at the center and each of the subthemes distributed peripherally. The connection between the central main theme and each subtheme is labeled as a “Child”, relating the fact that NVivo organizes codes in parent and child node systems.

The rest of the section of this chapter delves into what this theme means for teacher leaders’ practice, and what is illuminated through the sub-themes that form the skeleton of this theme.
One key theme that emerged from the evidence was that the teacher leaders were thinking about how to ensure that their work with other teachers was focused, and that a refined focus was a first step in creating investigations into their participants’ teaching practices. However, while teachers were thinking about this and frequently talking about how important it was, they were also noticing elements of their professional learning
communities that made incomplete foci and could be a source of extra support in helping future teacher leaders in their own work in professional learning communities.

It appears, from the emergence of this theme, that a common problem of practice among teacher facilitators, and one of the ways that teacher leaders can be supported, is in the ways that they define and communicate the focus of their learning communities and the connection of this focus to teaching practices. Some facets of this focus that they discuss is a need for it to: 1) create disequilibrium among teachers and give them a reason for investigating, 2) elicit students’ ideas, 3) become a lens for the selection of artifacts, and 4) allow for both individual and collaborative reflection and implementation.

In thinking about Ball and Cohen’s idea of disequilibrium (1996) during the second session of the PLC, Amanda talked about those moments when a teacher feels like they have taught something, then they realize that “The same kid who got everything right on multiple choice has no idea what’s going on during the open-ended questions.” Later on, Amy reflects on her own leadership in the final session of the PLC by saying that “It feels like everyone is continually doing the same thing that they have been doing, and part of that is how we set up our PLT to get people to track those things out.” In this sense, both leaders are talking about a need for a focus within their PLCs where the participants feel enough unease to want to investigate further.

However, this sense of unease is not enough unless there is an avenue for that investigation to proceed into the teachers’ classrooms. As the teacher leaders considered what this avenue should look like, in general and in reflecting upon their own groups, the idea that it must generate artifacts that have elicited student thinking came through. David, in considering the work of his own group, lamented the idea that it seemed like
the participants were using the sessions for pitching future ideas that often never transpired and, therefore, it never allowed the other participants to see the work as it happened in the classroom. Furthermore, they seemed to blame the way that he and Eric had set up the expectations within the first session of their group, even though they modeled the practice by bringing in artifacts from their own classroom in that session. To them, they were finding that modeling was not enough, and that it was tremendously important to communicate the focus as it transpired in the classroom as clearly as possible.

Kevin, Elizabeth and Melissa reflected upon a previous time that Kevin and Elizabeth had facilitated a group of teachers (where Melissa was a participant), and formalized their agendas to include a time where all of the participants share a piece of student work that they found interesting, either for the way that the teachers set up the problem, or for the way that students were engaging in it. By doing this, a process of investigating their focus through artifacts of practice became a norm for all participants of the group. While these investigations were often shallow in their scope (because the protocol had all participants share for a very short period of time), they allowed participants to progressively become comfortable sharing, and they allotted the majority of the rest of the time of each meeting to a more in-depth investigation of a single person’s lesson, and to implementing what they had learned in a future lesson.

A final key part of the focus that participants identified was that it allows for individual and collective reflection, and for implementation in the classroom. In reflecting upon the course of their PLC, Amy and Heather talked about how their work was “disjointed” because their participants split time between designing an activity over
the course of multiple sessions using primary sources, and also thinking about
experimental design from within the pacing of their curriculum. Because of this split
focus, the majority of the groups within the professional learning community did not
finish their activities, and only one of the participants implemented it in their classroom
and brought in student work, with that work being mostly multiple choice, preventing the
group from making any meaningful statements about what students were actually
thinking as they went through the assignment. While this participant was able to
implement the work in her classroom, because the focus of the group was on a product,
and not on a practice, teacher learning was limited throughout.

In a recent analysis of hundreds of video cases of teacher collaboration for
collective learning by Horn, Garner, Kane and Brasel (2017), they suggested that one
could find explicit tiers of learning opportunities within professional learning
communities. In lower tiers, the nature of discourse was monological, as participants
spent more time sharing but not necessarily listening, and the majority of time in
meetings was spent on pacing, logistics and tips and tricks (sometimes termed best
practices). In the higher tiers, the nature of the discourse became dialogical, as teachers
worked to collectively analyze and interpret instruction. At the highest sub-tier, this work
was extended and would result in linking to future work. In their analysis, they found that
the majority of the meetings that they were observing were at the lower tiers, in spite of
the fact that their observations were limited to districts and math departments that were
colloquially known for having a higher amount of teacher collaboration. The professional
learning communities that were observed by the researcher, with the possible exception
of the one facilitated by Amy and Heather, seemed to be on their way to providing higher
tier learning opportunities if they were able to refine and communicate a focus that was grounded in student learning to their participants.

In this way, helping teacher leaders refine the focus of their teacher meetings to create enough collective disequilibrium to propose investigations into teachers’ practice, guided by artifacts that elicit student thinking could be a key step in providing more and more opportunities for dialogical analysis of practice. In addition, by thinking not only about reflection, but also implementation, teacher leaders could find Horn et al.’s (2017) highest tier by linking to future work.

**Theme Two: Transparency of Practice Oriented by Artifacts**

The essence of Theme 2 is reflected in Samantha’s observation: “There was a weird giddiness in the room as people showed their videos and got feedback.” A major part of the facilitators’ discussions revolved not only around finding a focus within their teaching practice to investigate, but in the critical way that they were going to ask participants to bring work from their classroom contexts (i.e., boundary objects) into the context of the professional learning communities. These boundary objects would be critical in allowing teachers to investigate each-others’ practice because they would serve as the lens through which the teachers could see what was occurring. Even with these boundary objects, teacher leaders searched for ways that they could provide additional background and construct protocols that kept the focus in mind. In thinking through the subthemes that came out of Transparency of Practice, it is useful to look at the ones that appeared through coding, as seen in the radial diagram shown in Figure 4.2.
For many of the facilitators, they were aware that, to truly answer the questions that their foci were raising, it would be necessary to investigate how these ideas were playing out in the classroom. For many of the teacher leaders, the charge of asking other teachers to do this was a challenge, and they felt like they may have been infringing on the privacy of their teachers. Even when they were not sensing this, they were empathetic.
to the fact that this type of collective inquiry into participants’ classrooms is not a normal part of teachers’ experiences with professional learning.

For Samantha and Amy in particular, who came from schools where videotaping in a teacher’s classroom was for the purposes of inquiry where norms and access to videotaping equipment was easy, they found themselves in a position where they found their teacher participants were “Very skeptical of filming in their classrooms.” To lend support, I made video recordings in a couple of the teachers’ schools in order to demonstrate how easy it was, relatively. And by the end, every teacher was videotaping and bringing in artifacts to their sessions. When they brought artifacts from their own work into the teacher leader PLC (which appropriately included a set of videos from one of their sessions), they noted that the participants actually felt giddy in the end, as this was such new ground for them in sharing their work with other teachers. This suggests that, while the perception of the work of teachers as being a private domain of practice is a barrier for PD leaders, it is important to break through those norms of privacy. It is not only achievable, but necessary for opening new doors for reflection and change.

For all the facilitators, this unease associated with boundary objects was negotiated by becoming volunteers and subjects for the first cycle of inquiry, bringing in videos or student work from their own classroom in order to “break the ice.” For Elizabeth, and her professional learning community, this was her first time sharing work such as this, and when she brought in the work of her PLC in the third session, she said, “I learned a lot about how, even with them looking at it the whole time, I thought about the things I should have done. It was really reflective for me.” As the first volunteer, she
was also able to empathize more with future participants and even adapt protocols to make sure that the focus of her PLC came through.

For the teacher leaders, they were in the position of being what Lave and Wenger (1991) describe as brokers; i.e., people who find themselves in multiple communities of practice and are able to translate across them. Because the teacher leaders were teachers as well as PD facilitators, they were in the unique and powerful position of being able to serve as models for the remainder of the group, modeling the vulnerability and disequilibrium that they hoped would happen when other participants shared their artifacts as well.

As they looked to plan for the conversations that their groups were going to have, the importance of protocols, and the skills necessary to build and lead them, became apparent. Melissa found that the discomfort of introducing, using, and facilitating the consultancy protocol in their group’s second meeting with her group brought out disequilibrium because it elicited the idea that there was no perfect work or artifacts. However, one of her co-facilitators, Kevin, found that they did not necessarily feel like they had the tools to lean into that disequilibrium to find more depth to the conversations that they were having.

