ABSTRACT

TAYLOR, CHRISTINE MARIE. Sustainability Three Years after the Professional Development: A Collective Case Study of Elementary School Mathematics Teachers. (Under the direction of Paola Sztajn and Temple Walkowiak).

Professional development (PD) is a requisite part of teachers maintaining licensure, and there is growing consensus about elements that constitute high-quality professional development. However, less is known about how teachers continue to integrate practices learned from PD when they are no longer actively involved in the PD. One measure of PD effectiveness that has recently gained attention is Sustainability. While others have examined former professional development participants, this study is unique in that it looks at each of the participants more closely, through three lesson cycles.

This study examines PD sustainability via case studies conducted three years after the PD ended. This study develops a framework for describing the ways in which teachers continue to adopt core values from the PD. Findings indicated a myriad of factors that influenced sustainability of the PD such as strong adoption of the PD ideas at the conclusion of the PD, support from colleagues, and alignment of PD with school and district goals. By describing both the ways that teachers sustain PD ideas and the factors that influence them, the study concludes with teacher profiles that inform teacher and PD developers’ practices.
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Sustainability Three Years after the Professional Development: A Collective Case Study of Elementary School Mathematics Teachers

by
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A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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DEDICATION

This work is dedicated to Charlotte, Thomas, and Micah.
BIOGRAPHY

Christine Marie Taylor was born in Terre Haute, Indiana. She grew up in the Crossroads of America, playing trumpet in school band and puzzling over problems her grandfather, a former high school math teacher, brought to her. After graduating high school Christine went on to earn a Bachelor of Science degree from Indiana State University and a Master of Science degree from IUPUI, both in Mathematics.

Love and marriage then took Christine to North Carolina, where she worked as a developmental math instructor at a community college. Shortly thereafter, she enrolled in the PhD program in Mathematics Education at North Carolina State University. The program changed the way she thought about mathematics teaching and learning. Among the most influential experiences of her PhD studies was working as a Graduate Research Assistant for Project AIM. There Christine observed firsthand how to develop and deliver high quality professional development experiences. That experience also sparked her love of elementary school mathematics.

Life and family needs took Christine back to Indiana where she spent time raising her two young children. In recent years she worked as a professional development designer and facilitator for a statewide professional development grant called CATCH (Creating Algebra Teaching Communities for Hoosiers). She has also developed and supported the remedial math program and math tutoring at Indiana State University.

Christine has accepted an Assistant Professor position in the department of Mathematics and Computer Science at Indiana State University to begin Fall 2017.
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I wish to extend my sincere thanks to both Paola and Temple for supporting me and pushing me to improve. I am thankful to Temple for being steadfast in caring about my completion. I am most grateful to Paola that she encouraged me to pursue what interested me and never gave up on me.

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Chapter 1

Teacher professional development (PD) is widely established as an important means of supporting and nurturing teachers at all levels of K-12 education. According to a report by the National Center for Education Statistics (NCES, 2013), 99% of public school teachers in 2011 indicated that they had participated in professional development in the previous year, with 85% of teachers indicating that they participated in PD related to the subject(s) they taught. PD can take the form of one-shot workshops or longer-term training programs, and it can be completely embedded within teachers’ work or delivered through external workshops. The goal of many PD programs is to effect changes in teacher beliefs and practices that persist through time; thus, PD can be said to have fulfilled its purpose when it results in lasting improvement in the teacher participants, according to the criteria or standards set forth by the PD developers.

Educational researchers and practitioners refer to the persistence of PD-promoted teacher beliefs and practices as sustainability. Sustainability occurs, according to Fishman et al. (2011), when teachers engage in “continued use of the [PD] intervention in ways congruent with developers’ intent” (p. 330). Much of the research on PD effectiveness attempts to gauge whether or how teachers engage with PD over the course of the intervention, using pre/post measures that target the beginning and the end of the intervention. Although such studies can shed light on teachers’ adoption of PD-promoted beliefs and practices, they cannot assess to what extent those changes persist over time after the intervention is complete.
Research has established that one-shot workshops are less effective than PD that is implemented over time (Darling-Hammond, 2010; Garet, Porter, Desimone, Birman, & Yoon, 2001; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). Attention to PD effectiveness is important for sustainability because if the PD did not influence change, there would be nothing to sustain. Education researchers have begun to investigate which features of PD result in sustained teacher change. Preliminary results suggest these features include teachers continuing to work with peer teachers and teachers’ perception of the usefulness of the intervention, as well as the alignment of the PD with teachers’ current practices, with the content teachers are required to teach, and with other stakeholders’ expectations of instruction (Fishman, Penuel, Hegedus, & Roschelle, 2011; Franke et al., 2001; Coburn, 2003; Gutierrez & Penuel, 2014). However, despite recent advances in the understanding of PD sustainability, challenges persist. It is not always clear which aspects of the PD intervention may be integrated into everyday teaching practices after the PD ends (Fishman et al., 2011). Moreover, the field still does not know all of the factors that support or hinder teachers as they integrate PD interventions into practice.

Given the importance of sustainability as a measure of PD effectiveness, and the gap in research on how and why teachers sustain the practices they learn in PD, this study seeks to uncover the ways in which teachers sustain (or do not sustain) PD changes into their practices and the factors that affect the sustainability of the practices promoted in the PD. To address this phenomenon, the research presented herein employs an instrumental collective case study (Stake, 1995) method. Based on interviews with six second-grade mathematics teachers as well as classroom observations of their instruction, I examine each teacher’s
mathematics instructional practices three years after their completion of a professional development program. The program was a year-long PD designed to promote teachers’ use of effective mathematics discourse in the classroom. I develop thick, rich descriptions of each teacher’s case that yield insights on how and why PD-promoted practice are or are not sustained in the years after the PD is completed. I then describe, analyze, and identify factors that encourage or do not encourage the sustainability of the PD-promoted beliefs and practices.

**Significance**

Professional development is an expansive and expensive undertaking, with various state, university, and district organizations spending over $1 billion per year on professional development for teachers (Fertig & Garland, 2012). Professional development is so important that teachers are required to engage in it in order to maintain professional licensure. With such emphasis placed on teachers’ participation in PD, it is necessary to examine the effectiveness of the work in which teachers are required to participate. Generally, effective professional development has the following features: it is sustained over time, focuses on content, and occurs within a community of practice (Garet et al., 2001; Boston & Smith, 2009; Desimone, 2009; Louis, Marks, & Kruse, 1994). However, research on PD effectiveness has focused on immediate effects after the PD. Despite the importance of PD to teacher development, most research concerning PD ignores the importance of sustainability of classroom practices. Time and resources to study sustainability have been limited.

The study presented herein has significance for several groups of stakeholders. The significance of this study for teachers is that it can help them to make the best use of PD
offered or advocate for better PD. For schools and districts, the study may provide insights into what school-level PD features are associated with continuation of the PD effects. Finally, the results of this study have value for designers and implementers of PD programs, as they consider how to create professional development opportunities that promote participants’ professional learning even after the professional development is complete.

**Purpose Statement and Research Questions**

The primary purpose of this investigation is to identify factors that contribute or do not contribute to the sustainability of PD ideals three years after the PD intervention has ended. This study also brings forth the teachers’ perceptions of what was helpful for them in sustaining the teaching practices promoted in the attended PD. Two research questions are addressed:

1. In what ways do teachers sustain (or not sustain) the core values of a PD in their instructional practices in the years after the PD intervention?

2. What factors promote (or do not promote) the sustainability of the PD core values in the years after the PD intervention?

**Overview of Approach**

This instrumental collective case study (Stake, 1995) examined six focus teachers who had previously completed a one-year professional development with their respective school teams. The PD was part of an NSF-sponsored professional development program entitled Project AIM (All Included in Mathematics), which was designed to equip second-
grade teachers with strategies for promoting effective mathematics discourse (or “math talk”) in their classrooms.

This study began three years after the PD had been completed, and the teachers had varied experiences since the completion of the PD. Among the most notable differences was that some of the teachers had continued to work with the same teachers with whom they had attended the PD, while other teachers (or their colleagues from the PD) had moved on to other schools. In this study, based on my classroom observations and interviews with the teachers, I present teachers’ narratives of what had transpired since the PD concluded. In order to fully understand their experiences, I examine multiple lesson cycles for each teacher, describing the teachers’ current practices in relation to their practice at the completion of the PD. Examining the teachers’ current mathematics teaching provides insight into how the teachers had adapted and used elements of the PD.

Organization of the Dissertation

The next chapter reviews the literature on PD sustainability. The chapter also describes the study’s theoretical framework, which is based on learning theories and others’ work in sustainability. In the third chapter, I provide a detailed description of the research methods, including information about the context of the study, that is, the Project AIM PD that this study follow up on. The fourth chapter describes the individual teacher cases, and the fifth chapter addresses the research questions through cross-case analysis. Finally, the sixth chapter discusses implications of the research and makes recommendations for future work.
Chapter 2

This chapter presents an overview of the literature related to sustainability. In it, I first discuss teacher learning. Next, I connect teacher learning to sustainability, defining several ways in which teachers may demonstrate sustainability. Third, I discuss how others have studied sustainability of mathematics PD and their findings. Finally, I describe the foundation for sustainability, the effective professional development that serves as the impetus for teachers’ learning. By reviewing the existing literature, I demonstrate the importance of this sustainability study and the factors related to sustainability that it reveals.

Teacher Learning and Sustainability

One Vygotsky-inspired framework for learning is described by Gallucci, Van Lare, Yoon, and Boatright (2007). In their study, they adapt McVee at al’s (2005) work to describe the learning process of an instructional coach. In Gallucci et al.’s paper, they describe learning in the following steps:

- Individual *appropriation* of particular ways of thinking through interaction with others;
- Individual *transformation* and ownership of that thinking in the context of one’s own work;
- *Publication* of new learning through talk or action;
- The process whereby those public acts become *conventionalized* in the practice of that individual and/or in the work of others (p. 296).
I use these four steps to define the learning process that professional development providers may observe in teachers who participate in a PD program. The four-step learning process and its intersection with the Public-Private axis, as well as the Individual-Collective axis, is called the Vygotsky Space and is illustrated in the figure below:

Figure 1. The Vygotsky Space. This visual shows the learning cycle of Appropriation, Transformation, Publication, and Conventionalization. As it appeared in Gallucci et al., 2007.

These four steps progress in a cyclical process by which the four stages move through public and private spaces. In this study, I am particularly interested in the public space,
defined as the setting where a teacher is engaging with new ideas that others can observe. On the other hand, the private space is defined as the teacher making sense of ideas in a setting where thought or actions are not observed by others. The individual space refers to the actions of a teacher considering and internalizing new ideas, while the collective space involves actions taken together with others to further learning.

For the purposes of this sustainability study I am particularly interested in conventionalization, which represents the shift from the individual (IV) to collective (I) quadrants of the public space. Specifically, I study the actions available in such space, which are those that one can observe through the course of speaking and observing another. In conventionalization, the learner is demonstrating a deep understanding of a subject that is displayed, making it possible that others may also learn from his or her work. In this study I define the public space as those actions that one can observe through the course of speaking with a teacher, examining her lesson plans and instructional materials, or visiting her classroom; the private space is other thoughts or actions that are not immediately available to an observer and cannot be accessed through general conversations with the teacher. When a teacher’s learning is conventionalized, it is evident in her words, actions, and practice.

Using theory to describe sustainability. When a teacher displays a conventionalization of the work of the PD long after the PD is over, she is showing a strong sustainability of the PD ideas. In order to describe the ways in which teachers may conventionalize PD ideas, I adapted Franke et al.’s (2001) concept of learning with understanding. Learning with understanding is the notion that as a teacher learns something well, he or she is able to take that knowledge into new contexts and apply it to what he or she
is doing. In their framework of learning with understanding, Franke et al. define three “distinguishing characteristics” (p. 655-656) called generativity, being rich in structure and connections, and driven by the teacher’s own inquiry. These distinguishing characteristics are ways that teachers may conventionalize the PD ideas into their work:

<table>
<thead>
<tr>
<th>Conventionalized</th>
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<tr>
<td>Generativity</td>
</tr>
<tr>
<td>Being Rich in Structure and Connections</td>
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<tr>
<td>Driven by the Teacher’s Own Inquiry</td>
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Figure 2. Defining Strong Sustainability as Conventionalized. This figure lists three distinguishing characteristics of sustainability as types of conventionalization.

Generativity implies the ability to make connections to new circumstances. In other words, as a teacher learns new ideas in a professional learning context, she is able to go and apply those ideas in her classroom. Even when a new curriculum or set of standards is introduced, the teacher can apply relevant previously learned ideas to this new situation. For example, when a new textbook is adopted, a teacher may integrate former teaching practices into the next curriculum.

The concept of rich in structure and connections refers to having new knowledge obtained in the PD that is highly structured so that new ideas can be aligned and reorganized. As Franke et al. assert, “Consequently, learning with understanding is not only a matter of connecting new knowledge to existing knowledge, but also includes reorganizing knowledge to create rich integrated knowledge structures” (p. 656). In this characteristic, there is something particularly compelling about the way that the teacher is integrating perhaps disparate frameworks as they apply to her practice. For example, the teacher may learn about
frameworks from two different PDs, connect the frameworks, and use that new, joined framework to inform her instruction.

Finally, the characteristic “driven by the teacher’s own inquiry” entails an intrinsic motivation of the learner as constructor of his or her own knowledge. In it, the teacher adapts and moves their understanding of the concepts in a direction different than one of the imagined scenarios the PD developers had in mind. In their definition of this trait, Franke et al defined it to be, “viewing knowledge about teaching and learning as constructed, self-created, and continually changing” (p. 656). When displaying the trait, the teacher demonstrates that they have made the PD ideas uniquely their own. As an example, a teacher may learn about math PD for early grades, then move to teach sixth grade. Though the content is substantially different, the teacher may still be able to apply and adapt the ideas from the early grades math PD into middle school content.

Taken together, these three distinguishing characteristics represent three different ways that teachers may conventionalize the work of a PD program and continue to display it long after the PD is completed. This is important to my study because evidence of conventionalization observed after a PD program ended would imply sustainability. Conventionalization implies a strong sustainability of the PD ideas, yet it is also possible that a teacher simply speaks about some aspect of the PD after the completion of the PD. This may be considered publication in the Vygotsky Space, as it does imply the teacher is demonstrating some learning in the public space. However, I consider only publicizing the work a weak form of sustainability that I call recall. To account for varying strength of
sustainability, I expanded my conceptualization of sustainability into a continuum, shown in the following figure:

<table>
<thead>
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<th>Recall</th>
<th>Emerging Fluency</th>
<th>Conventionalized</th>
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<tbody>
<tr>
<td></td>
<td>Generativity</td>
<td>Being Rich in Structure and Connections</td>
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Figure 3. The Sustainability Continuum. This figure shows the full range of the sustainability continuum.

This continuum defines several different ways in which teachers may have sustained the PD ideas. Beyond the recall and conventionalized categories already discussed, the continuum allows for a transitional category that I call *emerging fluency*. Including this category is an acknowledgement that sustainability can present in a number of ways, and it may be possible that a teacher publicizes ideas from the PD and demonstrates some actions that support those ideas, but there is not enough evidence to support her having conventionalized the ideas. To further examine the connection between conventionalizing and sustainability, the next section describes more about sustainability.

**Sustainability and its Assessment**

In the context of mathematics teacher professional development, sustainability has been defined as “the continued use of the [PD] intervention in ways congruent with developers’ intent” (Fishman et al., 2011, p. 330). This definition has two important components: *continued use* and *developers’ intent*. A PD is said to be sustained if the ideas and practices promoted by the PD are not only adopted by the participating teachers, but also
used persistently by them years into the future. In order to say that the teachers are implementing ideas or practices that are in line with the developers’ intent, Franke et al. state that they would like to see the following as an indication that the ideas from her PD continue to be implemented as intended: “the interest is in having teachers come to see themselves as ongoing learners, seeking classroom practices that are responsive to the needs of the students and continually evaluating and adapting classroom practice” (2001, p. 658).

Some definitions of sustainability focus on the developers’ intended outcomes for the PD program. According to Franke et al. (1998), PD should not aim to impose a new “set of procedures to implement with fidelity,” but rather to change teachers’ assumptions. Only by helping teachers make “changes in their basic epistemological perspectives, their knowledge of what it means to learn, as well as their conceptions of classroom practice,” can PD lead to “self-sustaining, generative change” (1998, p. 67).

For Coburn et al. (2012), a key feature of PD sustainability is that it actually changes the teachers from the inside out, such that they continue to engage in PD-promoted practices even in the absence of external support after the PD. Coburn et al. (2012) defined sustainability as “teachers’ continued use of reform-related instructional practices in high-quality ways after resources and support for such practices have been withdrawn” (2012, p. 148). Here, again, are the elements of continued use and developers’ intent. In Coburn et al.’s (2012) study, the question of PD sustainability also hinged on the withdrawal of support after the PD, which had implications for participants’ continued implementation of the PD-promoted practices. For the purposes of this study, I combine the aforementioned definitions to define sustainability as follows: a teacher’s continued use of PD-promoted practices in
ways congruent with developers’ intent (Fishman et al., 2011) after resources and support for such practices have been withdrawn (Coburn, 2012).

**Sustainability studies of mathematics PD.** In this section I describe the methods, context, and findings from sustainability studies of mathematics PD. I also describe how each of these informs the design for my study.

**Social Network Theory to study sustainability.** Quantitative research on Social Network Theory has come from various theoretical approaches, including social network theory. Another effective method for investigating PD sustainability, less directly related to this study, is the use of social network theory to analyze teachers’ relationships and determine which types of relationships promote sustainability. This method was used by Coburn et al. (2012), who employed social network theory as a systematic way to analyze teachers’ relationships. By examining the relationships teachers have with one another, the researchers are able to give insights into the types of relationships that promote sustainability. Coburn and colleagues were collecting social network data during the professional development, which segued to a logical method for continuing to study sustainability after the intervention ceased.

The researchers found that when teachers formed strong social networks during the intervention, they were able to continue to sustain ideas from the intervention after the support ended. Sustainability can occur in one of three ways, according to Coburn et al. (2014):

Teachers may develop high-quality reform-related practices early in the initiative and maintain them over time. Or they may gradually develop and deepen their enactment
over several years such that teachers do not achieve high-quality reform-related instruction until the point when supports for the initiative are withdrawn. Or teachers might develop high-quality reform-related practices early on, decline in the quality of enactment, and regroup and deepen practice in ways that enable them to sustain it over time. (p. 143)

In my study, I expected that several of the teachers would be in the first two categories. As they self-selected to participate in the study, I expected that they would likely be teachers invested in their practice and further growth.

Although my study is not a social network analysis, it is informed by Coburn et al.’s (2012) work because it reminds me of the complex networks of relations in which my teacher participants are embedded. As I followed up with teachers who participated in the PD with other grade-level team members, grade-level team members were a natural starting point for investigating relationships and factors that may influence sustainability. As Coburn noted, “Existing studies tend to assume in advance locus of professional community, focusing on the school as the unit of analysis or on formal organizational structures like grade-level groups or departments.” (p. 141). However, the teachers’ narratives about their experiences and instruction did reveal other influential colleagues in their professional growth during and after the PD.

*Sustained use of a technology-based curriculum.* Fishman et al. (2011) implemented a curriculum-based PD which included several technology-based curricular units to replace previously implemented non-technology units, such as exploring rate by looking at an
animation of slope of a linear function. The authors implemented a mixed-methods study of 7\textsuperscript{th} and 8\textsuperscript{th} grade teachers who had completed the PD intervention, one year after the completion of the intervention. Their data was gathered both from a survey administered to teachers (sixty-seven of the original 189 responded) and by examining student learning data.

Fishman et al. used a survey and asked whether teachers continued to use the curriculum intervention, with about half responding they had. They defined this affirmative response of continued use of the curriculum as sustainability, with those who self-reported that they no longer used the curriculum as a lack of sustainability. Their results further looked at the factors that teachers reported for using or not using the curriculum. Among the most important factors associated with sustainability in their study were student socioeconomic status, as measured by free and reduced lunch, and students having strong conceptual math scores before the intervention. Factors that teachers cited as not promoting sustainability included the curriculum not aligning with state tests and lack of time.

This study brought to my attention a number of factors that may influence PD sustainability. It differs significantly from my study because rather than a binary question asking whether or not teacher continued to use a curriculum, I studied a smaller number of teachers and described their classroom practice in much greater detail. This approach was appropriate for the very different type of PD for which I was tracking sustainability; rather than a curriculum, the original Project AIM PD focused on discourse and associated teaching moves.

\textit{Sustained student calculator use.} Paul and Vaidya (2014) looked at an initiative to improve student performance at a high-needs K-8 publicly owned charter school. The school,
which had high teacher turnover (40% new each year) and low student achievement as measured by standardized tests, adopted a new curriculum and way of teaching. The authors describe this as a “balanced” approach that uses both procedural and conceptual approaches in turn to introduce new topics, with the stated goal of improving number sense.

The authors later did a follow-up study to examine sustainability of the program as a whole and student achievement results in particular. Their study, which involved 16 of the original 34 teachers involved in the PD, named a few differences in how the program was being implemented at the time of follow-up, such as increased calculator use and no longer using a particular tracking system. They also noted a new math support teacher position employed in the school at the time of follow-up. They further noted that student achievement continued to remain higher at the time of the follow-up.

My case addressed similar issues as their follow-up study, but studied a different phenomenon. Paul and Vaidya’s study looked for specific program elements that had been put into place during their three year PD intervention. I described in detail some of the changes in teachers’ instruction over the course of time, with the express purpose of determining if the teachers still implemented PD core values in line with the PD developer’s intent. In addition, I identified a more systematic way to categorize the factors that influence teachers’ ability to sustain PD ideas.

**Follow-up of CGI and sustained interest in student thinking.** Notwithstanding the useful work that has been done to measure the sustainability of teacher PD, this research area does present some methodological challenges. First, the effects of a particular PD can be difficult to measure because they may intermingle with other factors. In a study by Knapp
and Peterson (1996), the researchers interviewed 20 teachers out of a group of 40, three to four years after they had completed a Cognitively Guided Instruction (CGI) PD. The researchers reported that, despite their interest in determining whether CGI had “weathered the test of time,” the reality was that, “Whatever changes they may accomplish, the lessons learned in in-service sessions are usually interwoven with lessons learned elsewhere – through other in-service training, curricular and administrative mandates, and imperatives from communities and parents” (Peterson, 1990; Wilson & Ball, 1991). (p. 42). This point serves as an important reminder for my study; after the passage of time there are many factors that influence teachers’ practices.

Another difficulty with measuring sustainability is also exemplified by Knapp and Peterson’s (1996) study. Knapp and Peterson conducted a follow-up study of CGI teachers. Their data consisted primarily of a detailed interview with each of the teachers describing the day’s typical math lesson. Acknowledging that teachers’ accounts of their activities may not be completely accurate, the researchers also conducted some observational data on four of the twenty teachers. They found that for these four teachers, the observations of instruction closely matched the teachers’ own accounts. Nevertheless, teacher self-reports may be unreliable, and the inherent limitation of relying on teachers’ self-reported accounts of instruction informed my own decision to instead do a series of classroom observations for this study.

**Further study of CGI.** Franke et al. (2001) conducted another CGI follow-up study in which the researchers located a majority of the participants from the PD four years after the conclusion of the PD. The researchers used three methods to describe these teachers’ changes
over time. Their first method compared each individual teacher’s level of engagement with children’s mathematical thinking from the conclusion of the PD to follow-up. The levels of engagement classifying scheme was already developed from the original PD. The second method for describing teachers’ change involved case studies of two selected teachers. Finally, the third method was an examination of teachers’ perceptions of the factors that supported their success within their schools. My study focused on a small number of case studies and quantitative data was not collected. My research study, like Franke et al.’s, addresses each of those three factors in some way. First, I collected data that enabled me to look for changes between teachers’ instruction at the end of the PD and during follow-up. Second, I collected detailed mathematics instructional data in order to write teacher case studies. Finally, I looked at teachers’ perceptions of the factors that influenced sustainability. By making these choices similar to a well-established study, I had confidence in the depth of the data I was studying.

By reviewing these sustainability studies, I identified the ways in which others have studied sustainability. Insights from their studies helped me to more precisely define sustainability and informed my study design. In the next section, I present a summary of some of the key factors that promote sustainability from the literature.

**Factors that influence sustainability.** Research has shown that certain features of PD promote sustainability, teachers’ perception of the usefulness of the intervention, alignment of the PD with current practice, and alignment with other stakeholders’ expectations of instruction, teachers’ iteration and adjustment, and ongoing colleague support (Fishman et al., 2011; Franke et al., 2001; Coburn, 2003; Gutierrez & Penuel, 2014). Other
factors that promote PD sustainability include teachers’ continual work of iterating and adapting their PD learnings (Coburn, 2012 & Franke et al, 2001), and ongoing support of social networks (Coburn, 2012).

**Teachers’ perception of the usefulness of the intervention.** Fishman et al (2011) found sustainability was related to “teachers’ perceptions about ‘fit’ with either their preferred style of teaching or the capabilities of their students” (p. 347). This finding aligned with what Franke et al. found (2001). Among those teachers who had most fully adopted the CGI PD ideals of examining student reasoning, they continued to value and implement those ideas and look for ways to expand upon that knowledge years later at the time of the follow-up study.

**Alignment of the PD with current practice.** Fishman et al. (2011) found a correlation between teachers’ perceived coherence of the PD with a teacher’s learning goals. For those who found the PD to align with their goals, they sustained use of the instructional materials. This result was also found by Coburn et al. (2012), who gave the example of one teacher who had fewer strong ties of her social network after the conclusion of the PD, but because she had adopted the PD so fully she was able to sustain those ideas after the intervention.

**Alignment with other stakeholders’ expectations of instruction.** Among the factors for why teachers chose to no longer use the technology curriculum intervention was a lack of alignment with the state test (Fishman et al. 2011). This finding is consistent with Coburn et al.’s (2012) findings, in which elementary teachers struggled to focus on mathematics when their district initiatives changed “to focus on literacy and instruction for English language learners and a loss of assistance to deepen mathematics instruction” (p. 156). This shift in
district priorities led to less sustainability of the mathematics PD interventions previously implemented.

**Iteration and adjustment.** In practice, for sustainability to occur, teachers must continually iterate and make adjustments to the content they learned in the PD. As Coburn et al. (2012 p. 165) noted, “[S]ustaining new instructional approaches is not simply about continuing to do the same thing. It requires that teachers and others make continual adjustments to new conditions and needs at the same time that they maintain the underlying pedagogical approach.” Along similar lines, Franke et al. (2001) describe sustainability as a process: “Rather than training teachers to implement given practices, the interest is in having teachers come to see themselves as ongoing learners, seeking classroom practices that are responsive to the needs of the students and continually evaluating and adapting classroom practice” (p. 658). This disposition toward professional learning, displayed in both Coburn and Franke’s studies, appears to be associated with sustainability of those ideas.

**Ongoing colleague support.** Another factor that can promote PD sustainability is ongoing colleague support. Indeed, social networks have been found to play a key role in the process of iteration and adjustment described above. For example, Franke et al. (2001) reported that teachers found the continued support of school colleagues, most of whom had also participated in the PD, critical to their sustained practice. Coburn drew on social network theory to identify several factors that “influence diffusion of innovation, knowledge transfer, and innovation” (2012, p. 142). The researchers focus on three factors that influence on sustainability within social networks: strong ties, knowledgeable teachers, and depth of interaction. Strong ties include frequent interactions or social closeness; knowledgeable
teachers within a teacher’s group of colleagues have a strong knowledge of reform-oriented teaching, especially as related to the PD; and finally, depth of interaction includes opportunities to have meaningful interactions with others about instruction.

Still, further work is needed to understand the complex internal motivations and collegial supports that allow teachers to continue to implement PD ideas. This study seeks to further identify and catalog factors that support or hinder sustainability. By examining a small number of teachers in an in depth case study I address a unique situation. The teachers involved address a unique issue because in Project AIM, the PD of focus, the teachers attended with grade-level team members while others in their schools were not involved with the work. Teachers with varying support from other teachers who had also been involved with Project AIM produce narratives that conclude with high-quality mathematics instruction take different forms, as sustainability can take different forms for different teachers’ contexts.

In the previous section I defined sustainability in the mathematics PD context, identified the factors that promote sustainability, and reviewed approaches to studying PD sustainability. My study extends the existing literature to give more examples of the complex factors that promote or fail to promote sustainability of professional development practices. All of these sustainability measures depend on teachers first engaging in a high-quality PD experience. Thus in the next section I discuss PD effectiveness.