One other facet of the communities that seemed to be elicited by the teacher leaders was the need to make sure that there were different norms that needed to be established by the facilitators for working with each other, and as they also noted, crucially, talking about the work that the teachers were doing in their classrooms. Isabelle and Lisa found throughout the work of their professional learning community that participants were extremely comfortable bringing in artifacts related to the work of
the PLC, but they never could find a normative way of agreeing on what made the artifacts good or not, which meant teachers could never generalize upon their work. Lisa, who continued the professional learning community this year, found this struggle to continue, and it was only in refining the focus to emphasize the idea of using literacy strategies to elicit student explanations, that she found that the participants in her PLC could measure whether their strategies were fully working or not.

In thinking of this barrier in particular, Yackel and Cobb (1996) found in their work with mathematics teachers that it was necessary to differentiate between social norms, which would allow any group of teachers to work skillfully to explore other members’ mental models and assumptions (Garmston & Wellman, 1999), and what they defined as sociomathematical norms, which are normative understandings of what counts, within mathematics discussions in and out of the classroom, as sound mathematical explanations and justifications, and which should become the basis for daily mathematics instruction. WestEd’s program of developing mathematics teacher leaders expands upon these norms as a basis for their work (e.g., Elliot et al., 2009).

Heredia et al. (2016) found while working with two different teacher communities around formative assessment, that the degree to which the teachers would define their practice (the face of practice) and describe most fully those moments with other teachers (the transparency of practice) had a direct impact on how effective the teacher community was in investigating student learning and changing teachers’ practice.

Similarly, teacher leaders within this research study were trying to make sure the artifacts that were coming into their groups provided as comprehensive a look into the classroom as possible. In the end, by using and building protocols that were modified
with an eye towards transparency of practice and eliciting student ideas and explanations, and by acting as brokers between the community of teachers and PD facilitators and modeling vulnerability and an orientation toward investigations of practice using artifacts, teacher leaders were uniquely positioned to increase opportunities for teacher learning in the professional development context.

**Theme Three: Cycles of Inquiry**

Eight sub-themes were identified for this main theme of “Cycles of Inquiry” (Figure 4.3), and the essence is aptly captured in Lisa’s observation: “You set the stage for the next step, and then you have student work.” To most of the participants, professional learning communities seemed to have a progression, where habits could form between learning from each other, trying out new ideas in the classroom, and deconstructing them back in the PLC. As teachers explored the idea of a cycle of inquiry further, they started to name parts of the cycle by the practices that they expected participants to be doing, and the skills that the facilitators would have to leverage in different moments of the inquiry cycle. These practices compose the sub-themes of the Cycle of Inquiry theme and are outlined further in Figure 4.3.

It should also be noted that the idea of a cycle of inquiry is not atypical within science education; in recent work on formative assessments, it is seen as a way to detect what students are thinking and plan accordingly, ideally with other teachers as well (Furtak, Glasser, & Wolfe, 2016). In a similar spirit, the teacher leaders were trying to find ways to elicit ideas from their participants and come up with a set of practices that they could refine as the group reflected upon and implemented these ideas.
The theme of iterative cycles of inquiry became a method that teacher leaders could reimagine their learning communities, building upon the idea of co-evolution proposed by Kazemi and Hubbard (2008), and that the work of the PD and classroom context should inform each other. To the teacher leaders, this idea was extremely powerful, but also tenuous, because it challenged them to redefine their roles as teacher facilitators and not just teacher leaders. Furthermore, it suggested that they needed to find ways to leverage the collective expertise within their groups. As conversations progressed throughout the PD sessions, the teacher leaders named components of these
cycles of inquiry in a way that allowed them to productively plan their work. These components are the sub-themes illuminated in Figure 4.3, as explained further below.

However, it should be noted that, as conversations progressed, the researcher realized that each of these phases was not just about planning but was also related to practices that could be enacted at particularly relevant moments during appropriate sessions. This differentiation between practices as they are planned, and as they are enacted, may be critical in thinking of effective and authentic ways to support teacher leaders.

**Normalizing expectations.** Normalizing i.e., making the actions of an individual or the group appear normative (i.e., relevant to daily practice across classroom practices more generally), had multiple tiers in the participants’ thinking. It may have meant normalizing the group to the focus of the work that was expected of the professional learning community. But, it also meant being able to make sure when teachers expressed observations and opinions, that everyone had a shared sense what happened in that classroom was normal enough that the lessons from that particular investigation into practice could be applied in any other. Little and Horn (2007) make the point that in the act of normalizing among teacher communities they noticed teachers either normalize towards or away from problems of practice. If you normalize, but do not move on to the next step of specifying and generalizing (for instance, if a teacher had trouble within their classroom, and you were to say: “It’s okay, that could happen to anyone” and move on, you have normalized away from the problem by reassuring the person but not actually helping them learn from the opportunity. So, when we talk about the normalizing an event or circumstance occurring within the professional learning communities, we are
talking about normalizing as an action that orients participants towards problems of practice; not occurrences that are peculiar to, or even non-productive in, a given classroom.

Nearly every professional learning community involved in this study had to practice and puzzle over some idea of normalizing. For example, Amanda and Heather found that the diversity of schools represented in their community made normalizing incredibly important. Because they found without that action to clearly define what normalizing means, teachers could shut themselves out of opportunities for learning by insisting that what was happening could not happen in their classrooms. Similarly, for Amy and Samantha, they had to normalize their participants to the practice of videotaping. For Eric and David, they were not able to normalize participants to the expectation of generating work that they wanted to happen in their participants’ classrooms. For Eric, David, Amy and Samantha, this normalizing became a core part of their planning processes; or at least something they reflected upon and found themselves wishing they had addressed it in planning. For Amanda and Heather, they also had to enact the practice of normalizing in the moment, to make sure that all teachers they served were able to feel like they could be a part of what was going on.

**Specifying statements.** Specifying was a critical part of the inquiry cycles because it involved the collective effort of grounding the work in evidence specific to the questions being investigated, and generating questions, ideas and hypotheses for what the work reflected. This may have been through careful attention to the artifacts that participants were bringing into the communities, but it was also through the general discussion about them in what Horn (2010) refers to as replays and rehearsals – where
participants may have given crucial background information that was useful in interpreting the artifacts. In this manner, specifying is incredibly important for facilitators of professional learning communities to think about because of the inherent complexity in teaching.

Specifying is related very closely to the focus of learning that the teacher leaders expressed, and when there were any issues with the focus, they also came through in limiting how well they could specify. For Amy and Samantha, they found that they had defined the focus of their professional learning community so broadly that they were unable to specify the work of the participants in their general construct, which was based purely on student inquiry. Without that grounding, they found that the evidence that they were drawing from participants’ videocases were being applied towards lower level skills like classroom management and lesson planning, instead of the higher-level discussion techniques that they wish they had been able to reach through additional work specifying in their planning.

**Reflecting critically.** Reflecting in a constructive and critical way is often productive in the work of PCLs. If normalizing and specifying have gone well, productive critical reflection should follow naturally on the part of the individuals who are sharing their work. However, the teacher leaders, in reading and reacting to the work of Little and Horn (2007), also wanted to make sure that all participants had an opportunity to reflect. This meant not only acts of reflection, but also generalization, where the teachers who are not presenting their work are also a part of the process of imagining how what is being investigated applies in their classroom, as well. For groups such as those who Lisa and Isabelle served, this meant explicitly stating what parts of the
strategies that were being investigated each session were going to be assigned to the teachers who were going to try them out in the following month. For Kevin, Michelle and Elizabeth, it also meant coming back to a definition of the practice they were exploring in the first session, and then adding, subtracting and editing that definition through the lens of the work that they looked at in that session. This definition would then become the focus of the work time that they always gave participants in their sessions.

Coevolution and subsequent classroom outcomes. Finally, a core part of the teacher leaders’ planning sessions that addressed using coevolution necessarily focused on what was going to make its way back into the classroom. Interestingly, for a couple of the groups, this implementation seemed to be at the beginning of their inquiry cycles, as they stressed the creation of documents together. However, what appeared to be more fruitful were those groups that started by either bringing in their own classroom contexts to their sessions, or who spent time norming the group to what the expectations were for the work, or both. The implications of this for working groups of teachers is interesting, as it seems to suggest that transferring from the classroom context to the PD context has a greater ability to change practice than work that starts in the opposite direction.

While giving examples and adapting protocols are ways that teacher leaders can plan with these practices in mind, there are many opportunities within the PD where they would also have to enact these practices in the moment. For instance, while a teacher leader who wants generalization to happen may suggest that the teachers all free-write their reflections on the applications to their classroom, it would still be the responsibility of the teacher facilitators to ask or encourage follow-up questions in order to make sure that teachers were being as transparent as possible about their planned next steps. These
enacting practices are not easy, as Borko, Koellner and Jacobs (2014) noticed in their own work with novice teacher leaders of mathematics professional learning, and better defining what they entail, and how they can be rehearsed, may be critical for developing better teacher facilitators.