Teacher Professional Development

The prevalence of teacher professional development has raised concerns among education researchers as to what methods and approaches to PD might be most effective. More work needs to be done to better understand PD and its effectiveness. For example,
Borko (2004) suggested that research focuses disproportionately on better-funded PD such as math and early literacy, and calls for further examination of other types of PD. Although greater attention is paid to mathematics PD than other subject areas, Simon (2008) suggested that a lack of common vision hinders the ability to implement quality mathematics professional development.

**Characteristics of Effective PD.** Still, some consensus exists among researchers as to what characteristics make for effective professional development. According to a seminal paper by Garet et al. (2001), three elements are key to effective PD: duration, active learning, and coherence. Their findings, based on large-scale survey results from 1027 science and math teachers, have served as a useful basis for work by other researchers. Each of these three elements will now be discussed in turn, then this section will conclude with a discussion of professional learning communities (PLCs), as they are of particular interest to this study.

**Duration.** For Garet et al. (2001), time *duration* is the first factor associated with PD effectiveness. Longer PD duration had a significant positive impact on teacher outcomes. Duration includes both the *span* of time over which the intervention is implemented, as well as the total number of *contact hours* spent engaging with the PD activity. A study by Fennema, Carpenter, and Franke (1992) reported on professional development interventions that were conducted over a number of years, such as coaching from math coaches trained and embedded within school settings or long-term professional development by university researchers. Many other interventions follow a calendar year, often including some sort of summer workshop, followed by additional follow-up throughout the year. Between thirty
and one hundred hours of professional development, spread over six to twelve months showed significant student achievement gains. (Darling-Hammond, Wei, Andree, Richardson, & Orphanos; 2009). Overall, longer time spans and greater number of contact hours are consistently associated with PD effectiveness.

**Active learning.** The second important PD characteristic identified by Garet et al. (2001) is *active learning*. This characteristic involves more than simply attending a PD, but engaging students to analyzing the work of teaching and learning. The authors identified the following activities as examples that promote active learning: planning classroom implementation; reviewing student work; and finally presenting, leading, and writing. They established an index that describes the quantity of opportunities a PD provides. One example of the push for active learning in professional development is Taton’s (2015) argument that effective professional learning engages teachers with both mathematics content and pedagogical discussions.

**Coherence.** The third element that Garet et al. (2001) identified in effective professional development was *coherence*. In this context, coherence refers to the way that professional development complements participants’ other work. Professional development tends to have a more positive overall effect on teacher outcomes when it fosters connections among the different activities in which the teachers are engaging. Building on Garet et al. (2001), Fishburn et al. (2011, p. 335), identified three elements of coherence: connections, alignment, and participation. According to this definition, a given PD can be said to be coherent if it (a) makes connections with other activities in which teachers are engaged, (b) is aligned with state and district standards, and (c) is completed by teachers as part of a larger
group. Darling-Hammond et al.’s study found that applying knowledge from PD activities implies a greater chance of improving teacher practices (2009).

Professional Learning Communities. Professional Learning Communities (PLCs) are a key feature of PD programs in a number of professions. PLCs can be formed once teachers are in PD or can be a part of the professional learning experience, such as teachers choosing to pursue a book study. Two science educators, Dawkins and Dickerson (2007), describe the value of PLCs as follows: “For adults, working in collaborative groups to enhance knowledge, skills, and productivity has become the norm in industry and is certainly becoming a factor in the professional development of teachers, even though teacher isolation remains a troubling reality in many school settings” (p. 68). Such collaboration and communal engagement has been found to promote professional development in many contexts.

Effective PLCs tend to be deliberately structured to promote group continuity (Kanold, Fennell, Adams, Dixon, Kobett, & McCord, 2012). For example, grade-level teams, which will work together for at least one year and potentially many, may form a learning community by experiencing professional learning experiences together. One well-known structure for PLCs, which has been found to promote continuity and sustainability, is lesson study. In lesson study, teachers have the opportunity to observe one another’s work, reflect on their own work, and refine their lessons through discussions. Researchers have reported that implementing this type of learning community not only benefits the teachers participating at the time, but also can form bonds that continue this type of collaborative
work after the completion of the supervised lesson study period (Lewis 2009, Lewis & Hurd 2011).

On the other hand, when PLCs lack continuity, they are less effective. According to the WestEd *Knowledge Synthesis of STEM PLCs*, continuity is a defining characteristic of an effective PLC: “In a PLC with lots of turnover […] the PLC work could not advance because the culture kept changing and they didn’t develop a common language” (WestEd 2010, p. 38). Although PLCs are a powerful setting for learning, a gap remains in researchers’ understanding of how these communities function outside the context of research-based PD programs. To date, most research on PLCs tends to focus on PLCs formed primarily for another purpose, such as to participate together in a research-based PD (WestEd 2010). However, many teachers also work together in PLCs in their schools on a regular basis, without research to understand what factors contribute to those groups’ effectiveness. In 2010, the WestEd PLC knowledge synthesis called for further research studying PLCs in their native settings.

The present study helps to address that gap by focusing on teachers who worked together in their school-based PLCs, specifically during the 2011-2012 PD. By following up with the teachers in this study, I saw them closer to their natural PLC settings. In studying what did or did not promote the sustainability of the PD in which these groups participated, I examined and interviewed teachers within their regular-grade level teams and looked for other PLC structures in the schools. This work addresses the research gap noted by WestEd.

The PD attended by the participants in this study was designed to be experienced in community. By design, the Project AIM PD teachers were required to attend the program...
with their grade-level school teammates, or professional learning communities (PLCs). Many
of the PD activities involved teachers collaborating within their respective PLCs.

This final section on effective PD is essential because effective PD makes
sustainability possible. In other words, the teacher must have learned something in the first
place in order to sustain and carry on with those ideas later. The Project AIM PD, the PD
which this study follows up on, was designed to meet the preceding four criteria. Project
AIM occurred over a sufficient length of time, actively engaged teachers through homework
and experiences to try out new ideas, coherently aligned with district standards, and
encouraged PLCs by design. These design criteria justify further research into sustainability,
so I investigated sustainability in the context of a PD that has features of what has been found
to be effective. Further background information about the original PD will be presented in
Chapter Three.

Synthesis

This chapter began by describing teacher learning. I then defined a sustainability
continuum based on teachers’ publication and conventionalization of PD ideas.
Conventionalization was further elaborated to describe three distinguishing characteristics of
strong sustainability. The chapter concluded with a review of the relevant literature on
sustainability of mathematics PD and effective PD. Overall, this study addresses two
research questions: (a) In what ways do teachers sustain (or not sustain) the core values of a
PD in their instructional practices in the years after the PD intervention? (2) What factors
promote (or do not promote) the sustainability of the PD core values in the years after the PD
intervention? The next section describes the methods used to answer these questions.
Chapter 3

The primary purpose of this study is to describe factors that contribute to or hinder teachers sustaining the practices fostered in a discourse-promoting, year-long mathematics PD. In particular, this study describes ways in which teachers plan, implement, and reflect on what they consider discourse-rich lessons that relate to their participation in the PD three years prior. In this chapter, I describe the design of the study and provide context for its implementation. I outline the parameters of the cases to be examined and describe the study’s data sources, data collection, and data analysis processes. I also discuss the trustworthiness of the study. Finally, I present a subjectivity statement and discuss limitations.

Design of the Study

The case study approach is most appropriate for this research because I sought to understand and describe a complex social phenomenon, and I looked at a limited number of participants for a pre-specified amount of time. The case study methodology has been used across social science disciplines for many years to provide an in-depth look at issues with a defined beginning or end. This study is a collective case study (Stake, 1995), which implies an instrumental case study design with multiple cases. The instrumental case study was chosen because there was a particular phenomenon that I wanted to understand more completely; in this case, the phenomenon was sustainability of the Project AIM core values three years after completion of the PD intervention. For this study, I first described each of the teachers as a separate instrumental case; then, I looked for themes across all of the teachers’ cases to answer the research questions stated above. Each of the six cases
represents a teacher who participated in a year-long PD and then agreed to participate in this follow-up study.

**Context for the Study**

In describing their sustainability studies, both Franke et al. (2001) and Fishman et al. (2011) present information about and data from the original professional development interventions. Yet, the professional development was not the focus of their studies. Rather, the professional development provided context for what happened next. This precedent shaped the design of my study because it reminded me that sustainability requires some knowledge of the initial intervention, but the majority of my study focuses on the data that I collected. In the following section, I give further context for the Project AIM PD.

**Project AIM PD Structure.** Because this is a sustainability study, I first briefly describe the initial professional development program in which the participating teachers engaged. During the 2011-2012 school year, 26 teachers participated in the Project AIM PD, a year-long, forty-hour professional development program that was offered as part of an NSF-sponsored research and development effort. Project AIM 2011-2012 consisted of 12 meeting sessions called blocks. The first five were offered in a summer institute format, and the remaining seven were offered over the course of the 2011-2012 school year.

The teachers in this study participated in the first full implementation of the program. They were compensated for their participation in the original PD and compensated for their participation in this study. Conditions of participation in the PD included being a second-grade teacher and attending the PD in school teams. The professional development focused
on mathematics discourse or “math talk.” There was also a focus on English Language Learners (ELLs), and more broadly, a focus on students with emerging language skills. Thus, another selection criterion for Project AIM was that teachers worked in schools with large ELL populations. As all of the participating teachers taught second grade, the content focus of the professional development was place value, with particular attention to subtraction.

All teachers (n=26) participated for the duration of the school year, completing forty contact hours of professional development as well as homework tasks outside of meeting hours. The homework tasks were meant for the participants’ enrichment, and at times also for research data collection purposes. Homework tasks included collective planning sessions within school teams.

**Project AIM Content.** Overall, the Project AIM PD was designed to support teachers in promoting *responsive discourse* as a fundamental aspect of instruction that supports conceptual understanding in mathematics. Responsive discourse is defined in Project AIM as the quintessential mathematics discourse with student-centered discussions of rich mathematics concepts. In order to help teachers to work toward responsive discourse, the PD created and used frameworks for conceptualizing mathematics discourse and *strategies* to test out those ideas. Strategy held a special meaning in the PD, representing a type of teaching practice that teachers could immediately test out in their classrooms.

To help teachers understand how to implement the strategies, a framework for the structure of a mathematics lesson was provided, called a Mathematics Teaching Guide. This guide presented an organization for mathematics lessons in terms of a launch explore discuss sequence. It also included planning and reflecting as important aspects of the lesson. Each
strategy introduced during the PD was situated within one of the phases of the mathematics lesson. For example, a Think Aloud was one strategy the teachers learned for launching a mathematics lesson (Trocki, Taylor, Starling, Sztajn, & Heck, 2014). In the Think Aloud, the teacher discusses a mathematics problem, making her thinking explicit to the students. One reason for using that strategy is to highlight unfamiliar vocabulary that might occur throughout the upcoming lesson.

**Project AIM Core Values.** This study examines one particular discourse-promoting PD, Project AIM. The PD was influenced by these other discourse instructional practices and elements of effective PD design. Through an analysis of Project AIM materials and information, I identified five *core values* of the PD. These core values were then reviewed and validated by the principal investigators of Project AIM, who were responsible for the design of the PD. It is essential that I discuss these core values because without them, it is impossible to understand the teachers and how they may have sustained the PD’s ideas:

- a. Teaching students how to participate in mathematical discourse,
- b. Establishing norms for math discourse,
- c. Planning for math discourse,
- d. Collaborating with your team to plan math, and
- e. Promoting conceptual mathematical thinking through rich discourse.

**Teaching Students how to participate in mathematical discourse.** In this core value, AIM sought to help teachers understand that participating in mathematical discourse is a process that must be taught. AIM emphasized that ALL students need to learn how to talk about mathematics, in particular English Learners and emergent communicators. Particularly
important to this concept was the idea that the control of the conversation would move from the teacher to the students over the course of time. In order to give teachers tools to teach students to participate, the PD presented strategies the teachers could implement in their classrooms right away. Strategies held a special meaning in the PD and referred to a set of specially-designed activities that could be adapted and used by teachers.

**Establishing norms for math discourse.** AIM emphasized that teachers must establish norms for math conversations. These norms go beyond classroom management and being a comfortable environment for every student to speak. They must include how to share a mathematical explanation, what the community accepts as a valid mathematical justification, how to respectfully agree or disagree with or build on a mathematical explanation, and how to ask a mathematical question.

**Planning for math discourse.** Math discourse takes a great deal of planning. This planning includes setting a mathematical goal. It also includes planning for discourse that will help students make progress toward and attain that specific mathematical goal, as well as improve their abilities to communicate about mathematics more generally.

**Collaborating with your team to plan math.** Teachers were only accepted into Project AIM if they were able to attend with other teachers from their team. AIM believes that that structure strengthens teacher collaborations and that team collaboration helps teachers plan better.

**Promoting conceptual mathematical thinking though rich discourse.** This core value returns to the reason for supporting mathematics discourse. Math discourse allows students to voice their thinking and hear others’ thinking processes. Through these
interactions, students have access to much deeper mathematics than simply listening to their teacher’s explanations. This core value reminds teachers that this difficult work of facilitating math discourse is worth it because of how much students are able to learn. It also emphasizes how much teachers can learn about their students’ mathematical thinking, which can improve their current and future practice.

**Study participants and selection process.**

Study participants were selected from the pool of 26 teachers who had participated in Project AIM Professional Development in the 2011-2012 school year. Project AIM recruited teachers from a large Southeastern school district, and by design, required teachers to attend the PD with colleagues from their grade-level school teams. For this study, an important selection criterion was the willingness to participate by more than one person from the same 2011-2012 Project AIM PD school team; this was because one of the considerations of the study was to examine any sustainability effects of teachers’ school teams on their instruction. For logistical reasons, any teacher who no longer taught for the school district was not eligible.

I sent an email to all twenty-six of the 2011-2012 cohort Project AIM teachers. Of those, ten teachers expressed interest in participating in the study. Based on the preceding criteria, six teachers were selected for participation. These teachers were selected in pairs from three different AIM 2011-2012 school teams. The three participating school teams selected were Barnes, Drake, and Fayette.¹

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¹ All names used in this study, for school and for participants, are pseudonyms.
The original Barnes team consisted of three participating teachers, who constituted three fifths of the second-grade team at that school. These teachers continued to teach together in second grade for two years after the completion of the Project AIM PD. In the third year after the completion of the PD, one teacher left the teaching profession, while the other two remained teaching in the same school in second grade. The remaining two teachers represented two cases who continued to teach, work, and plan together for an extended period of time after the completion of the PD. The two teachers from Barnes who participated in this study are named Nora and June.

Similarly, Fayette’s team consisted of two teachers who attended the 2011-2012 PD together and continued to teach together at the second-grade level. These two teachers, however, were the only two members of a larger grade-level team who attended the AIM PD. Similar to the Barnes teachers, the situation of the Fayette teachers also provided the opportunity to observe teachers who continued to have one another for support long after the professional development concluded. These teachers, named Sarah and Melody, worked on second-grade team with three other teachers who did not attend the PD.

Drake’s team originally consisted of five teachers who attended the AIM PD. After the completion of the 2011-2012 PD, the teachers went to different teaching assignments, and all but one either moved to different grade levels at the same school or moved to different schools. In the 2014-2015 school year, one teacher still taught second grade at Drake, another taught first grade at Drake, and a third member had taken a teaching assignment in another school district. The fourth and fifth of the original five AIM PD participants from Drake agreed to participate in this study, and at the time of data collection
for this study, those two teachers were still teaching in the same school district but no longer at Drake. They were teaching at elementary schools within the district, one in second grade and the other in kindergarten. Ultimately one of those teachers chose to leave the study before completing any portion of the study. The other teacher, Margaret, participated for a portion of the study and chose not to continue with the rest of it.

After losing the participation from the teachers originally from Drake, I chose to re-open the search to the original 26 teachers. Ultimately, one additional teacher, Karrie, agreed to join the study. This teacher had originally attended Project AIM with a team of four teachers. After AIM concluded, she moved to a different grade level at the same school. At the time of this study, she had moved to a different school and was working as an instructional resource teacher (math coach). I chose to include Karrie in order to have more teachers involved in the study and because her experiences represented a significantly different set of contexts from the other teachers. The recruitment of the additional teacher led to a total of six teachers participating in the study. In order to provide a more complete picture of these six teachers’ experiences and instructional styles principals from the schools where the teachers still taught were also interviewed.

Data Sources and Collection

Some of the data examined for this study was collected as part of the original data set for Project AIM. I first present the existing data, then describe the data collected between October 2014 and February 2015.

Existing data. There were several types of data collected during the first full implementation of the 40-hour professional development. I was involved in the original PD
and helped to collect some of that data. I describe two types of existing data: PD Data explicitly used in this follow-up study and PD Data used to better understand and triangulate information about the PD and its participants.

**Demographic Data.** At the beginning of the 2011-2012 AIM PD, some demographic data were collected. This demographic data provided a baseline. Data included such information as education background, years teaching, and grades taught.

**PD Data explicitly used in the follow-up study.** In the final session of the professional development, all teachers were asked to submit information about a planned and implemented mathematics lesson. These data were submitted in the form of an *artifact package* (Appendix A). Artifact packages from the six focus teachers are considered in this study. The original artifact package, collected during the PD, was used as baseline data to consider what changes the focus teachers made since the conclusion of the PD. This artifact package will be referred to as the “Post-PD Artifact Package.”

Finally, the teachers completed a short pre- and post- open-response questionnaires during the 2011-2012 PD year. The questions asked the teachers about facilitating discourse in their classrooms and teachers’ responses to these open-responses were also used in my study.

**PD Data used to better understand and triangulate.** In addition to the artifact package, Project AIM’s evaluator conducted focus groups and took field notes from those sessions with the 2011-2012 PD school teams. As Project AIM is an NSF-sponsored endeavor, the project evaluator submitted annual reports about the project. The evaluator’s
focus group notes and the 2011-2012 evaluation report are treated as secondary data for the purpose of understanding background information about the entire 2011-2012 cohort.

**Data collected for this study.** Additional data were collected between October 2014 and February 2015. All of this data is considered “follow-up” data. The following figure presents a chronological summary of the data collection:

<table>
<thead>
<tr>
<th>2011-2012 School Year</th>
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</thead>
<tbody>
<tr>
<td>- Demographic Data</td>
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<tr>
<td>- Post-PD Artifact Packages</td>
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<tr>
<td>- Evaluator focus groups of school teams and NSF Annual Report</td>
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<tr>
<td>- Pre- and Post- questionnaires</td>
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<table>
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<tr>
<th>October 2014</th>
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<tbody>
<tr>
<td>- Follow-up Artifact Packages</td>
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<tr>
<td>- Semi-structured teacher interviews (includes demographic data)</td>
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<table>
<thead>
<tr>
<th>November 2014</th>
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<tbody>
<tr>
<td>- Math lesson cycle #1</td>
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<td>- Principal interviews</td>
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<table>
<thead>
<tr>
<th>January 2015</th>
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<tbody>
<tr>
<td>- Math lesson cycle #1 for Karrie (the teacher who joined later)</td>
</tr>
<tr>
<td>- Semi-structured interview for Karrie</td>
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<tr>
<td>- Math lesson cycle #2</td>
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<tr>
<td>- Focus groups with teachers in original school teams</td>
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</tbody>
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<table>
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<tr>
<th>Spring 2015</th>
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<tbody>
<tr>
<td>- Karrie Follow-up Artifact Package</td>
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</table>

Figure 4. Data Collection Sequence. This figure chronologically lists the data collected for this study.

**Demographic data.** In order to describe sustainability, I collected additional demographic data to describe changes and how those changes may be related to whether the teachers make sustained use of PD ideas. At the initial teacher interview, I asked the teachers to describe their current schools, as well as the schooling experiences and PD experiences they had had since the Fall 2011 demographic data were collected.
Semi-structured teacher interviews (Appendix B). Each teacher participated in a semi-structured interview, reflecting on work they had done since the completion of the PD in 2012. The interviews included questions about the experiences teachers had with Project AIM ideas since the completion of the PD. For example, interviewees were asked about changes they have made in their mathematics instruction since the completion of the PD and about any challenges they had faced in implementing PD ideas. The interviews also included questions about school culture and issues outside of their classroom relating to their implementation. Finally, some questions were specific to the AIM PD, including questions about specific structures and frameworks from the PD and their perceived helpfulness.

Classroom instruction. This study examined classroom instruction for each teacher three times during the 2014-2015 school year. Teachers completed an artifact package and then engaged in two observed lesson cycles. Each time, the teachers were asked to teach a discourse-rich mathematics lesson.2 The artifact package and each observed lesson cycle were conducted approximately one month apart.3

Follow-up Artifact package. Teachers taught a mathematics lesson and shared with the researcher their planning for the lesson; then, teachers reflected on the lesson in the form of an artifact package to be turned in to me. The artifact package included a lesson plan, the sample task to be used for the lesson, a description of the implemented lesson with reflection, and a reflection on a particular piece of student work from the implemented lesson.

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2. Several teachers asked me if I expected them to use AIM discourse strategies, or asked what sort of lesson I wanted to see. In response, I repeatedly used the word “authentic” to indicate that I wanted to see the sort of work that was typical in their classrooms.

3. One exception was the teacher recruited later. Her two lesson observation cycles were completed in the same week. Her artifact package was completed about a month later.
The artifact package was similar to the one participants completed at the end of the 2011-2012 Project AIM PD. The Project made changes to the artifact packages in subsequent years since 2011-2012, making the instructions for completion clearer. The teachers in this study completed the revised artifact package. This may present some limitations, which are discussed in the limitations section.

There were two purposes for collecting the artifact packages. The first purpose was to gain a clearer picture of each teacher’s instruction before conducting the semi-structured interview. The second purpose was to provide a more complete picture of each teacher’s instruction and triangulate the observations from the math lesson cycles.

*Two lesson observation cycles (Appendix C).* Teachers taught two math lessons that were observed and video-recorded by the researcher. Before each lesson, the teacher provided the researcher with a lesson plan and some additional reflection on the lesson, outlined in the *Before the Lesson Planning* portion of Appendix C. Immediately after, or as soon as reasonably possible, the teacher debriefed with the researcher, reflecting on the implemented lesson. This debrief was guided by the researcher’s observations in the lesson and the *After the Lesson Debrief Protocol* provided in Appendix C.

*Focus groups with teachers in original school teams.* The Barnes and Fayette teams each participated in a focus group. Teachers discussed factors that supported or hindered their sustaining of practices from the PD. In the focus groups, there was a particular focus on team planning aspects from the PD and their sustained use (or not) after the PD. (See Appendix D.)
Principal (Appendix E). In an effort to triangulate data collection and get a sense of factors outside of the classroom that influences teachers’ sustained practices, principals from both schools where the teachers stayed in the same building were interviewed. These principals were asked about their teachers’ participation in Project AIM, as well as any observations they had about school culture in relation to the project, and any supports they may have offered to teachers.

Research Questions with Data Sources. This table shows the alignment of the data sources with the research questions.

Table 1

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Primary data sources</th>
<th>Secondary data sources</th>
</tr>
</thead>
</table>
| RQ1. In what ways do teachers sustain (or not sustain) the core values of a PD in their instructional practices in the years after the PD intervention? | • Post-PD Artifact package  
• Fall 2014 Artifact package  
• Fall 2014 Math lesson observation cycles and debriefing interview  
• Fall 2014 Focus Groups  
• Fall 2014 Teacher interviews | • Principal interviews  
• Spring 2012 Evaluator focus groups  
• Administrator interviews  
• Fall 2011 and Spring 2012 Questionnaires |
| RQ2. What factors promote (or do not promote) the sustainability of the PD core values in the years after the PD intervention? | • Post-PD Artifact package  
• Fall 2014 Artifact package  
• Fall 2014 Math lesson observation cycles and debriefing interview  
• Fall 2014 Teacher interviews | • Spring 2012 Evaluator focus groups  
• Principal interviews  
• Fall 2014 Focus groups |
Data Analysis

In order to describe my analysis, I looked to Johnny Saldaña’s *The Coding Manual for Qualitative Researchers* (2016). In it, he states that “descriptions of coding and analysis procedures generally include references to the literature that guided the analytical work, qualitative data organization and management strategies for the project, the particular coding and data analytic methods employed and their general outcomes, and the types of […] programs and functions used” (p. 284)

I drew from Stake’s *The Art of Case Study Research* (1995) and Creswell’s *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (2013) when designing my study. These choices directly impacted the type of data with which I was working. The goal of the data analysis was to “to highlight the most salient features of the data” through “the richness of the quotes, the clarity of the examples, and the depth of the illustrations” (Ambert, Adler, Adler, & Detzner, 1995, p. 884). I used Saldaña’s work to structure the organization of my analysis. In the rest of this section I describe my data organization and then the analysis.

As I conducted observations, I took field notes. I also wrote memos at the conclusion of my two data collection rounds. In both of those instances I made note of some of my early impressions of the data I was observing while in the field. I transcribed all of the interviews and focus groups. Furthermore, I watched all of the video-recorded lessons, noting “critical moments” and transcribing those excerpts of dialog. I chose these critical moments based on a number of factors, including some of my initial impressions of important interactions from
watching the lessons in the field and what I noticed from teachers during interviews. I then gathered all of that data and imported it into Atlas TI. For each document, I tagged appropriate identifying information such as teacher, school, and type of data. This ensured that I was able to search by those features later.

With all of the data organized, I began to look at it as a whole to better understand what I had collected. I began this process by reading through each of the teacher’s data individually, trying to understand each participant. I then began coding using a mix of a priori and open coding. The a priori codes came from the literature on sustainability and my knowledge of the original PD, Project AIM. For example, I was actively looking for evidence of team interactions based on my reading from the literature and various strategies from Project AIM. The open coding was an extension of my early analysis in the field, including my field notes and memos. For example, immediately after the November 2014 data collection trip, I wrote a memo that expressed my amazement at the number of adults in the classroom, in addition to the classroom teachers, at both Nora and June’s school and Sarah and Melody’s school. This observation was later refined to describe two factors that support sustainability: employing teaching assistants and finding parent support.

In my second round of coding, I returned to my research questions. I began to organize the codes into categories. For example, in my first round of analysis, I labeled each strategy by name. In order to answer the research questions, I combined all of those strategy codes into the category strategies. After organizing the codes into categories, I looked at how the categories aligned with the five core values of the Project Aim PD. I re-organized the categories with data for each of the teachers that I had already identified from my first rounds
of coding. Then, when I had a teacher without information for one of the core values, I considered if that was an oversight on my part or if I could speak to that core value for that teacher. When needed, I went back to the original data. These categories, along with background information from each teacher, formed the teacher sketches.

**Research Question 1.** I then went back to the categories to consider the cross-case analysis. For Research Question 1, I began the cross-case analysis by looking at each of the core values. I then considered, through searches with Atlas TI and my own interpretation, the themes that emerged from the core values. Important themes that emerged were re-named to highlight the interpretation. For example, when looking at team planning, some of Karrie’s data was coded “team planning”. When I looked at all of the codes together, I noticed that she seemed to thrive in a variety of different situations and teacher groups. I called this theme adapting to any team.

During this process I struggled with how to characterize some of the themes that did not seem to fit neatly into the “Conventionalized” portion of the continuum. For example, teachers may have shown some recall of the PD, but were not conventionalizing that idea in their work. Or, the teacher may be attempting some ideas from the PD, but I did not witness enough evidence to convince me that the teacher had conventionalized that work. I ultimately chose the following definitions to define the weak sustainability that I noticed.

I define recall to be a very weak sustainability where a teacher may be able to talk about a concept from the PD or say that she valued an important idea from the PD, but I was not able to provide further evidence of that idea in her work or speech. In other words, recall meant only that the teacher spoke about an idea that clearly came from the PD (such as a
strategy, or naming a type of discourse) in a superficial way, but I was unable to incorporate this concept as an active part of her part of her classroom practice.

In the next category, emerging fluency, I may have witnessed some evidence of sustainability, but it was not fully realized enough for me to consider it to be conventionalized. For example, I saw a teacher try out an idea that she recalled from the PD, but it was a weak implementation. That was clearly not something that she did regularly in a manner consistent with the vision of the original PD.

**Research Question 2.** For the second research question concerning supports and hindrances, I maintained a separate document with a list of all supports and hindrances that I found for the teachers. I took this list and sorted the supports and hindrances into teacher level, teacher team level, and “beyond” factors. I went on to examine the lists for each of the three categories and, using my knowledge of the teachers and the original data, identified which teachers were influenced by which supports and hindrances.