**Research Question Two**

*Research Question 2: How can teacher leaders navigate those issues in order to lead a successful PD?*

The practical implications of the themes in the prior section and how the themes play out in professional learning communities are not easy to master without the help of a place where teacher leaders can bring in their own work and investigate what is occurring. Co-evolution as a process of reciprocal enlightenment through professional planning and a lucid understanding of the realities of daily classroom practice should not only occur between the classroom and PD context alone. Rather, it should occur between the PD context and another critical aspect; i.e., how it affects teachers as participants in a community of practice, where the teacher leaders can analyze problems of practice that are not specific to the classroom, but to the facilitation of learning by teachers with teachers.

Short (2006), in trying to come up with a framework for curriculum reform for science teachers, borrowed from earlier work in mathematics professional development to posit what he called “circles of learning” (Figure 4.4).
Within each successive larger circle, each of the smaller internal circles of learning had to be addressed. For professional development, this meant that the interaction between teachers, students and the curriculum had to be thought of in the design of the professional development. Moreover, if the curriculum involved reforms in teaching practices, those needed to be addressed explicitly through the work of the PD. Similarly, if the professional development was reform-oriented, then the reforms of the classroom and the PD context had to be thought of when working with PD providers. While the implications of this idea are clear (that leaders of professional learning need a place where they can learn as well), there are still missing elements that should be added, especially if it is to be useful as a social construct for future design.

Figure 4.4. Circles of Learning, adapted from Short (2006)
One glaring aspect that is missing from the circles of learning is the fact that PD does not involve one teacher, and while this is a very useful construct, you can just as easily imagine ten “teacher circles” within the professional development circle. Because the interaction between the teachers, students and the science will differ depending on the teacher, their content and pedagogical content knowledge, and the way that they interact with their students and understand their students’ backgrounds. This merely places additional stress on the skills that are necessary to lead good professional development. Namely, good practices of the leader(s) includes eliciting and reacting to the participants’ needs (much the same way that the teacher in a classroom should be able to generalize their work to all students, while still being able to individually tailor as necessary).

Another missing idea is the form and context of the situation, where the student, adult and PD provider of learning takes place. During the time when the learning circles were designed, they were intended to advance inquiry-oriented reform. The idea of inquiry-oriented reform is something that modern science standards such as NGSS have taken care to avoid. This is very likely due to the myriad definitions that are used for the word “inquiry-oriented.” Instead, emerging teaching practices posit ambitious goals of creating a classroom environment with a complementary aspect to inquiry but with more attention to the dynamics of authentic ways science is discussed and practiced. Namely, this is an intellectually open atmosphere where students can: 1) share, and mutually elicit, their ideas, 2) create arguments using evidence that attempts to evaluate and better explain scientific phenomena, and 3) critically and respectfully react to the arguments of other students to build classroom models that have explanatory power. In order to do that, teachers will themselves need opportunities to experiment with these practices, and to
reflect upon them. And teacher leaders will need to find a way to create a PD context that encourages this work in the classroom, while giving teachers an opportunity to reflect on how well it worked. And perhaps most importantly, the teachers need a place where they can reflect upon their own practice of working with other teachers.

In the later sessions of the professional learning community for teacher leaders, we experimented with a co-evolutionary idea of grounding the work of the teacher leaders in their own PLCs. To this end, multiple groups presented on the work they were doing, and as it progressed, they provided more and more transparency to the moves that they were making, and the reasons that they were doing it. Elizabeth provided the group with two circles of work, providing the student work from her classroom as well as the protocol that her PLC used to analyze it. In the final session, Samantha and Amy offered videotape from their PLC, edited down to provide a section where they were giving participants’ instructions and trying to normalize the process; and where Samantha was giving feedback to one of the teachers. While these videos were not exemplars or even possibly not fully appropriate considering the low-level feedback they were giving, the other teacher leaders were fully engaged in the process and were considering the ways that they give feedback to others during their own sessions.

In answering the research question, it has been useful to identify the themes for teacher leader learning that can be used to build tools that support them, but it is also clear that there needs to be a place where they can work with those tools, adapt them for their own professional learning communities, and reflect upon what they learned.
Research Question Three

Research question 3: How do teacher leaders, as brokers in professional development, become more comfortable in facilitating other teachers, as evident in participation shifts that occur between the teacher leader and participants as well as between the teachers themselves?

In answering this question, the interview evidence shows how the agendas of the sessions depended more and more upon boundary objects from the participants’ own professional learning communities, so the participation shifted from a stance of interpreting relevant findings of research they were considering, to how a lens could be applied within the participants’ own work. If this engendered discomfort or malaise among the participants, any discomfort in these shifts in participation would have been found by looking through the surveys that were given at the end of the final session (Appendix C).

The detailed responses of each participant are summarized as entries in the participant survey as shown in Appendix C. In reading through the participants’ feedback, the participants gained comfort, if not with each other, then at least a growing sense of confidence in their skills leading other teachers, especially around the use of boundary objects in the PD context that were drawn from their participants’ classrooms. For some of the teacher leaders, this professional learning community also pushed them to experiment with their own practice, either by instituting protocols for reviewing boundary objects, for thinking about the focus of their own groups, or both. The fact that multiple participants asked for further analysis based on videocases of their professional learning communities shows how novel this was for the teacher leaders.
The majority of the participants cited work that would affect not only their practice in terms of leading other teachers, but their own teaching practice as well (which is more evidence of planning from a circles-of-learning perspective). In addition, all participants except one rated the researcher’s effectiveness positively, with the omission being due to time spent reading articles (which was an appropriate, albeit superficial, change for the next iteration of this community).

One of the most important parts of the design experiment methodology is that it puts the theory in harm’s way by putting it to work. At least, in looking at how the participants extended their participation by bringing in boundary objects from their own professional learning communities, and in the ways that they positively rated the experience of being a part of this community of teacher leaders, the idea of supporting them in this way appears successful. Future work based upon this idea should extend research to the participants in the teacher leaders’ own professional learning communities, and possibly their classrooms as well.
Chapter V

DISCUSSION, IMPLICATIONS AND CONCLUSION

The data collected in this study of 11 6th-12th grade teacher leaders and their professional learning communities offer insights into the practices of leading professional learning communities and supporting those who do lead them. In addition, all of the teachers expressed a positive perception of the PLC composed of teacher leaders and were able to name moments within their own PLCs where they were adapting and using the work they were learning more about in the study group. In this first measure, the design experiment was a limited success by being able to begin to support teacher leaders, but the findings suggest extensions to theory as well as ways that the framework can be adapted for further use.

In seeking the answers to the research questions that guided this study, three themes emerged for supporting teacher leaders around finding a focus for the professional learning community, developing transparency of practice by orienting the work around artifacts, and reimagining the work of planning and enacting the professional learning community around a set of practices that reimagine the PLC as a continuous set of inquiry cycles. Although the work is consistent with current research on teacher learning (Borko et al., 2017; Heredia et al., 2017; Horn et al., 2017), it extends that work by generalizing it to the professional learning community context as a whole, instead of placing it within individual step-by-step PD structures for teacher learning. I hope that the themes that emerged here could be as useful to department leaders as it would be to PD and teacher leadership developers.
Once more, the research questions for this study are:

1) What problems of practice typify professional learning communities as they are discussed in the professional learning community of teacher facilitators, and what were the challenges in using boundary objects such as formative assessments or student work as professional development tools?

2) How can teacher leaders navigate those issues in order to lead a successful PD?

3) How do teacher leaders, as brokers in professional development, become more comfortable in facilitating other teachers, as evident in participation shifts that occur between the teacher leader and participants as well as between the teachers themselves?

A review of the literature pertinent to answering these questions in Chapter Two established the study’s framework, as situated cognition, communities of practice, professional learning communities, and ambitious teaching practices. This examination of the literature provided a lens for how aspects of teacher learning could be extended to teacher learning communities. The overall research methodology presented in Chapter Three outlined a design experiment grounded in qualitative research with the purpose of using grounded theory to find emergent themes. The purpose of the design experiment was to investigate the experiences of teacher leaders as they applied work within a community of teacher leaders to their own professional learning communities, and to design with a goal of supporting their work. The work within the teacher leader community as well as interviews and observations from the teacher leaders’ own
professional learning communities became the basis for the findings of this study in determining the supports that teacher leaders would find most helpful in future work of this kind.

Before going on, it is important to note a couple of caveats, which may have contributed to an increased positive participation of the teachers in the professional learning community. For one, the researcher purposefully assumed a role as a participant in each teachers’ own learning community. This certainly increased the feeling that the teacher leaders had in being supported by the researcher. In thinking about the circles of learning, it seems as if it is important for the PD leader to be involved in multiple contexts, so they can see and evaluate the fidelity of the practices that they would like for the teacher leaders to implement and react in real-time with the design of the sessions. In addition, the researcher’s role as a program officer at Math for America meant that the participants may have seen him as atypical of leaders of professional development. I hope that readers of this study keep these caveats in mind as they consider the generalizability of the findings and their possible extensions that are presented here in the Discussion.