For both research questions, I identified themes (RQ1) and factors (RQ2). In order to be considered a theme or factor, the idea only had to emerge for a single participant. For example, one of my themes was “adapting to any team.” I only had evidence of that theme from one participant, Karrie. If I had chosen another type of analysis which demanded more than one participant to show evidence of the theme, I would miss some of the unique characteristics that teachers brought to this study, particularly for Margaret and Karrie, whose circumstances were substantially different from the other teachers.
Validity and Reliability

The four criteria used for judging the quality of research designs are construct validity, internal validity, external validity, and reliability (Yin, 2009, p. 40). This section addresses three of those four, setting aside internal validity because this is an exploratory, not explanatory, case study. In this section, I describe each of the three criteria and address the ways in which my study fulfills them.

In construct validity, one must ensure that the case parameters are well-defined and related to the objectives of the study, and then must also show that the designed study is aligned with the research field’s conventions on how to address those problems. Construct validity is primarily concerned with the study design. In this study, I seek to learn more about what factors led to teachers sustaining (or not) professional development ideas several years after their PD experience. In order to satisfy construct validity, I chose case teachers and a research design that align with my research questions.

External validity is concerned with extending the findings of a study to other work. In my cases, I strengthen external validity by considering two factors. First, I seek depth within each case. Through multiple sources of data, and three different mathematics lesson data points spread out over time, I look closely into each of the teachers’ current practices. Second, I consider six different cases. Each of my six teachers has a unique set of classroom experiences, school settings, and other factors, which will provide diverse results. Because of these unique situations, common themes may imply that those results may be found in other settings, as well.
Finally, Yin (2009) describes *reliability* as the ability of another researcher to be able to find the same findings and conclusions as I did with this set of data (p. 45). In order to make my results reliable, I maintained careful records of my data collection and analysis processes. My study includes audio- and video-recordings of various data collection measures so that I am able to go back and reference any of the interactions that I had previously made. This record-keeping was indexed in a way that allows any outside observer to examine my data collection and subsequent data analysis. In order to triangulate the instructional and interview data from each teacher, I also interviewed principals when the teacher still taught at the same school.

**Subjectivity Statement**

My Bachelor’s and Master’s degrees are both in Pure Mathematics. By the time I began my teaching career as a Developmental Mathematics Instructor, it had been years since I had last seen most of the elementary mathematics that was covered in the PD for second-grade teachers. Some of the mathematics I had not seen since I had been in school myself. As such, I was not as familiar with the complexities of elementary mathematics as the teachers themselves, especially of specialized content knowledge for teaching. However, I have deepened my understanding of elementary mathematics throughout my doctoral coursework, my previous work with professional development, and my experience interning in an elementary math methods course. As I concluded my analysis, I was teaching elementary mathematics content classes.

My own teaching experience is with college students, many of them older, non-traditional students. Due to my lack of classroom experience with younger children, I may
not fully understand the unique demands on the generalist elementary teacher. Still, given my previous work with the Project AIM professional development and my belief that professional development is a collaborative, not a prescriptive enterprise (Stein et al., 1999), I believe that my perspective on teaching and learning makes me an open listener and observer. As I was concluding my analysis, I was volunteering in elementary classrooms and teaching pre-service elementary teachers, making me more aware of the challenges of elementary classrooms.

Over the course of analyzing the data, I began working in another professional development context and teaching pre-service elementary content courses. Both of these sets of experiences gave me a much better understanding of PD and elementary math, respectively. Those experiences both made me a more effective researcher, as they enhanced my view of the phenomena studied here.

Finally, I acknowledge that my closeness with the original Project AIM PD intervention shapes my view of the PD itself. Because of the hours that I spent collaborating with the research team, I tend to view the original PD and its quality in a positive light.

Limitations of the Study

This study, like any other, has its limitations. The fact that I am the primary researcher for this study could be seen as a limitation because of my potential bias as a teacher; however, I mitigate potential biases by triangulating the data from multiple sources. Another possible limitation is the sample of teachers. The sample is a convenience sample, and teachers self-selected to be a part of the study. For example, it would have been helpful to include the remaining teachers from each school team if they had agreed to participate in
this study. Still, this study provides thick, rich descriptions of particular teachers’ and school teams’ experiences after completion of a carefully designed professional development experience.

Another potential limitation is one of the methods used to evaluate teacher change from the completion of the PD to the present. At the end of the PD, teachers were asked to complete an artifact package to describe a mathematics lesson. The 2011-2012 PD year was the pilot year of the professional development, so the artifact package instructions were also being piloted. Since that time, the artifact package instructions have been refined and improved. I chose to give the teachers the improved version of the artifact package instructions for this study, but it is possible that the improved instructions would make a difference in the quality of reflection and results from the focus teachers. Still, the artifact packages are only one aspect of data collection in this study. By triangulating from classroom observations and taking multiple opportunities to speak with the teachers about their instruction since the completion of the PD, I aim to minimize the potential problems with this discrepancy.

**Ethical Issues**

Consent to conduct this study was obtained from both the North Carolina State University Institutional Review Board (IRB) and the school district data office. Each participant signed a legal consent form before participating in this study, and all participants were given pseudonyms in the written and audio data. A few known risks may be associated with participation in this study, including the risk that focus group participants may not be able to keep their comments anonymous from those with whom they participate. Another
ethical consideration was that teacher participants receive a stipend for their involvement in the study, so that may influence how they responded to the interview questions.

Measures were taken to protect participants in the video-recording of data. As lessons were video-recorded, the focus of the video and the unit of analysis were always the teacher. Any student who lacked a permission form for school district videotaping was seated out of range of the camera. The video-recorded lessons were only used for data analysis and were not shown for any presentation purpose. Regarding data protection, all data were stored on the researcher’s personal computer, and written documents were securely stored in the researcher’s home office. Back-up files were also stored securely on an external hard drive.

After completion of the study, all teachers were given the opportunity to ask questions about the research study. I offered to review my research notes with any interested participant.

Summary

In this chapter I described the methods that I planned and enacted in order to answer my research questions. The design of this study was informed by my reading of other similar studies. I included both interviews and classroom observations to ensure that I had enough data to answer the research questions thoroughly. As a result of my interviews and observations, I begin sharing my results by describing each of the six teacher participants in Chapter 4.
Chapter 4

This chapter presents teacher sketches for the six participating teachers. The teacher sketches in this chapter are intended to illuminate the ways in which teachers plan, implement, and reflect on what they consider discourse-rich lessons that relate to their previous participation in the PD. In Chapter 5, I will present a cross-case analysis in which I describe, analyze, and identify features of the PD that encouraged or did not encourage sustainability.

These teacher sketches capture the varying narratives of what transpired for each teacher after the PD concluded. Although all six teachers in this study participated in the same one-year professional development program with their school teams, they went on to have different experiences after the PD ended. Some continued to work with the same teachers with whom they had attended the PD, while others changed jobs or saw their team members do so. As this chapter shows, the six cases represent varying levels of adoption of the Project AIM ideas, and variations in the teachers’ current practices in relation to their practice at the completion of the PD. Though I cannot point to a single circumstance that defines each teacher’s instruction, through these sketches I can show a number of circumstances that give insight into why the teachers teach the way they currently do. Table 2 includes a brief description of each of the six teacher participants to remind the reader of each teacher’s unique circumstances:
Table 2

Summary of Teacher Backgrounds

<table>
<thead>
<tr>
<th>Teacher Name</th>
<th>Description</th>
</tr>
</thead>
</table>
| Margaret     | • Moved schools after PD  
               • Taught third grade  
               • Currently teaching second grade |
| Karrie       | • Moved schools after PD  
               • Taught Kindergarten  
               • Currently a Math Coach |
| Nora & June  | • Taught at Paideia school  
               • Second-grade colleague left  
               • Continues to teach second grade |
| Sarah & Melody| • Taught at same school as during PD  
                       • Recruited more colleagues to do a subsequent math PD  
                       • Continues to teach second grade |

The six teacher sketches that follow are organized using a similar structure. For each sketch I will first provide a brief background of the teacher, describing some of the most salient features of her background and teaching. I then provide evidence of each teacher’s sustainability of the Project AIM core values and supports and hindrances to that sustainability. Finally, I summarize the most important attributes of the teacher. This structure is described in the following table:
Table 3

Teacher Sketches Format

<table>
<thead>
<tr>
<th>Case Teacher Introduction</th>
<th>Teacher Sketches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Window into the Teacher’s Practice.</td>
<td></td>
</tr>
<tr>
<td>Project AIM Core Values.</td>
<td></td>
</tr>
<tr>
<td>• Teaching students how to participate in mathematical discourse</td>
<td></td>
</tr>
<tr>
<td>• Establishing norms for math discourse</td>
<td></td>
</tr>
<tr>
<td>• Planning for math discourse</td>
<td></td>
</tr>
<tr>
<td>• Collaborating with your team to plan math</td>
<td></td>
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<tr>
<td>• Promoting conceptual mathematical thinking through rich discourse</td>
<td></td>
</tr>
<tr>
<td>Supports and Hindrances to Sustainability.</td>
<td></td>
</tr>
<tr>
<td>Teacher Summary.</td>
<td></td>
</tr>
</tbody>
</table>

Margaret

At the time of the professional development, Margaret, a white female, was in her third year teaching elementary school. She began her teaching career by earning a Bachelor’s degree in a 6-12 Vocational Education field and teaching high school for one year. She then decided she wanted to teach elementary, returned to school for several courses in elementary reading, and became certified to teach K-12. In an interview with the researcher, she reflected, “looking back, it hurt me not to be in Elementary Education. Because I didn’t have a lot of… I didn’t have student teaching. And a lot of core classes that would have helped I guess.” Margaret appeared insecure about her teaching path.

In Margaret’s first elementary position, as a math intervention teacher, she benefited from the mentorship of colleagues. She reflected that being chosen for the position was “hilarious, you know, because I’m not… I don’t have a math background, and it was like a job that was available. It was a blessing because I probably learned as much as the children did from my partner, who is amazing.” Margaret also highly praised another intervention
teacher for her math expertise and her mentorship while Margaret and she held math resource teacher positions. The next year, Margaret moved to second grade, where she stayed for two years. It was in her second year in this position, during the 2011-2012 school year, that she attended Project AIM.

Margaret attended the Project AIM PD with the entire five-person second grade team at her school. At the time of the PD their principal enthusiastically supported their participation, with the teachers reporting that their principal loved math talk and loved seeing her teachers participating in PD outside of school. A year later, this administrator enthusiastically nominated her first-grade teachers to participate in a first-grade implementation of the AIM PD. During Margaret’s year in AIM, she completed all of the assigned professional development tasks throughout the year with her team.

At the conclusion of the professional development, teachers were asked to submit an artifact package. When submitting her artifact package, Margaret noted: “Please keep in mind that this is a REAL [sic] classroom in the [less affluent] part of the [district] and probably looks very different from the other classrooms represented here in our [PD cohort.]” Her artifact package did not reflect much evidence of math discourse, with Margaret focusing on the difficulty of the math content and seeming to agree with the student statements that the math topic was too complex to understand well.

During the current study, I was able to debrief with Margaret about the lesson I observed in her classroom. Much of my debrief with Margaret was not centered the specific lesson I had observed, but rather her teaching struggles more generally. She described some of the work she would like to do with math, citing another teammate’s success using centers
for small group work. She obviously cared deeply about her students and their success, but she found that many of her students had very challenging life circumstances that made for challenging interactions in her classroom. She felt a lack of support from parents, and her classroom was “like a revolving door” of kids coming and going. Margaret described the climate:

Yeah, I have prayed a lot this year. More than ever. I have prayed for these little students, and I pray for me, and I pray for me and their parents. Because, you know, it doesn’t need to be a fight between me and Momma. Like, I don’t want your child not to be able to do good in math.

Margaret was overwhelmed with teaching and seemed dissatisfied with some of the challenging parent interactions that she was experiencing. These parent interactions, along with the challenging student behaviors, were the majority of what we discussed in our conversations. These behaviors, rather than content, appeared to be her primary focus.

**A Window into Margaret’s Practice.** In order to illustrate how Margaret encouraged discourse in her classroom, I describe the single lesson I observed:

I made my way out to the classroom trailer, coming in just behind Margaret’s class as they came back from lunch. When I entered the door in November 2014, the students were curious about having a visitor in the classroom. The 21 students in the class were racially diverse. Margaret quickly got the math lesson started, asking students to grab their white boards and have a seat on the carpet.
Margaret began the lesson by placing some math vocabulary on the board related to the day’s lesson. She then explained to students that they would be working that day on a new strategy to help with addition, the number line. On the board she modeled how to solve the problem 31+12. She explained that she would put 31 on her number line, then drew and counted 12 tick marks to the right of the 31. After drawing the tick marks, she counted on from 31, writing the numbers on above the tick marks. “32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43. So, 43 is the answer.”

After modeling the problem, she passed out a worksheet to the class. She referred to a vast stack of paper by her desk, stating that these were the papers the district expected them to use. Each student stayed at their place on the carpet, working on problems on white boards. When talking through one problem, Margaret read the problem 20+25. She then asked students which number should be put on the number line first. Some students said 20, others said 25. She asked one student who answered 20 and one who answered 25 to come to the board and show their method so that they could compare. This was a slow process, as the students were first placing their chosen number on a blank number line and then were left with the task of placing 25 or 20, respectively, tick marks on the number line. Both students had difficulty counting and keeping track of the tick marks, and eventually Margaret asked the students to continue to work while the rest of the students went on to work on other problems independently. Margaret also pulled a few students to a table at the side of the room to work with them more closely on the worksheet problems. Eventually, the two students shared the results of their 20 versus 25 starting number experiment with some
assistance from another student acting as the teacher. The explanations took a bit of time and then the lesson was over, with students being urged to put on coats for recess.

In debriefing with Margaret after the lesson, she expressed discouragement with behavior management issues from the lesson. She also expressed a larger displeasure with the mathematical content she was expected to cover that week. In the pacing guide for the county, there were several different addition methods to be used in that week of school. Margaret expressed her frustration: “But it’s gotten to be sort of a joke. It’s stupid, you know? You don’t need to teach 500 different ways to add numbers. I learned just fine.”

I asked Margaret about her choice to have the students come to the board to decide which number would be better to start with. “But I think every time I give them time, it’s stressful to me, but every time I can turn them over to talk with each other, and still keep tight reigns on their behavior, I think that they do get something out of it. They hear it another way, it’s coming from another eight year old.” Margaret appeared to have some desire to implement math discourse in her classroom, but lacked both the mathematical knowledge necessary to facilitate it and the overall classroom management skills needed to do so.

*Teaching students how to participate in mathematical discourse.* Margaret mentioned that she had recently asked her students to act out a math story problem in front of the class, which is a strategy that she recalled from Project AIM. When describing the event Margaret seemed enthusiastic about the activity and stated that the children enjoyed the activity. However, she reflected that time kept her from trying more of that type of activity.
**Establishing norms for math discourse.** Margaret believed that establishing classroom norms was essential, but her primary concern in establishing classroom norms was her desire to set expectations for behavior. For example, Margaret discussed at length the fact that she was having trouble keeping students in line when transitioning between specials and the classroom. As Margaret shared with me, this trouble with keeping student behavior under control had led to the students being dismissed early from their specials (e.g., Art, Music) class. When I worked with Margaret during the follow-up study, I did not observe any evidence that she was looking for ways to establish classroom norms related to mathematics discourse.

**Planning for math discourse.** I began to understand how Margaret planned for discourse by looking at her culminating activity from the Project AIM PD, the final artifact package. In that artifact package, Margaret described a representative lesson of what she had learned from the PD. In the planning documents, the mathematical goal was understanding fractions of a group of items. Margaret reflected that her students were already familiar with fractions of a whole, but believed that the day’s lesson would be difficult for them. For her discourse goals, Margaret stated that, “This lesson lends itself to responsive discourse because students have to explain their thinking and there are multiple ways to show how they arrived at their answer.” Margaret chose a discourse strategy from the Project AIM PD, the Think Aloud.

In her Launch, Margaret began by reminding students of their previous learning of fractions of wholes, referencing candy bars. In her Think Aloud, Margaret described a problem in their own class, that of dividing the class of twenty students into fourths to test in
other teachers’ classrooms. “I showed students how to make four groups and start assigning one child per teacher until I have run out of children. Each teacher gets five students.”

After that example, she dismissed students into three ability groups. She worked with one group, another group did math games, and another group worked on math independently. Margaret explained, “This particular lesson needed to be taught in small group because of the difficulty of the lesson.” When it was a group’s turn to work with her, they worked on a problem involving colored tiles. The lesson continued into the next day, but Margaret did not describe any sort of wrap-up or Discuss portion of the lesson. When reflecting on students’ learning from the lesson, Margaret related the following:

Two students did not understand that one third of twelve is four. I just explained it the best way I knew how, but the whole time I kept thinking, “Would I be able to understand this when I was eight years old?” Probably not.

Margaret was straightforward in how she answered one of the questions about student discourse. The question asked, “In what ways did the discourse help develop students’ understanding of the mathematical ideas of the lesson? How do you know?” Margaret’s response was, “It didn’t.”

Margaret planned for ability groups. She expected that her “lowest” group would need her explicit help to understand this concept because she found it to be a hard concept. Her planning for discourse included anticipating the difficulty of this subject, anticipating that some students would need her additional help, and that some students would understand what she had explained well enough to do other things.
Collaborating with your team to plan math. Margaret, who had worked in several different teams since AIM, stated that her team struggles to plan. Margaret described some of the challenges associated with planning for mathematics with a team when she is asked to plan in isolation for her entire team:

But now we’re trying to find our groove this year. We’re not a new team, we’ve been together for, you know, a little while, but our reading specialist wants us to, she was like urging us to, like each person plan a subject. She said a lot of schools are doing that now. A lot of grades at our school are doing that, and we’re getting into it. We’re not there yet. I mean, we’re doing it. I mean, I’m planning the math, but I’m not planning the math. I’m just taking it off [the district curriculum guide] and plugging it in to Google Drive. And then it’s never really getting, there’s not an elaborate plan.

Margaret also described some of the challenges she had faced in planning with her team because of moving schools and moving teams frequently. One year, her teaching grade-level assignment changed unexpectedly just before the start of a new job and new school year.

Promoting conceptual mathematical thinking through rich discourse. Margaret, when asked, stated that she valued student discussions as a way for students to share their thinking in her classroom. Throughout my interview conversations with her, she expressed interest in doing more discussions, as they are a way for students to learn from one another. Most of Margaret’s comments were focused on how she found other teachers’ math work more interesting than how she was able to try these things in her own class.
Margaret demonstrated that she had math discussions in her classroom, but had less success with facilitating those conversations when faced with challenging interactions. She recounted this episode of a discussion in her classroom:

And just today I had some kids come up and try to explain something. I said, because [I] have talked and we’re talking about odd and even, and I have a very smart child who knows numbers that are odd and even, but he can’t explain how he knows. So I’m getting him, I was trying to get him to explain it. He just kept saying on his exit ticket […] He just kept writing down 20 is even, and I just know 20 is even. Over and over. Like he honestly didn’t get… Well, see he has some behavior, a lot of ADD-type behaviors, so I don’t know. I’ll try again tomorrow because he was not very receptive to the kids trying to explain it to him. Now some kids would be embarrassed. Like, if my classmates were trying to explain something to me, I don’t like that…. He wasn’t being embarrassed, he just kept playing with stuff. He wouldn’t even listen to their explanation. The explanation was good, so I said you know, thank you girls for explaining that. So I thought, well, it wasn’t a total loss, because they were able to explain something in math and be a leader in the classroom. I don’t do that as much as I should. Maybe we can get there this year.

This example from Margaret’s classroom led me to believe that though she has stated beliefs in the core value, she was not yet able to facilitate those sorts of conversations in her classroom on a regular basis.
Supports and Hindrances to Sustainability. The year after AIM, Margaret moved to a different school. She was hired as a second grade teacher, but was asked to teach third grade in her first year there. She moved back to second grade in the subsequent year and was still teaching second grade when I spoke to her in Fall 2014. This movement from team to team and between grades prevented Margaret from developing strong team relationships that may have helped her grow her adoption of the Project AIM ideas.

Furthermore, Margaret’s adoption of the Project AIM core values was not well-developed at the completion of Project AIM. This was especially evident in the artifact package that she completed at the end of the professional development. In that document, she stated that she found the mathematics in the lesson she was teaching difficult and did not believe that her teaching of the lesson led to math talk.

Margaret Summary. Margaret participated in the interview and one lesson observation for this study. After the observation, she chose to stop participating in the study. As a result, I know less about Margaret’s classroom than the other teachers. I include what I observed in her class but acknowledge that I have less information about her than the other teachers.

Margaret did not have a well-developed implementation of the PD ideas at the end of AIM. In addition, she left the colleagues with whom she attended the PD and moved to another school. Margaret also displayed a weak understanding of the mathematics she was teaching, including emphasizing the difficulty of the subject of her artifact package lesson and showing a less sophisticated use of the open number line in her observed lesson. For example, it would have been more appropriate to show jumps of tens in addition to ones on
several occasions during the observed lesson. Her current students had significant needs outside of the classroom which had an effect on their focus in the classroom.

With so many basic student needs to attend to and little support for mathematical or discourse goals, I did not find evidence of further growth of the AIM core values in Margaret’s instruction. She spoke about certain math talk ideas that she would like to implement in her classroom and when I observed her she had student leaders explaining work on the board. She had some recall and emerging fluency of the Project AIM core values, but those were not conventionalized in her own work.

Karrie

Karrie, a white female, earned her Bachelor’s degree in Elementary Education. During the 2011-2012 school year, she was in her twelfth year of teaching. At the time of the PD, Karrie attended with a team of four teachers, none of whom participated in this study.

The year after AIM concluded, Karrie switched to kindergarten at the same school. In the two years after AIM finished, Karrie actively sought out additional professional learning opportunities. While in the classroom, she developed and led training at her school, which combined ideas both from a previous CGI PD she had attended and AIM. She also worked with the county’s math team, giving feedback on lessons, developing new lessons, and writing assessments.

At the time of this study Karrie had just begun a new job. She was working as a math coach at a new school. This role required her to regularly work with teachers to improve their math instruction.
Reflecting on her teaching, Karrie described herself as primarily focused on the subject matter. She recognized two kinds of teachers, stating most teachers are “really about the kids, and they really love them,” but “there’s this other faction of teachers that really enjoy curriculum and really enjoy the planning piece of it.” She considered herself as falling into the latter category: “I mean, I really like kids and I really love working with kids, but I get really excited about the curriculum and that side of it, and so that’s always kind of been the interest.” Karrie is a lifelong learner, and actively seeks out additional professional learning opportunities.

A Window into Karrie’s Practice. Though Karrie guest-taught in classrooms occasionally, there was always a coaching purpose for her doing so. As she explained, “I am modeling this problem-solving structure (all week) for third grade because they have expressed that their students are having difficulty understanding story problems, and am hoping that this structure will help strengthen their abilities to tackle and make meaning from story problems.” Both of her lesson cycles for this study were completed in third-grade classrooms as a part of this coaching cycle for the third-grade team. Karrie clearly articulated her coaching (teacher level) goals for the lesson, as well as the mathematical and discourse (student level) goals.

I present here the second observation of Karrie’s teaching, as it highlights many of the most unique features of Karrie’s work. Based on conversations with Karrie and another instructional coach with whom she works, I knew that the regular classroom teacher was in her second year of teaching and was still unsure about giving up control of classroom
interactions. She struggled with managing some behaviors in the classroom, and Karrie anticipated that the teacher would want to interject and respond to certain students throughout the class.

Karrie had many of the same goals for this lesson as the previous lesson I had observed but not detailed herein. She also made the following observation: “After teaching the introduction to perimeter in another third-grade class, I know that the children have worked with area previously and tend to confuse area and perimeter, which is why we are starting with the All Talk and review.”

I set up equipment in the classroom teacher’s classroom before Karrie arrived. The classroom teacher brought the students to the carpet and began her own mini-lesson on area and perimeter, having the students chant a rhyme about the two concepts. As Karrie came in from lunch duty, she greeted the class and asked about the PowerPoint she had sent to begin class. After setting up, Karrie began her planned lesson with an All Talk about perimeter and area. She followed up with several photos of rectilinear shapes on the board. For each shape, she called students to the board to outline the perimeter with one color marker and shade the area with another color marker.

Karrie then transitioned to discussing the day’s word problem. She went through a similar cycle as the last lesson: discussing what the problem told the students, asking what they could infer from the problem, and brainstorming strategies for solving the problem. Karrie guided a discussion on what it meant to have “enough border”, discussing inequality. One of the students pointed out a typo in the problem: that two of the sides that should have been labeled had been left unlabeled.
Figure 5. Border problem. Karrie introduced this visual in a teaching demonstration.

After labeling each of the legs that were missing labels (1 ft), and talking with the students about how to find the other unlabeled segment, Karrie dismissed the students to work on the problem. Karrie circulated the room, spending time with individual students and groups who were struggling. Some students finished early, and she challenged those students to flip their papers over and design a bulletin board for which Miss L would have enough border. At the conclusion of their work time, she brought the students back to the carpet, asking two students to share their work. With time running short, she wrapped up the discussion and skipped her planned exit ticket.
After the lesson, Karrie reflected that the students in this class did not confuse area and perimeter in the same ways that students from the other class had. She thought this was logical, as the students had been exposed to both area and perimeter before, but, “interestingly, from the All Talk, not all of them were able to articulate [the difference.] They really wanted to jump at how you [compute], and I couldn’t really bring them back to [contrasting their characteristics].” Karrie also stated that she had spoken to the classroom teacher briefly about the emphasis on “length times width” for area, as use of the formula is not the expectation for third grade. Karrie reflected on the teacher’s procedural approach to area: “It’s not going to steer them wrong, but it’s not going to give them a complete understanding of what they’re doing, either.”

Karrie reflected that since her goal for those lessons had been to demonstrate a problem-solving structure to the third grade team, she did not have much time to discuss expectations for partner work. She expressed interest in following up with the third-grade classrooms to do a lesson that involved more norm-setting for talk. She stated that gathering the students together for a conversation about math talk expectations would be beneficial both for the students and the teachers.

*Teaching students how to participate in mathematical discourse.* Karrie described the challenges in giving up control to her students. She described her classroom as one where she worked to put control of the conversation in the students’ hands. She reflected on the experience as she worked toward changing the culture of her classroom during the AIM year and in the subsequent year:
I guess learning the culture was a big challenge. Sort of like the math talk culture, understanding that that takes time, and that it doesn’t happen overnight, and that you really have to train your kids that are not used to it. Just to, I think, it can be challenging, I don’t think it feels so challenging any more. But to sort of give up the control to them. Like not really knowing what is going to happen with this lesson, but I’m going to roll with it.

In other words, Karrie stated that Project AIM PD changed how she thought about math instruction, but her implementation of those ideas posed some challenges as she first tested out the ideas.

**Establishing norms for math discourse.** Karrie planned thoroughly and carefully. In her role as math coach, she always had goals both for the students she was teaching and for the teacher whose classroom she was teaching in. After I observed one of her lessons, Karrie reflected both on the lesson itself and her larger goals as a coach working with the classroom teacher. About the lesson, she lamented, “So it’s hard when it’s not your kids and you don’t know them! … I don’t know well how to anticipate what their misconceptions were going to be, and there were many! So I might have done things differently…” Another unanticipated issue was the time it took the children to get used to the expectations of speaking in class, so things like talking through a story problem took much longer than it would have had it been her own classroom. She knew that the students may not be accustomed to having rich classroom discussions, but she was disappointed to find that they had not heard of All Talk. Using All Talk had been one strategy built into the third-grade teams’ coaching plan in a
recent coaching cycle. In another written reflection Karrie lamented the challenges of instructing in others’ classrooms:

   In this unique role of Math Coach, I often find it difficult and frustrating to “guest teach” in classrooms that have not yet developed the level or culture of discourse that I am accustomed to. While I wish to retain high expectations for what students “can do,” I often find myself over planning because my memories from my own classroom do not match the management style and classroom culture that I walk into. I guess I have Project AIM to blame for that. ;)

   At the time of the study Karrie had already found her routine for planning as a classroom teacher and was adjusting to a new role, planning to teach and model teaching in others’ classrooms.