Discussion of Major Findings

There are three major findings that emerged from this study. First, the teacher leaders found themselves in differing positions of being able to find and communicate to their teachers a focus of their professional learning communities, as well as a way to make sure that the work teachers brought in around that focus was a useful entrance into their individual classrooms. Second, teacher leaders were able to identify core practices that they could use in reimagining professional learning communities as engaging in
cycles of inquiry. Third, as the professional learning community of teachers progressed, it became just as important to ground the work of the professional learning community in the work of the teachers’ individual PLCs, as it was for the PLCs to ground its work in teacher’s individual classrooms. These findings point towards a possible reconceptualization of how teachers and teacher leader professional learning communities react to the act of constructing explanations at various levels.

**Supports for Defining the Work for a Professional Learning Community**

One of the central facets of a professional learning community is supposed to be its focus on student learning (Easton, 2011). However, the nature of what that looks like is not well defined, which can create communities of teachers that are monological, talking past and not to each other (Horn et al., 2017).

As teacher leaders talked about, and demonstrated through artifacts, what did and did not work well in their individual professional learning communities, there were certain traits of a good focus that emerged. This included, most importantly in my mind, that it had to elicit student ideas, so that the teachers actually had something to collectively explore. In addition, it had to create disequilibrium among the teachers, so that it could encourage reflection and future implementation. Finally, this focus had to be able to provide a common vocabulary for the participants, so that, whether they were working individually in their classrooms or collaboratively in the PLC, they were aligned in the work they were doing.

In thinking about this need to be able to cross between the classroom and PD context, teacher leaders also talked about how to make the practice of teachers more
transparent when in conversations with each other. To me, the work of a focus of practice and transparency of practice go hand in hand, as a weak focus will not give the teacher a lens to make their practice transparent, and vice versa. The teacher leaders found they could create deeper connections to classrooms by structuring the conversations specifically around student thinking, by modeling the necessary vulnerability by volunteering for the first round within their PLCs, and by noticing when a teacher’s representation was selective or partial, and adapting in the moment to give extra context when necessary.

If I were asked to summarize what and where the teacher leaders did the most amount of learning, it would be in carefully making sure that there was a clear focus for their professional learning community, that they made sure that that focus connected to clear boundary objects, and that they organized talk around those artifacts to elicit ideas from their participants about what they thought they were seeing. The organization of talk could be thought of as practices they could plan for, and those that had to be enacted in the moment, and included normalizing ideas, specifying how they play out, reflection that is both personal and collaborative and thinking this learning with an implementation mindset.

In future iterations of this experiment and in future work around this topic, one should move from the elicited ideas that occurred in this community, to a more active approach of creating and refining tools that meet the needs of teacher leaders. One such tool, on creating a focus for your professional learning community, that is the focus of current work, can be found in Appendix D (it has already undergone multiple iterations with other teacher leader communities). In looking at this tool, it is hopefully apparent to
the reader how it incorporates the sub-themes from the “Finding a Focus” theme. A similar tool on finding transparency of practice in the PD context is a part of current work by the researcher and another program officer at Math for America.

In addition, it is important to apply what was learned through this design experiment to reflect upon and add to the framework of domains of inquiry that was used in the original design (Short, 2006).

**Practices of Teacher Leaders in Cycles of Inquiry**

Not everything that the teacher leaders talked about as possible supports for working with teachers were explicitly about how the professional learning community was framed. In addition, they talked about how there could be certain aspects that were fundamentally important to creating cycles of inquiry within that focus – to normalize the work that is happening in the classroom, to specify what within that work is interesting, for individuals to reflect upon what was learned, for the group to generalize that learning to something applicable to everyone, and to be able to implement that learning in a future cycle.

In thinking about these practices, it is useful to imagine how they could become a lens for individual planning; for instance, teachers could adapt well-known protocols such as the consultancy protocol to their focus, still making sure that these individual aspects are retained. In addition, however, it may become foci for the teacher leaders in their work together; for instance, the community of teacher leaders could adapt the work of replays and rehearsals (Horn, 2010) among other teacher leaders to see if they understood the choices that could be made in the moment to enact these practices.
Fundamental to these practices working, however, is that the artifacts that are being collected in the classroom for teachers to investigate are of sufficient quality. In considering what this means for future work, it is tremendously important to also frame what does and does not constitute interesting work to explore from the classroom.

**Grounding the Work at Each Level**

As the teacher leader learning community progressed, it became more and more apparent that boundary objects were not only important for the work of the teacher leaders in their professional learning communities, but they were also important to the teacher leader and professional development community as well. Many of the themes from this work emerged only once the teacher leaders were trying the ideas out in their PLCs, and then reporting on how it went, whether in the interviews after their sessions or in the artifacts they brought back to the group. While this in some way reflects the research questions that were asked, it also relates to the problem of crossing boundaries between the classroom, PD, and PD leader contexts.

Much of the professional development landscape is divorced from the classroom, and the professional development leader landscape is even more distant. Even in work that embeds itself in trying to re-envision professional development and PD leadership to link to the classroom, that vision is based on a reform-based vision of the classroom and not on the lived experiences of teachers and their students (Carroll & Mumme, 2001; Short, 2006). This is not to say that this context is not useful in introducing the vision of ambitious teaching practices. Teachers should know what the classroom can and should look like, especially if it is a drastic departure from teachers’ current vision of the
classroom. However, recent work on professional development has found that student learning is best advanced when teachers engage in collective work that is connected to their own classrooms, instead of case studies of ideal ones (Heller et al., 2012).

In trying to create a framework that ties all of these findings together, I suggest that we reframe the PLC and leadership landscape to embed certain characteristics of ambitious teaching, especially seen through an adapted lens taken from the mathematics education literature on sociomathematical norms.

**Drawing from Sociomathematical Norms**

From their classroom research, Yackel and Cobb (1996) introduced systems of norms that they thought should be present in the math classroom. Social norms, which are content agnostic, are ways to contribute to a positive classroom culture. Sociomathematical norms, on the other hand, involve the ways that students and teachers engage in mathematical work in the classroom and in the professional development setting, especially involving things like what constitutes a mathematical argument, justification or explanation. To these researchers, such norms exist, whether publicly acknowledged or not, and they are negotiated by teachers and students through their interactions. When, for instance, answers to a problem are elicited through teacher explication rather than by the collective creation of mathematical arguments, then the norm of what constitutes a mathematical answer is being defined in the classroom. In this case, the idea that mathematics is merely a set of solutions to problems is being negotiated implicitly by the interactions of the teacher and their students.
In sitting in the participants’ professional learning communities, and in looking over the findings, it is my opinion that they all seem to point to a need for teacher leaders and teachers to explicitly establish what could be called norms for scientific discourse, and to see how those norms are negotiated in the PD and classroom contexts. Some sample norms for scientific discourse that could be explored through future iterations of the design experiment, as well as by other professional learning communities (adapted from work in mathematics by Carroll & Mumme, 2007) can be found in Table 5.1.

By using these norms for scientific discourse, classrooms as well as professional learning communities can become places of exploration, focusing on how scientifically deep arguments are elicited, what teachers can do to create more communal discourse, and how questions can be formed by the teacher and modeled for students so that they can feel like they can contribute in the future. For many teachers who are attempting these more ambitious practices, creating classrooms that empower their students, it will be important to have a place where they can share their struggles and grow within their practice. What will be important about these professional learning communities is not that they merely talk about the ideal, but that they collect instances from their own classrooms as examples and as dilemmas.

It is important to note that while the connection to the PD context is clear through the work of this design experiment, the extension of these norms into the classrooms of participants is something that would require a more encompassing study, including a look into the teacher leader and their teachers’ classrooms, and an argument could be made that the ties to the classroom suggested here are a more tenuous result of this design experiment. However, recent work in defining what ambitious science teaching practices
look like in the classroom (Windschitl, Thompson, & Braaten, 2018), and the way that these norms would generate boundary objects that could be analyzed in the PD context justify this reach in my estimation.

Table 5.1. Theoretical Norms for Scientific Discourse

<table>
<thead>
<tr>
<th>Norms for Scientific Discourse in the Classroom and PD Setting that Promote Science Learning</th>
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<tbody>
<tr>
<td>• Tasks/Investigations have the stated goal of creating scientific arguments that can be generalized to scientific explanations.</td>
</tr>
<tr>
<td>• Confusion and errors are embraced as opportunities to compare and contrast ideas, explore contradictions, and suggest alternate strategies.</td>
</tr>
<tr>
<td>• Questions are raised by students as well as the teacher (or teachers as well as the PD leader) that push on understanding of science.</td>
</tr>
<tr>
<td>• Scientific arguments and explanation form the basis of the learning process, where individuals take a collective responsibility for classroom learning.</td>
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</tbody>
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A Future Framework for Professional Learning Communities

An important part of design experiments is that, through future iterations, they inform future implementations of the work. In considering the themes that emerged, especially around finding productive foci for the work of professional learning communities and also choosing artifacts that, with some classroom context, make practice transparent, the importance of exploring explanations in the classroom and in the professional learning communities become apparent. Explanations are a special extension
of sociomathematical norms and norms for scientific discourse because it is easy, through videotaping and student work, to translate them into artifacts that can be explored at other levels.

In recent work on ambitious teaching practices and the reframing of classrooms around models, Windschitl, Thompson and Braaten (2008) set the goal for students (and therefore for instruction) as the continual development of defensible explanations of the way that the natural world works. What makes this vision ambitious is the way that teachers are charged with providing the environments for students to elicit these explanations, and then reacting to them in the moment through discussions and the presentation of more work that can fill in the gaps. Classrooms based around this work are outlined in Figure 5.1.

![Figure 5.1. A classroom vision based on student explanations](image)

This vision works well with the themes found by the design experiment because explanations have a fairly robust definition that allows it to become a focus for practice, and it generates artifacts that are interesting for other teachers to investigate. In fact, in continued work with preservice teachers (Windschitl et al., 2011), they found
communities of their teachers who focused on the quality of explanations from their students was critical in advancing the novice teachers’ practice. In considering this work, along with the research into teacher leaders’ professional learning communities, it seems that a useful construct for all science PLCs should be that, within the exploration of science classrooms, students construct explanations that then become the foci for teacher investigations into practice. This focus is outlined in Figure 5.2.

Figure 5.2. A professional learning context framed around investigations into student explanations.
Unlike the traditional circles of inquiry posited by Short (2006), the explanations serve explicitly as a link between the two contexts. In addition, just as investigations serve as the link between the students and the content they are exploring in order to produce an explanation, it is acknowledged that student explanations are interpreted by teachers through the lens of their teacher content knowledge, which can be used to produce an explanation of practice as it is occurring in the classroom. This extra information can find its way back into the classroom in order to inform future work with the teacher with their students.

Finally, in considering how this work could influence teacher leader learning, this idea can be extended to one more layer, as it is in Figure 5.3. Future work of this kind would be consistently generative, as teachers have the opportunity to work with and react to student explanations in creating their own explanations of practice, which would give teacher leaders opportunities to consider their own work in leading teachers to create explanations of what was and was not working with their own facilitation.
Figure 5.3. A leader learning context revolving around explanations

**Conclusion**

Interpretations of the finding are by no means complete, and as continued iterations of the design experiment continue, it is my hope that the development of tools and frameworks for cycles of inquiry give teachers and teacher leaders added support in engaging in ambitious teaching practices.
Schools around the nation are continuously searching for effective and efficient ways for teachers to engage in continued learning that has a direct impact on the students that they teach. Professional learning communities hold a tremendous amount of promise for allowing teachers to inquire into their own practice, but they are not all created equal—those that are able to have a continued focus on student learning, and those that engage all teachers in interpretive work are the most successful (Horn et al., 2017).

Leading these communities is not easy, and as professional learning communities become more and more prevalent in not only the professional development context, but also as they become continually situated in the normal life of schools, being able to give teacher leaders opportunities to learn from the leading that they are doing will be crucial to the success of PLCs in schools.

Folding in the idea of ambitious teaching practices also requires grounding the context of the classroom into one that continually generates and honors student ideas. While these practices are tough to enact, the consequences of using them mean that they generate student explanations of the content they are exploring that can become rich texts for teachers to explore in professional learning communities. Teacher leaders who are adequately prepared can continually advance these practices in the classroom by pushing the thinking of teachers through practices of their own, creating cycles of inquiry in the learning communities that filter their way down to the level of the classroom.

It is my hope that the themes that were raised in this research, and the possible framework, building classrooms and classroom investigations around norms for scientific discourse, enable teacher leaders to better plan and facilitate professional learning communities that advance classroom practice and learning for all students.
REFERENCES


DuFour, R. (2004). What is a "professional learning community"? *Educational Leadership, 61*(8), 6-11.


Erickson, F. (1986). Qualitative methods of inquiry. In M. C. Wittrock (Ed.), *Third handbook of research on teaching* (pp. 23-42). New York: Macmillan


Appendix A

Session Agendas for the Professional Learning Community of Teacher Leaders

Session One

(Note, italics were added later during the session)

I. Opening/Explanation of Research
II. Gaining informed consent
   1. slack/google drive
   2. Permission for interview, permission to video
III. Norm setting
IV. Excerpted article on professional development (Kazemi & Hubbard, 2008)
V. Working/Planning in our PLTs
   Questions to consider
   1. Planning around the work today/your own work

III. Norm Setting

Values

<table>
<thead>
<tr>
<th>Openness</th>
<th>Respect for our work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curiosity</td>
<td>Professionalism</td>
</tr>
<tr>
<td>Collaboration</td>
<td></td>
</tr>
</tbody>
</table>

Norms
1. Be present.
2. Be a part of the group and contribute freely.
3. Name your comfort/discomfort.
4. Figure out what you can apply.
5. Stay true to the goal.

IV. Kazemi & Hubbard, 2008

Note - these are excerpts, although covering a majority of the paper. In thinking about the three methods outlined in the last 4 pages, the table is incredibly useful.

Questions to consider while reading
1. What do they mean by coevolution? What does this mean for our PLTS?
2. They identify three trajectories that teachers can take during PD - did these feel real to you?
3. They think of three methods to make the context of the PD more like the context of the classroom - depictions, artifacts, enactments. Can you think of examples of each?

V. Working/Planning
Chart paper
- What aspects of teachers’ practice are represented in the context of my PLT, and how?
- (the harder question) How are aspects of my PLT represented in the context of participants’ classrooms?
Planning w/15 minutes at end for debrief
Session Two

Agenda

I. Research corner
II. Revisit Norms
III. Revisit Kazemi/Hubbard’s research questions, after the first session of your PLT
   - What aspects of teachers’ practice are represented in the context of my PLT, and how?
   - How are aspects of my PLT represented in the context of participants’ classrooms?
IV. Excerpted article on professional development - Ball & Cohen, 1999
V. Working/Planning in our PLTs
   - Questions to consider
   - Planning around the work today/your own work

II. Revisited Norms
   Values

<table>
<thead>
<tr>
<th>Openness</th>
<th>Respect for our work</th>
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</thead>
<tbody>
<tr>
<td>Curiosity</td>
<td>Professionalism</td>
</tr>
<tr>
<td>Collaboration</td>
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</tbody>
</table>

Norms
1. Be present.
2. Be a part of the group and contribute freely.
3. Name your comfort/discomfort.
4. Figure out what you can apply.
5. Stay true to the goal.

III. Kazemi and Hubbard suggest two research questions - introduce the ideas with chart paper:
What aspects of teachers’ practice are represented in the context of my PLT, and how?
Thoughts through one session

How are aspects of my PLT represented in the context of participants’ classrooms?
Thoughts through one session

IV. Excerpted article, Ball & Cohen, 1999 - pp. 12-19
What do they mean?
“One particularly crucial entry criterion for records that might be included is that they not merely reinforce extant practices, beliefs, or ideas, for practice-centered professional learning of the kind we are describing would be contrary to teachers’ conventional socialization in two respects. It would intervene in the isolation of practice, in which the only material for learning is one’s own practice. By enabling encounters with very different practices, such work would broaden and diversify teachers’ knowledge and create opportunities to see new versions of teaching and learning, and to understand things differently.”

“A second crucial entry criterion for candidate records of practice is that they be used to focus teacher education on the investigation of practice - that is, to make systematic study and analysis of learning and teaching the core of professional education. To do so, teacher educators and teachers would have to cultivate the capacities to investigate teaching and learning, develop new claims on the basis of such investigation, and defend them with evidence and argument. Simply looking at students’ work would not ensure that improved ways of looking at and interpreting such work will ensue.”

“Lacking concreteness and common ground, teachers (when they even have opportunities to talk or work collectively) often talk past and around one another. They rarely grapple with core elements of their work, seeking to discover and use their differences in assumptions, experience and reasoning.”