   **Planning for math discourse.** In her role collaborating to design math curriculum for the county, Karrie observed a close connection between her Project AIM work and the county’s current discourse goals related to Common Core. In her current math coach job, she encouraged her teams to plan for discourse:

   One thing that I have really been encouraging my teachers to do is to plan [talk] in their lesson plans. Like, write down we’re going to do this. Because if they don’t do it intentionally, it’s not going to happen organically. You have to do it intentionally, particularly when you’re learning from it and you’re getting comfortable with it.
In another instance, Karrie further described the specific work she does with teachers to help them grow their mathematics questioning:

You know, I’m actually working with some of my teams right now about getting students to ask questions, […] but one of the little slides in my Powerpoint is, ‘What kinds of questions do your kids ask you?’ And without fail, [the teachers I work with are] like, ‘What do I do?’ ‘What’s next?’ And they’re all just sort of procedural, on that basic level with Bloom’s. And then my next question is always, what kinds of questions do [your students] ask each other. And that’s even more basic, it’s like, ‘What’d you get for number five?’ And that’s so, they’re kind of starting out there. And I kind of feel like that’s where I was, with just question answer, question answer, question answer. And not really opening it up to explanation and not really opening it up to justification.

In the course of describing the way she teaches questioning to teachers, she described her own evolution in terms of planning for mathematics:

And so I feel like that at the beginning, and even during that year in Project AIM, it was difficult, and it was not natural, and I feel like now I’m much better able to plan strategically, because I’ve had a couple years practicing and it does come much more naturally. So that’s a big evolution just for me, in terms of my ability to ask questions to students. And to further that, to help them ask each other questions.
Karrie described how she believed that careful planning for discourse was exceptionally important to getting started, especially because at first “it was not natural.” But as she reflects on her own evolution of facilitating discourse, she saw that the action has become much more natural and she is now able to facilitate discourse and specifically question students with less preparation because of her confidence with the work.

**Collaborating with your team to plan math.** Karrie described fond memories of planning with colleagues during the Project AIM PD year. Since that time, Karrie taught two different grades before landing in her current instructional support role. Karrie described positive relationships with her grade level peers in those varying teaching assignments, but there was not enough evidence to say how close those connections were or how she planned with those teams. There was evidence of how Karrie nurtured the grade-level teams with which she worked to plan mathematics together. There was also evidence that Karrie worked well with a reading resource teacher with whom she shared an office in her current role.

**Promoting conceptual mathematical thinking through rich discourse.** In the year immediately after Project AIM, Karrie moved to Kindergarten. She described the transition as challenging, going from second-grade students who “could do all this math talk,” to “these babies [who] can’t talk!” Her first year in Kindergarten was particularly challenging. She reflected on her experience trying out some of the strategies with the younger kids, particularly one child with special needs. The student, a selective mute, was capable of talking but often chose not to. In describing this student, Karrie emphasized the value of talk as a window into students’ thought processes:
It took a long time for her to be comfortable talking. She’ll talk to her friends, you know, if it’s a whole group class response, she’ll yell it out. But if it was just her, she would just not talk. But, you know, in time, I could get her to do that. I think that’s super helpful because it gives you such a big window into what they can and can’t do and what they… but you know hearing what they’re thinking and hearing what their connections are and hearing about what their process is. That’s how you find out about them.

For Karrie, the challenge of switching to a lower grade level further emphasized the importance of math talk to promote deep math thinking and make apparent what kids know.

**Supports and Hindrances to Sustainability.** Karrie had several circumstances that hindered her ability to continue to implement the core values from the Project AIM PD. Most notably, Karrie changed grade levels and then moved to an instructional support position since the completion of AIM. Karrie managed to adapt her instruction in ways congruent with the Project AIM core values. Karrie’s ability to adapt seemed to be dependent on her personal drive to continuously improve her instruction and her strong adoption of the Project AIM core values by the end of the professional development, as evidenced by her reflections at the end of the PD.

**Karrie Summary.** Karrie was very invested in the Project AIM ideas. Based on her previous professional development training, she already believed that student thinking was important in math and liked the idea of incorporating math talk into her lessons. She believed that the AIM PD gave her a set of concrete tools that she could take into her classroom to scaffold talk. Her work was transformed as a result of the PD. Even after the PD, when she
switched to Kindergarten, she continued to be able to adapt strategies in order to get students talking about math. In her role as a math coach, her work shifted to working with teachers to improve math instruction. In this role, she has been able to work with other teachers, giving them strategies for math talk in their own classes. The ideas of the PD have been conventionalized into Karrie’s work.

Nora

At the time of the PD, Nora, a white female, was in her second year of teaching. She and her teammate June discussed how at that time of the PD she was still quite new to the job and June, the veteran of the group, was mentoring Nora and another teacher. Nora held an elementary education licensure obtained during completion of her Bachelor’s degree. During the professional development Nora chose to return to school online to complete her Master’s degree in Education, which she completed the year after she finished the Project AIM PD.

When Nora attended the PD there were a total of five second-grade teachers at her school, Barnes Elementary. Nora attended the Project AIM PD with June and one other teacher. Those three teachers attended all PD meetings and completed all homework assignments. At the final PD session which dealt with developing norms in the classroom, all of the teaches were asked to record advice for future offerings of the PD. Those three teachers recorded a brief video on developing norms that was shown to different PD participants in a subsequent offering of the PD.

Since the completion of the Project AIM PD, Nora engaged in many additional professional learning activities. She completed a Master’s degree in Education and was
active in the National Paideia Center attending conferences. She also presented at the Paideia Center in an effort to join their faculty.

Further, she took on a number of leadership roles in both her school and county. Her school leadership included serving on her school’s museums committee and serving as grade chair. For her county work she wrote and reviewed math lessons. As of the 2014-2015 school year, the county no longer officially adopted a textbook for elementary math. Instead, lessons were created by teachers and teacher leaders from within the district. Nora described the work as follows:

With Common Core a couple of years ago they had to revamp everything… Re-align and re-pace everything. So they developed these focus groups with their [National] money, and so at the end of each quarter we go and we sit and it’s a half day, and we just go day by day, what worked, what didn’t work, and we change. And then based on that feedback I’ll take that and write a lesson.

At the time of this study Nora was in her fifth year of teaching second grade. She spent her career thus far teaching with the same 4-5 second-grade teachers at Barnes Elementary.

The type of classroom Nora set up for her students, including the morning work routine with which the class engaged, was exemplified by the following observation of her classroom’s morning work.

As students trickled into the classroom that morning they immediately noticed an observer in the room and long rows of masking tape on the ground throughout the classroom. The observer they quickly dismissed, as Nora had forewarned students that I would be in the
room and observers frequently visited. The masking tape was a puzzle. Students guessed about their use, and one student even suggested that the lines might be number lines. Nora smiled and encouraged them to begin their morning work. Morning work included some math review and a problem that tied into the day’s lesson. Students periodically brought their math journals to Nora, asking her to check work or help with a struggle.

When it was time to begin the day, Nora asked the students to gather on the carpet for morning meeting. The morning meeting consisted of a handshake greeting passed around the room and several students sharing possessions from home. As students took turns sharing, other students asked questions about the object: “Why did you choose to bring that?” “Where did you go on that vacation?” “Is that your sister in that picture?” When the discussion was over, Nora turned students’ attention to the morning work, asking a few students to share their work for those questions. The students were well acquainted with this routine. When a student shared he or she would call on others to ask questions and then respond to each question. From time to time Nora interjected. As the discussion of the morning work problems drew to a close, Nora brought the students’ attention back to herself so that she could introduce the lesson.

Nora maintained routine in a way that valued all of the students’ opinions and allowed them to express themselves. The students clearly felt confident to voice opinions and questions in order to better understand one another. These routines were familiar and well-established in their classroom.

A Window into Nora’s Practice. In order to better understand how Nora encouraged discourse in the classroom, I describe one of the lessons I observed her implement. During
this lesson, Nora used a lesson from the county with a few modifications. On this day, students did not seem interested in the observer in their classroom at all; Nora’s classroom had hosted several visitors lately.

The morning started with a similar pattern as the previous lesson, with morning work and a morning meeting with students sharing. Students had been studying money over the course of the week. In previous days, Nora had given her students opportunities to explore plastic coin manipulatives independently. At the beginning of the unit, the class had created an anchor chart together to record observations about the coins. Those observations included things like the names of the presidents on the coins and the color, size, and value for each coin. This anchor chart was displayed prominently at the front of the room, and Nora referred to it while working with small groups.

One of the morning work problems had students counting coins, which made the transition to math time flow easily. During math time Nora briefly went over the coins, then spent time explaining use of the worksheet using a document camera and student helper. She then went into an explanation of the different roles that students would use during the lesson. This lesson employed a modified Talk Triangle, so students would rotate using different roles to scaffold their small group work. The roles included Questioner, Recorder and Group Leader, and Money Counter. Each child had a card with a reminder of the role.

The Questioner role included the following: “Your job is to ask questions to your group. Some questions you can ask are: Show me how you will count this? What strategy did you use? Why did you do it that way? Did you use the fewest amount of coins?” The Recorder and Group Leader was given the following prompt: “Your job is to record the coin
combinations on your recording sheet. You are also responsible for keeping your group on task.” Finally, the money counter was given this prompt, “Your job is to listen to the group leader and create two coin combinations for each value. Your group can help you if you need it!”

The lesson provided by the county gave a worksheet with the following instructions: “Representing Coins in a Variety of Ways. Show two different ways to represent the value shown on the left. Put a * next to each way that uses the fewest amount of coins.” The monetary values included twenty-five cents, forty cents, and fifty cents.

Nora used pre-chosen mixed ability groups for the lesson. Throughout the Explore phase of the lesson, Nora circulated the classroom. In the beginning, much of her work was making sure each of the individual groups understood their roles. This included explaining each of the roles again or ensuring that students were rotating roles. As students became more accustomed to their roles, Nora spent more time responding to students’ mathematical questions or scaffolding their math conversations. As some groups began to wrap up the sheet in front of them, Nora gave them another sheet to work on. In that one, students were asked to come up with all of the ways to represent a given coin value, such as 1 cent, 40 cents, etc. Eventually the entire class was working on the extension sheet.

Nora reflected later that this extension sheet gave her a better sense of how well the students were understanding money. She thought that at the beginning of the unit very few would have been able to confidently engage with the extension sheet, but on that day she observed a majority of her class doing so.
At the end of the lesson, Nora was curious to see what the students thought of the roles they had engaged with during the course of the lesson. Though not planned ahead of time, she brought the students to the carpet to ask several questions, including the role that helped them understand the best. To her surprise (and mine!), the first several students stated that they liked being the questioner best. They also said they learned the most from being the money counter.

In this lesson Nora demonstrated that she was able to take her knowledge of mathematics discourse to appropriately plan and then implement a discourse-rich lesson. She also showed that she was able to adapt mid-lesson, as demonstrated by her spontaneous decision to take her students to the carpet to have a discussion on the roles. This type of action showed her ability to flexibly use her plans and to effectively integrate routines from other parts of her school day (the paideia seminars) in her math instruction.

Teaching students how to participate in mathematical discourse. In the artifact package completed for this follow-up study, Nora described the ways that she was building discourse with her students, such as getting used to taking turns and doing more seminars in her classroom. The artifact package lesson was implemented in October of a typical school calendar. Nora stated that she was still fairly early in the year with the students and was therefore building to more and more sophisticated discourse with her class.

Establishing norms for math discourse. Due to the Paideia emphasis at Barnes Elementary, Nora held the absolute expectation that her students would discuss and reason through their answers. This meant that she held firm to that belief in how she approached this
idea with her students. In the following quote, she describes how she sets expectations for discourse in her classroom:

But I think just opening up the door to conversation at the beginning of the year. Making that a norm during our math, our math learning. That they’re going to be expected to share their answers, they’re going to be expected to, um you know, sometimes write their responses or present to the class. So, I think really just trying to set that standard at the beginning of the year, so that two weeks later, two months later, they understand why I’m doing that. And they kind of expect it.

Planning for math discourse. Nora reflected that she felt comfortable planning for math. She also demonstrated the ability to amend lessons to fit her discourse goals. This was evident in the previously mentioned descriptions of her work with the county and also evident when I went to observe her classroom.

When I observed her, Nora adapted a talk triangle strategy that had been in the county’s pacing guide for the day. Specifically, she took a county lesson that already had a discourse strategy, assigning roles, and made some of her own modifications to further aid the discourse, including making cards for each of the different speakers. During the course of the lesson, I observed a parent come into the classroom to support the instruction in the classroom and ask probing questions of the students.

Collaborating with your team to plan math. Nora stated that the school focus was on literacy which meant much less time to plan for math as a team. As grade-level chair, Nora stated that she was checking into whether or not their grade level team might be allowed to
devote some of their team planning time to math. Nora acknowledged that June tends to get behind the pacing guide by spending multiple days on some lessons. Nora further highlighted the differences in their two classrooms by pointing out the high number of special needs students in June’s class and how that population demands some different structures and support. When asked specifically about math planning, they said that most of their math discussions came at informal, “playground talk” moments.

Promoting conceptual mathematical thinking through rich discourse. Nora’s belief in the power of student justifications was apparent in the way she describes her philosophy toward her students learning math:

We are starting number sense now. You know, that’s so important in second grade, the major work that we do, and I wanna make sure that every kid understands it. But sometimes you have to kinda let that go and hope that maybe they will understand it better when they’re hearing conversation and hearing their peers share. You have to, kind of, take away some of the control from me and give it to the kids.

Supports and Hindrances to Sustainability. Nora had many supports for her continued sustainability for the Project AIM core values. External supports included working in a museum magnet school with strong parent support in her classroom. Nora also had a very strong final artifact package from the Project AIM PD that reflected her willingness to fully try out and test new ideas in her classroom. Moreover, she showed herself to be an independent learner by completing her Master’s degree and seeking faculty status at paideia summer workshops.
**Nora Summary.** Nora found the AIM PD to be meaningful and impactful on her instruction. Even after the PD, Nora continued to have informal support in planning PD with her school teammate, June. Nora’s school environment encouraged seminars across subjects; her principal expected discussions in all subjects. When I went in to observe her classroom, there was a talk triangle (a strategy suggested by the Project AIM PD) in the county's lesson for the day because former AIM participants, including herself, are among those who have written the county's lessons. Nora fully adopted the core values of AIM and has conventionalized that work in her classroom.