V. Working on your PLT
A. Based around one of the quotes above - what can you do to choose the right practice to investigate, create the right focus, and inspire the right talk.
Session Three

Agenda
I. Research corner
   a. Questions
II. Revisit Norms
III. Quick quote warmup from Ball/Cohen - post-it notes
IV. Article on Normalizing Practice - Little and Horn, 2010
   a. What does this mean? Grounding two PLTs within their practice
      1. Discussion Driven Chemistry
      2. Literacy in the Living Environment
V. Working/Planning in our PLTs
   a. Questions to consider
   b. Planning around the work today/your own work

II. Revisited Norms

**Values**

<table>
<thead>
<tr>
<th>• Openness</th>
<th>• Respect for our work</th>
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<tr>
<td>• Curiosity</td>
<td>• Professionalism</td>
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<tr>
<td>• Collaboration</td>
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</table>

**Norms**

1. Be present.
2. Be a part of the group and contribute freely.
3. Name your comfort/discomfort.
4. Figure out what you can apply.
5. Stay true to the goal.

III. There are various quotes from Ball and Cohen’s article we read last time around the room
Everyone has two color post-it notes:
   • Yellow - What do I think about this quote and my role planning and acting during a PLT
   • Pink - What challenges do I see with this quote, especially as pertains to my PLT
After a silent 7 minutes, spend one minute at each quote with your PLT partner and talk over the notes

IV. Excerpted article, Little and Horn, 2010
Horn and Little’s thoughts on conversations about problems of practice
For the table below (and on your organizer), what are the ways that we can take artifacts or discussions about the classroom, then normalize them, ask teachers to be specific, but still generalize the work to be generally applicable.

<table>
<thead>
<tr>
<th>Normalizing</th>
<th>Specifying</th>
<th>Generalizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>What’s missing?</td>
<td></td>
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</tbody>
</table>

Protocol discussion - 2nd session of PLT 1
- 5 minutes - facilitators recap the work that they did, and explain the artifacts that participants explored, the way that they had participants explore the artifacts, and the discussions that occurred
- 5 minutes - clarifying questions
- “How did you feel it went”
- Thoughts from the group:
  - Co-Evolution
  - Practice-based Teacher Learning
  - Normalizing, Specifying, Generalizing

Protocol discussion - 2nd session of PLT 2
- 5 minutes - facilitators recap the work that they did, and explain the artifacts that participants explored, the way that they had participants explore the artifacts, and the discussions that occurred
- 5 minutes - clarifying questions
- “How did you feel it went”
- Thoughts from the group:
  - Co-Evolution
  - Practice-based Teacher Learning
  - Normalizing, Specifying, Generalizing

V. Working on your PLT
A. Using our generative tool
Session Four

Agenda

I. Research corner
   A. Questions

II. Revisit Norms

III. Jigsaws of Frameworks in Place w/in Science Teacher Learning
   - Furtak
   A. What is necessary for analysis of practice PD to work within PLTs at MfA
      1. What is common between this research and PLTs?
      2. What is different?

IV. Analysis of Facilitator’s Practice - Inquiring Minds Need to Know

V. Working/Planning in our PLTs
   - Planning around the work today/your own work

II. Revisited Norms

Values

<table>
<thead>
<tr>
<th>Openness</th>
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<tbody>
<tr>
<td>Curiosity</td>
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<tr>
<td>Collaboration</td>
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</tr>
</tbody>
</table>

Norms

1. Be present.
2. Be a part of the group and contribute freely.
3. Name your comfort/discomfort.
4. Figure out what you can apply.
5. Stay true to the goal.

Be thinking about:

- What insights might I gain from this snapshot of practice as it relates to my PLT?
- How does this experience help me think about my role as a science education leader?

A Caveat

- The teachers in this PD all gave permission for this to be shared to allow us to carefully examine a real instance of practice. We are examining, and not critiquing.

Three clips

1. The Task: take a minute to look through the protocol that they are using
   a. Listen to the instructions
   b. What do you notice?
2. We will watch the first videos two times, then the second video (A’s response) two times
a. In the first pass through, notice the science being discussed as well as the teacher’s engagement
b. In the second pass through, focus on the choice A is making in responding to the video.

3. Share out, with opportunities for S and A to share
Interview Questions

Post-Session One Interview

- How did you feel like it went?
- Was there anything unusual you noticed during the session?
- Were there any challenges that you see this semester?

Post-Session Two Interview (Participants also completed a separate survey at this time to make sure that they still felt that this was a minimal risk study and that they still wanted to participate – all participants answered to continue)

- How do you feel like your session went, in terms of searching for coevolution?
  - What aspects of teachers’ practice are represented in the context of my PLT, and how?
  - How are aspects of my PLT represented in the context of participants’ classrooms?
- Characteristics that came up during our second session for successful PD included finding disequilibrium, using the teachers’ work to find a focus, and finding ways to deepen conversations so that teachers are talking with each other, and not around each other. Was there anything that came up during your session where you felt these struggles as a facilitator?
- Is there any work that you can bring to the next session to consider with the group, especially in relation to a dilemma or challenge you want to think about with the group? If so, what do you think you could bring?
Post-Session Three Interview

- In terms of facilitating this session, please use the space below to think about anything that came up related to the topics that we have been discussing in our PLT around:
  - Co-Evolution (the act of the PLT and classroom affecting each other)
  - Practice-based Teacher Learning (grounding work within teachers’ practice, finding a focus, allowing deep conversations, finding disequilibrium)
  - Normalizing, Specifying, Generalizing (as ways of seeing how teachers talk with and to each other)

- Is there anything in particular that you want to think about in the next session of the PLT for Facilitators?

Post-Session Four Interview

- Could you please explain what the 4-session scope of the PLT was? If it deviated from your plan, how did it do so, and why?

- If there was any influence from the articles we read and discussed this semester, what was it? What are you thinking about for future work with other teachers?
# Appendix C

Questions and Participant Responses from End-of-Course Survey

<table>
<thead>
<tr>
<th>Name</th>
<th>This course introduced me to new STEM content</th>
<th>Elaborate</th>
<th>This course improved the way I understand my students</th>
<th>Elaborate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amanda</td>
<td>Yes</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Amy</td>
<td>N/A</td>
<td></td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>David</td>
<td>N/A</td>
<td>N/A</td>
<td>I learned more about the importance of teachers reflecting on their practice through student work.</td>
<td>N/A</td>
</tr>
<tr>
<td>Elizabeth</td>
<td>N/A</td>
<td>Yes</td>
<td>Makes me think about learners in general. More focused on teachers.</td>
<td></td>
</tr>
<tr>
<td>Eric</td>
<td>N/A</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heather</td>
<td>N/A</td>
<td></td>
<td>This PLT truly reinforced the significance of analyzing student work in order to make sense of student thinking. Not only that but reflecting on teaching practice in accordingly.</td>
<td></td>
</tr>
<tr>
<td>Isabelle</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kevin</td>
<td>N/A</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lisa</td>
<td>N/A</td>
<td>Yes</td>
<td>The PLT informed my understanding of what Learning experiences student need to improve their understanding.</td>
<td>N/A</td>
</tr>
<tr>
<td>Melissa</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samantha</td>
<td>Yes</td>
<td></td>
<td>I learned so much about the theory and studies done behind STEM practices.</td>
<td>N/A</td>
</tr>
<tr>
<td>Name</td>
<td>I gained a practice or strategy that will change the way I teach.</td>
<td>Elaborate</td>
<td>How effective was the facilitator?</td>
<td>Elaborate on the facilitator’s work</td>
</tr>
<tr>
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<td>-------------------------------------</td>
</tr>
<tr>
<td>Amanda</td>
<td>N/A</td>
<td>Very Effective</td>
<td>As mentioned, PI was FANTASTIC. He was engaging, reflective, and collaborative. He set the agenda with his PLT groups in mind and adjusted course when it was helpful.</td>
<td></td>
</tr>
<tr>
<td>Amy</td>
<td>N/A</td>
<td>Very Effective</td>
<td>There was a clear predictable routine that was followed in each session. We read primary papers in education research highlighting concepts important fostering successful PLTs and discussed how our PLTs either did or did not currently embody these concepts. We worked together towards figuring out how to make our PLTs &quot;model&quot; learning teams. All participants seemed comfortable in openly sharing with each other, well focused and all tasks were clearly outlined. John did a really good job of keeping us tracked to the tasks at hand and the material he had us reading was really interesting making discussions quite rich.</td>
<td></td>
</tr>
<tr>
<td>David</td>
<td>N/A</td>
<td>Very Effective</td>
<td>The facilitator planned the sessions well and stayed on schedule, had clear objective, and allowed us time to work together.</td>
<td></td>
</tr>
<tr>
<td>Elizabeth</td>
<td>Yes</td>
<td>By &quot;students&quot; I am meaning fellow colleagues that I work with in facilitating my PLT. I learned more about how to use student artifacts as a focus of teacher reflection.</td>
<td>Very Effective</td>
<td></td>
</tr>
<tr>
<td>Eric</td>
<td>Yes</td>
<td>Focus on protocols</td>
<td>Very Effective</td>
<td>Very transparent and open</td>
</tr>
<tr>
<td>Heather</td>
<td>Yes</td>
<td>During this PLT we implemented various protocols for analyzing text/student artifacts. One protocol included asking clarifying questions followed by probing questions. In __ we adapted this protocol for analyzing student work. For example, students were presented with two images and worked in groups to answer the following question on chart paper: &quot;In which image does transcription and translation of the structural genes occur? Explain.&quot; Students first asked clarifying questions on post-its followed by probing questions in order to convince each other their selected image was the appropriate one.</td>
<td>Very Effective</td>
<td>This PLT made me think more about how to facilitate AP Biology PLT in such a way that would promote teacher reflection of practice and enhance student learning.</td>
</tr>
<tr>
<td>Name</td>
<td>Response</td>
<td>Elaboration</td>
<td>Effectiveness</td>
<td>Elaboration on the facilitator's work</td>
</tr>
<tr>
<td>---------</td>
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<td>------------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Isabelle</td>
<td>Yes</td>
<td>The PLT helped me to question further and assess whether our delivery of content and discussion about that content is meaningful, reflective and questioned to ensure success for all.</td>
<td>Very Effective</td>
<td>There were many opportunities for discussion, we all respected each other’s opinions, there were no wrong answers but thoughtful discussion that continued to build after each session.</td>
</tr>
<tr>
<td>Kevin</td>
<td>Yes</td>
<td>The PLT helped me think about practices/strategies that I could implement to improve teaching and learning</td>
<td>Very Effective</td>
<td>The PLT was well organized and grounded in research-based practices.</td>
</tr>
<tr>
<td>Lisa</td>
<td>N/A</td>
<td></td>
<td>Very Effective</td>
<td>I enjoyed reading the articles that were shared and getting direct feedback of my facilitation of my own PLT.</td>
</tr>
<tr>
<td>Melissa</td>
<td>Yes</td>
<td>This helped me think about how I will facilitate adults, as I prepare to take on the role of grade team leader.</td>
<td>Moderately Effective</td>
<td>Our facilitator was thoughtful and reflective, and provided us with a clear framework for our investigation into facilitator moves and practice. Sometimes, however, I wasn’t 100% clear on the purpose of a specific activity or how it connected back to our learning.</td>
</tr>
<tr>
<td>Samantha</td>
<td>N/A</td>
<td></td>
<td>Very Effective</td>
<td>It’s just the best. He’s so knowledgeable and often asks interesting and engaging questions.</td>
</tr>
<tr>
<td>Name</td>
<td>I will share what I learned in this course with another teacher or colleague</td>
<td>I plan to continue working on an idea/strategy from this course</td>
<td>Elaborate</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Amanda</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
<td>PI was fantastic as a PLT facilitator. He challenged me and my colleague to broaden our ideas of what true and valuable &quot;inquiry&quot; in a classroom is, and he thoughtfully reflected on research to drive his own practices. I have shared many of the research on PD with our DCI at school</td>
<td></td>
</tr>
<tr>
<td>Amy</td>
<td>Agree</td>
<td>Strongly Agree</td>
<td>This PLT helped me to learn how to better facilitate teachers working together collaboratively towards improving the classroom experience for students. I have already started implementing strategies learned in a PLT that I facilitate at MIA, in my teacher team in the ----- Department at my school, and sharing strategies with the Professional Development Planning Committee that that I am a member of at my school. One of the biggest ideas that I have learned about, shared, and plan to keep working on, is how to successfully foster co-evolution of what happens in PLTs and what happens in the classroom.</td>
<td></td>
</tr>
<tr>
<td>David</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
<td>I look forward to seeing how what we discussed can be applied to future PLT’s I participate in or perhaps PLT’s I facilitate.</td>
<td></td>
</tr>
<tr>
<td>Elizabeth</td>
<td>Agree</td>
<td>Agree</td>
<td>I plan to utilize student artifacts more frequently in teacher reflection and future professional development sessions in which I am involved in the planning/implementation.</td>
<td></td>
</tr>
<tr>
<td>Eric</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
<td>I would like to use what I have learned to reshape the way I approach future PLT facilitations</td>
<td></td>
</tr>
<tr>
<td>Heather</td>
<td>Agree</td>
<td>Agree</td>
<td>I shared the protocol for analysis of student work and reflecting on teaching practice with the science department as we analyzed our mock regents data.</td>
<td></td>
</tr>
<tr>
<td>Isabelle</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>The work we did in the PLT was enlightening, the discussions around pedagogy and how to use student work to revamp instruction must be brought back to my school so we can jump into our own inquiry cycles and establish a true PLC that is cyclical in nature where student work is at the forefront.</td>
<td></td>
</tr>
<tr>
<td>Kevin</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>The PLT focused on identifying practices that can improve student understanding. I'm going to continue to implement strategies like discussion protocols to facilitate group discussion.</td>
<td></td>
</tr>
<tr>
<td>Lisa</td>
<td>Agree</td>
<td>Strongly Agree</td>
<td>This PLT has led me to think about what it means to be a facilitator, how to plan for a successful PLT and how to better support teachers.</td>
<td></td>
</tr>
<tr>
<td>Melissa</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
<td>I will be facilitating learning both at my own school, and at MfA again next year. I plan to use the strategies we discussed when thinking about my practice as a teacher learning facilitator.</td>
<td></td>
</tr>
<tr>
<td>Samantha</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
<td>I am excited to learn more about the research done behind teaching practices!</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>This PLT prompted me to reflect on an aspect of my teaching.</td>
<td>This PLT had a clear and consistent focus on students and/or student learning.</td>
<td>What suggestions do you have that would strengthen the work of this PLT?</td>
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<td>--------------</td>
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<td>------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Amanda</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
<td>I would love to conduct more video review - many of our fellow participants described what they did in their sessions, but much like when teachers talk about what they do with students with no artifacts to study, it was sometimes hard to learn from others.</td>
<td></td>
</tr>
<tr>
<td>Amy</td>
<td>Strongly Agree</td>
<td>N/A</td>
<td>I may have missed this since I joined the PLT in the middle of the year... But I would have liked to have known more about the other participant's PLTs, both the focus and the format. I think this would have helped me to better understand and learn from what is working vs. not working in each other's PLTs.</td>
<td></td>
</tr>
<tr>
<td>David</td>
<td>Agree</td>
<td>Strongly Agree</td>
<td>simply that these discussions continue</td>
<td></td>
</tr>
<tr>
<td>Elizabeth</td>
<td>N/A</td>
<td>Agree</td>
<td>I appreciate that we didn't have any &quot;homework&quot; but I think I would have preferred reading the articles beforehand so we had more time to talk and work together. I understand and appreciate that we were not asked to do so beforehand since we are so busy, but I think I would have personally preferred to have more time to read and reflect ahead of time. So maybe give a paper copy of the article for the next PLT the session before which would give plenty of time for teachers to read it ahead.</td>
<td></td>
</tr>
<tr>
<td>Eric</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
<td>Continue with the work and implement the feedback for MFA PLTs</td>
<td></td>
</tr>
<tr>
<td>Heather</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isabelle</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kevin</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>More time to execute.</td>
<td></td>
</tr>
<tr>
<td>Lisa</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Melissa</td>
<td>Strongly Agree</td>
<td>N/A</td>
<td>T would be interesting if we had filmed the PLTs that we led and looked for connections between what we saw and the literature that we read</td>
<td></td>
</tr>
<tr>
<td>Samantha</td>
<td>Strongly Agree</td>
<td>N/A</td>
<td>It would be helpful to have spent time as a whole PLT group to think through our goals in facilitation, and have more time to dive more deeply into each other’s practice.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
<td>Having the readings during the session be done as pre-work instead of during the PLT</td>
<td></td>
</tr>
</tbody>
</table>
Appendix D

Sample tool for helping teacher leaders with one of the themes for leading PLCs

(Finding a Focus)

**Refining a Focus Tool for Professional Learning Teams at Math for America**

The purpose of this tool is to help you as you write and refine the focus of your PLT. This is something that we understand takes time – we even encourage you to revisit this tool from time to time and see how your focus has developed, even as the PLT progresses.

<table>
<thead>
<tr>
<th>Start with a Question</th>
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<tbody>
<tr>
<td><em>What question do I have about teaching and student learning, as it happens in classrooms like mine?</em></td>
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<table>
<thead>
<tr>
<th>Identify a Focus (which you will refine using the rest of the tool)</th>
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<tbody>
<tr>
<td><em>Using the question above, the focus for the group of teachers composing my PLT is:</em></td>
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<table>
<thead>
<tr>
<th>Refine it (to be completed at the end of the tool)</th>
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<tbody>
<tr>
<td><em>After completing the tool and upon reflecting upon my answers, the (refined) focus for my PLT is:</em></td>
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Once you have drafted the first iteration of your focus, please make your way through the rest of this tool.

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<tr>
<th>Connected to Teaching Practices</th>
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| Think about a teaching practice that impacts student learning that you would like to investigate in a Professional Learning Team. Practices can be general (fostering argumentation among students) or content specific (leading students through experimental design, engaging students in cognitively demanding mathematical tasks).

*What is the specific teaching practice, and why is it important as it relates to student learning in the classroom?*

<table>
<thead>
<tr>
<th>Embedded in the Classroom</th>
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| Consider opportunities participants have to use the practice in their classrooms. The practice should be specific enough that it can be thoughtfully explored, but able to be broadly used (so that participants are able to find multiple opportunities in their classroom).

*How can the practice be investigated so that, in participants’ classrooms, it can be thoughtfully explored throughout the duration of the PLT?*
Connected to Student Thinking
Think about how the teaching practice will elicit student thinking that can be then explored by the team. This is incredibly important in moving the conversation from a teacher telling what happened in the classroom to using student evidence to investigate what they are thinking.

*How will student thinking be elicited? What artifacts (student work, video, etc.) will teachers need to collect in order for others to investigate their work?*

**NOTE:** Not all artifacts are useful. A multiple-choice exam typically doesn’t give teachers working in collaborative teams as much to investigate as thoughtful open-ended questions, or a videotape of student discussions.

Grounded in Research
Think about how this work can be an opportunity for teachers to look not just at each other’s classrooms, but also bring in research and outside resources to expand the work even beyond the context of participants and their students.

*What resources (articles, books, etc.) can you bring in to study this practice and its importance to student learning?*

Centered on Reflective Practice
Consider how participants will grow and change their practice through this work. The work of the PLT should allow participants opportunities to identify generalizations about teaching practice based on the specific cases explored.

*What are the ways you hope that reflecting upon the practice through the artifacts will support teacher learning?*
Appendix E

Samples of Data Collected in the Design Experiment

Samples of Transcript with nvivo codes

<table>
<thead>
<tr>
<th>Line</th>
<th>Time</th>
<th>Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>1:03:38.8 - 1:07:58.3</td>
<td>paragraph that explains what those three steps are in case you need it.</td>
</tr>
<tr>
<td>37</td>
<td>1:07:58.2 - 1:08:10.2</td>
<td>Specifically, what do people think is missing. What did people write... I feel like missing is the bigger one.</td>
</tr>
<tr>
<td>38</td>
<td>1:08:10.2 - 1:08:28.6</td>
<td>For me, it feels like she is walking away, and she doesn't know what to fix. There are no concrete action steps. Someone mentioned follow through or follow up that she should do, it wasn't clear to me.</td>
</tr>
<tr>
<td>39</td>
<td>1:08:28.6 - 1:09:45.8</td>
<td>I mean, in the end, she has, I think, an initial reflection, where maybe I should not have been angry at my students, because as I look at it, she realized that some of them are just generally confused from the do now or the start of the lesson. So maybe, I'm hoping the next step that she does is to come with that generalization and then she can apply that understanding before she has them play with the manipulatives. She should reflect on it so that the next time she plans a lesson, it would have somewhere in the lesson where she could have a check for understanding before they even play with the manipulatives. But the fact that she wasn't even safe enough in that space to share whatever she wanted to share out - there was openness there. She wouldn't have done that unless on some level she would have gotten some sort of help from that. So in the end, I'm hoping she did reflect and make more meaning after this meeting was over. Maybe in future lessons, because I don't think the article left us with that.</td>
</tr>
<tr>
<td>40</td>
<td>1:09:45.8 - 1:09:57.1</td>
<td>Do we think Alice grew as a teacher, is almost what you are saying, do we think she grew as a teacher in this episode?</td>
</tr>
<tr>
<td>41</td>
<td>1:09:57.1 - 1:10:02.1</td>
<td>I hope so, because it has more meaning if it did!</td>
</tr>
<tr>
<td>42</td>
<td>1:10:00.8 - 1:10:38.8</td>
<td>I would say that we are not sure... we'd have, even if we thought that she changed how she felt, is that really what's important. Did she change how she teaches? Sometimes you think about things differently but if you don't do anything about that...</td>
</tr>
<tr>
<td>43</td>
<td>1:10:38.8 - 1:10:48.0</td>
<td>I mean there's minimal self-reflection... nothing that shows a way of looking at practice...</td>
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<tr>
<td>44</td>
<td>1:10:47.9 - 1:12:24.6</td>
<td>I think a huge part, other than, having any form of evidence for them to look at. So we were talking about more probing around her objectives or her vision, so she mentions a couple of times I have this vision of groupwork that they never discuss or, from what this is presenting to us, they never talk about. What that vision is and then where that broke down. So even if she doesn't have any kind of artifact with her other than her anecdotal recounting, there isn't a lot of you are saying that the vision in your classroom wasn't matching, or what you were seeing in the classroom wasn't matching your vision, where did you notice that it was like that, or what was actually happening other than saying it was mayhem they were doing things that wasn't expected. So I wonder if, even though a couple of people mentioned protocols in their posters, they didn't have a formal protocol here but they were just asking more questions of what is the objective, what did you want to get out of that. Was it the skills of working in a group that you were focusing on, was the objective for the day... there was never any discussion of what students were supposed to be mastering other than her talking about how it looked like pandemonium in her classroom.</td>
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<tr>
<td>45</td>
<td>1:12:24.6 - 1:12:58.3</td>
<td>I thought a lot about how protocols... good protocols, done well, sort of approach each one of these aspects. They normalize by stating a dilemma or at least setting the stage. And then they allow you to look at the specific work that's going on, and they hopefully allow everyone to generalize and apply to their own work, but not all protocols do that. I would hope the good ones do.</td>
</tr>
<tr>
<td>46</td>
<td>1:12:58.3 - 1:13:09.1</td>
<td>It should be exploratory.</td>
</tr>
<tr>
<td>47</td>
<td>1:13:04.1 - 1:13:46.9</td>
<td>Even just, building off of this idea of the vision. I would want to, there is a difference between what you envision the perfect classroom to look like and what the learning objective is. You may have a vision of what it is like for students to learn something but, learning it really well doesn't look necessarily like what you hope it would look like. So even just, sort of interrogating that a little - how comfortable are you with students talking to each other, or playing around with something and what are you doing in the classroom structure so you can get information about what they've actually gotten out of it instead of just getting a gauge that was saying &quot;well, there was a lot of talk so they weren't getting a lot out of it&quot;. What were the measurements of how and what students were getting...</td>
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**Notes:**

- **Heather:** Mentioned the need for more self-reflection and that her perception of the lesson was that the students were not sure if they had changed how they felt about the lesson.
- **Elizabetth:** Suggested that sometimes the students needed to talk about things differently but didn't actually do anything about it.
- **Isabellle:** Commented on the minimal self-reflection of the teacher and the lack of a way of looking at practice.
- **Amanda:** Discussed the importance of groupwork and how it related to the objectives and the vision in the classroom.
- **David:** Noted the need for exploration in the classroom to help students develop a better understanding of the learning objectives.
- **Melissa:** Highlighted the impact of protocols on classroom dynamics and student learning, suggesting that effective protocols facilitate deeper learning experiences.
Sample Primary artifact from a session, with process codes highlighted
Congratulations on another session!!! Please use the space below to answer a couple of questions in order to help jog your memory at the next session (this work is coded without your name in order to keep anonymous. Only you are shared to this document)

How do you feel like your session went, in terms of searching for coevolution (the questions we’ve been thinking about are below):
The session went well in terms of coevolution, almost all students brought in student work. All of them were willing to share about the PLT in relationship to their classrooms.

What aspects of teachers’ practice are represented in the context of my PLT, and how?

In particular we focused on discussion, assessment, protocols, and reflective practice. We talked about discussion in terms of prompts/student work. We also talked about discussion protocols to use in the classroom. We showed a video of how to assess students. Through the share out & consultancy protocol we reflected on teacher practice.

How are aspects of my PLT represented in the context of participants’ classrooms? Teachers are utilizing ideas from the PLT in student activities demonstrated by artifacts that we reviewed at the share out.

Characteristics that came up during our second session for successful PD included finding disequilibrium, using the teacher’s’ work to find a focus, and finding ways to deepen conversations so that teachers are talking with each other, and not around each other. Was there anything that came up during your session where you felt these struggles as a facilitator?

For me, there is some struggle between the need to focus on content and test taking skills. While I don’t think anyone made be feel this way, I feel like I internalize some of the pressure that since we are the facilitators we should be “experts” while we are all still learning and growing as effective educators.
Interview As

In 1 artifacts

Key shows high expectations of students, but it seems from interviews that there were issues with its introduction.

Bridges of the question of how you introduce an artifact, and since video seemed to go over better - why is this? Can be of types?

Does the content take away from the question? Things like 'academic language,'