**June**

At the time of the professional development, June was in her eleventh year of teaching at Barnes. Of her ten previous years teaching, three were in third grade and seven were in second grade. During her first year teaching at the school, the school began the transition to becoming a seminar-based school, so her teaching career was spent in one place with a unique teaching philosophy. She earned her undergraduate degrees in Elementary and Special Education.

June continued to teach second grade at Barnes since the completion of her participation in AIM, making the 2014-2015 school year her 14th year of teaching. She remained enthusiastic about her love of second grade, both its curriculum and the age of the kids. “I love the age of the kids because they’re now independent enough, but then they still need you and they still want to do the fun stuff and school’s not awful yet.”

In the years since AIM, June remained an active member of her school community. She led various in-house workshops and took leadership of the school’s mentoring program
for newer teachers. This mentoring work included connecting the new teachers with mentors, supervising mentors, and doing monthly workshops for the new teachers.

June demonstrated herself to be a thoughtful teacher who had seen many changes at her school, Barnes, over the course of the fourteen years she had worked there. Her school is a museum magnet school, with “a lot of paideia and a lot of problem-based learning” where there are opportunities for students to pursue diverse interests and describe their work in a museum format. She began working at the school before it was a museum magnet. The shift in the school required re-applying and re-interviewing to stay at the school. June, as one of the veterans at the school, trained and helped new teachers to integrate into the school philosophy. June’s conversations also demonstrated that she did not see the different subjects that she teaches as distinct, but rather interwoven and connected. For example, June had recently completed a week-long arts-institute training to integrate the arts into teaching. She shared, “We talked about how we can use music curriculum to teach math and science and art. And I mean, truly hit your standards.” She continued, “So you’re not just coloring a picture about this. [It gave ways to blend] lots of the different standards and different curriculum.” She also described the methods taught in the PD as ways to simultaneously teach the arts and meet requisite school standards such as English Language Arts and Mathematics.

This type of instruction showed up in her classroom where she found ways to substantively integrate a variety of lessons such as 21st-century skills and group-work strategies throughout her various lessons. The school’s parent organization paid for June and a team of school colleagues to attend this institute.
A Window into June’s Practice. I observed June’s class one drizzly November morning of 2014. The day began as June described it would: students trickled in to the classroom and began morning work, which included several math problems. The classroom had various student projects piled around the room in preparation for parent conferences that week. June later told me that the parent conferences are student-led, with groups of parents coming in shifts to the classroom for each student to share some examples of current work at school. During that time, each teacher in the school plays more of an advisor role, interjecting as needed.

Toward the end of morning work, June chose to show her students a video compilation she had made of a recent field trip. The short video showed students exploring a working pioneer village and would be shown to parents at the conclusion of the parent conference night. After the video students began explaining and sharing the math morning work but were interrupted by the fire alarm. The students calmly filed out into the cool drizzle, with occasional murmurings about the chill. As it turned out, this was not a drill. Fire trucks arrived and students murmured. June quickly diffused any worry, reminding students that one of their 21st century skills was flexibility and that they would surely be fine in the elements.

Even as students received the all-clear to return to the building, the fire alarm blared. June was cool and calm in the situation, and her students followed her lead. She returned to discussing morning work, but then checked in with me, asking if I would be able to understand any audio if I videotaped with the fire alarm still ringing. Thankfully, we did not have to find out, as the alarm finally turned off.
June quickly returned to her planned lesson. From our discussions, I knew that several of her students had high emotional needs and there were a number of students with Individual Education Plans in her class. June began by showing a video that she had recorded of herself shopping for toys in a toy aisle. She had placed post-it notes for the prices of two toys and asked students to think about which one cost more or less. June then dismissed students in pre-selected mixed ability groups to compare three-digit numbers. Their task was to use a poster and marker to explain why one was more or less to her kindergarten friend.

As June circulated among the groups, she pulled one student, Jorge, aside. Jorge has limited language skills, behavioral issues, and math skills at a Kindergarten level. When discussing how to group him with other students, June said that it depended on the task and her purpose. On this day, she chose to use more individual instruction time with him to compare two-digit numbers. She juggled her time during the Explore phase between Jorge and the rest of the groups. Throughout the lesson she was pushing for students to use proper mathematical terms to describe their thoughts, especially naming the individual place values. As she approached one group, she remarked on the amount of writing on the poster. “My Kindergarten friend doesn’t read that well yet!” In the debrief June mused over her students’ work:

I honestly was not expecting to have so much words. That was probably the biggest surprise for me. I didn’t think that they would explain in writing. Because they never do that. I mean, it’s like, ‘Hey, here’s a journal prompt.’ ‘Do I have to write in words?’ ‘It’s a journal prompt. Yes.’ That is like, they will do everything but. And
then to see all of this, these words written down I’m like… ok. (Laughs) That is not what I expected but I’m very happy.

As students wrapped up their posters, June chose a few students to come up and compare their answers. She reflected on her choices for the discussion: “I purposely didn’t call up one group that had used the [inequality] symbols very specifically ‘cause [tomorrow] we will start with theirs…” June reflected that the majority of her students had a good understanding of comparing numbers, and the next day’s lesson would move on to using inequality symbols and reasons for comparing numbers.

**Teaching students how to participate in mathematical discourse.** In order to better understand this core value in June’s work, I describe a second lesson I observed in June’s classroom from January 2015. On this day I entered to hear an animated, though respectful, argument about sound. Students were going back and forth, disagreeing and starting their own opinions on exactly what they were hearing as they discussed sounds in their own classroom (e.g. radiator whistles, door creaking, etc.) After several minutes I heard June’s voice as she told the students to wrap up their discussion. As students put away supplies and transitioned to math, I noticed a Thinking Teams poster prominently displayed on the wall. Based on conversations with June and my own previous observations in her class, I knew that she was constantly referring to expectations for group work in her lessons.
June pulled the students to the carpet to discuss the day’s lesson involving money. This was the students’ first day in their money unit, but June explained that her students had experienced many opportunities to think about money by engaging with money morning work problems over the course of the year. June began with the same county lesson plans that I observed in Nora’s Observed Lesson Cycle 2 but made significant modifications. June used what she called a “modified talk triangle,” which was pair work with specific roles and
expectations for each pair. As the lesson unfolded, it became clear that this decision was carefully planned to meet the unique learning needs of her class.

June launched the lesson by reviewing coins. She then spent a significant amount of time using the document camera to introduce the task. In the task, students are asked to find all of the ways to represent different coin values. After describing the task, she brought a student up to work with her at the document camera to demonstrate the pair work. This demonstration included structures such as who should be holding the pencil, who should be talking, and how to take turns performing the roles. One person explained what coins should be used to make the given value, and the other person held the pencil, listened, and wrote down their partner’s idea. Students were expected to rotate the roles and the pencil was a reminder of who had each role.

![How Many Ways? Recording Sheet](image)

Figure 7. How Many Ways Recoding Sheet. June used this lesson prompt in an observed lesson.

June dismissed the students to Explore with pre-determined partners. The class was loud and animated as they engaged with the task. One student, Joe, needed frequent support
to perform his partner role. June described Joe as “very, very, very social,” but needs to be reminded to listen and be a good partner. Not long into the lesson a Special Education teacher pushed into the classroom and helped Joe and his partner with the task.

During the Explore phase June’s primary tasks were encouraging perseverance in continuing with the task and reiterating her expectations for group work. June said that scaffolding partner work has been an ongoing conversation in her classroom.

But I knew after something we’ve done last week and earlier in the week that they just don’t listen to each other. And part of it is [Joe], but then there’s a few others. … Just, not sharing that pen. And not listening, like, ok, here, yep, we’re both going to write our own ideas. I don’t care what you say. So that’s where, like I said, we’re going to go ahead and you’re going to have to listen and you’re going to have to write and then you’re gonna switch. Because that’s where we are. (Laughs)

Though June had expected to see some of her students noticing a pattern or systematic way of finding different ways to make a certain value, that concept did not emerge during the Explore phase. When June moved her students back to the carpet for the Discuss portion of the lesson, she chose a student to share a few different ways to make a certain coin value. She concluded the lesson with some probing questions during the discussion to begin to allude to a pattern.

Over the course of this lesson, I observed that June worked in several ways to encourage and scaffold her students’ discourse. Through visual reminders on the wall, clear
expectations for the group, and consistent feedback and monitoring throughout her mathematics lessons, June consistently reinforces this idea to her students.

**Establishing norms for math discourse.** June found it an exciting challenge to nurture students into the expectations she sets for discourse throughout the day. When I interviewed her in the eighth week of the school year, she shared. “These first few weeks are always really hard because you’re always like, okay, when is it going to start clicking? When are we going to start moving that thinking along?” As I continued to speak with June during the subsequent lesson cycles throughout the school year, it became apparent that the groundwork that she had laid for classroom discourse norms was reaching fruition. The students expected conversations with respectful disagreement in order to be able to help one another think.

**Planning for math discourse.** When June reflected on planning for math talk, she stated that at their school they do “a lot of talk and justify our thinking and kind of pushing these things.” Because of that justification at their school, the idea of ‘math talk’ was not new. However, when reflecting on her experience in AIM, she stated “some of the strategies were new and definitely exciting to try and work with.” She said that the main piece that was new for her was the idea of math rigor. She was intrigued by the idea of recognizing a challenging problem beyond what was labeled as ‘Challenge’ by the textbook. When I asked June to expound on what she was calling rigor, she explained her thought process for selecting good problems: “Are the kids going to be able to think about it, figure it out in their head and move on, or are they going to have to really think, justify their thinking, use the
strategies that we’ve learned, maybe ask each other for help?” Further, “It’s what’s going to push them to get wrong answers at times and really use their precision.”

**Collaborating with your team to plan math.** June and Nora continued to work together and plan together since the conclusion of AIM, though they lost their third team mate with whom they attended AIM. June and Nora continued to plan together and were happy to talk together during the focus group, but it was less clear how this pair continued to plan math together. June and Nora both described how much they appreciated having time to plan math together during the Project AIM PD and expressed desire to have time like that again. Indeed, both teachers were in very different places in the pacing guide.

**Promoting conceptual mathematical thinking through rich discourse.** When completing the artifact package for this study, June planned a lesson comparing a 100s chart and 200s chart using a Venn diagram. In the Launch, she reviewed previous knowledge of the 100s chart and related use of the Venn diagram to use in literacy. Before dismissing the children to work in pre-determined mixed ability groups, she went over small-group work expectations. This is a regular part of her classroom work and goes by different names in different contexts. Sometimes this work is called “Thinking Teams,” and sometimes the work relates to 21st century skills of which she emphasizes a different skill each month. These cooperative learning skills are so entrenched into her teaching across the curriculum that she does not necessarily make a distinction for how she uses them in math in particular.

**Supports and Hindrances to Sustainability.** June, as a veteran teacher at her museum school who frequently mentored new teachers, was well-situated to integrate the Project AIM core values in to her already well-adopted museum values. Though June said
that she valued student talk before Project AIM, she found the idea of task level of demand particularly transformative in the way that she plans for and questions her students. Her continued sustainability was also supported by the other professional development opportunities supported by her school’s parent-teacher organization.

**June Summary.** June found the AIM PD to be worthwhile and have an impact on her instruction. Like Nora, she continued to work in the same school environment, with like-minded colleagues who also value student talk. The ideas of modeling classroom expectations and scaffolding small-group work fit particularly well with her experience in both Elementary and Special Education. June had conventionalized the core values of Project AIM in her work.

**Sarah**

Sarah earned her undergraduate degree in Elementary Education, but worked in non-profits for the first part of her career. A move back to her home state brought her to Fayette Elementary as a second-grade teacher. When she attended the 2011-2012 Project AIM professional development, she was in her sixth year teaching there.

Sarah attended the PD with Melody. Both women described how their relationship was strengthened through Project AIM. Sarah and Melody described their relationship as one where they “hit it off immediately.” Their relationship was strengthened by their physical proximity, with their classroom doors directly across the hall from one another. Sarah and Melody stated that they did not know what to expect when they began AIM.

**Sarah:** And I got that email about the first AIM, and I was like, we’re going to do this. I was like, it’s the university, this is what they’re doing, and we kind of went in blindly. But we’re like, well, we’re in this together. And we live close together so we
carpool. And we would leave talking about stuff that we were going to do in our class.  
**Melody:** That’s true. We did. We talked the fifteen minute, ten minute car ride. And we talked about…

**Sarah:** We would talk about math. We would also talk about somebody saying something that kind of we thought was funny or got on our nerves, but you know that’s human nature but it was funny. And we like to be funny. So we balance stuff…

**Melody:** …. In a snarky way. In a British dry humor kind of…

**Sarah:** But that was, I would say, and we would come back and talk about it in our grade level. […] it simply improved our teaching, and our friendship, which all of it has been very positive.

**Melody:** Absolutely.

Another illustration of Sarah and Melody’s close working relationship, strengthened during the AIM PD, comes from their reflection on working on a homework assignment from the PD involving sorting problem types:

**Sarah:** I will tell you something that something that stands out to me from that time was when, it was a teacher workday in the Fall, and it may have been Halloween. Megan and I spent a lot of time that day at my desk analyzing those stupid word problems. Are these a collection word problem, are they… and we, I will say that we probably pushed each other. And it’s good that we did it together, because we’re both, not trying to impress each other with our academic language, but we were analyzing…

**Melody:** Well, and it balances, if one person’s mentally not in the game and tired, the other person, chances are, might be ready to work. And so you kind of push each other like in any good relationship to get it done.

**Sarah:** But what stands out to me that we really did not want to finish that. And were…. I hadn’t eaten lunch that day. I remember going home and scarfing one of those fried green tomato pimento cheese sandwiches… like crazy sandwiches.

**Melody:** That we get ‘to go.’

**Sarah:** That we normally share but I ate the whole thing.

I share the last portion of the conversation to highlight one aspect of Sarah and Melody’s relationship that was evident throughout my interactions with them. Sarah and Melody were clearly very in-sync, both personally and professionally. So much so, that they
would finish one another’s thoughts about math and decadent fried green tomato pimento cheese sandwiches.

Sarah has continued to teach second grade at Drake since the completion of Project AIM. She also completed more PD, including working with Melody to recruit teachers at her school to do another year-long math PD. In addition to those math PDs, Sarah participated in and led several literacy workshops. When asked about her other professional learning experiences, she stated, “I’m sure there are other things that just seem so natural to do that I don’t even know what they are. I have to think a lot on what I’ve done because I… just do it. Does that make sense?” She also stated that much of her other professional development seemed in line with Project AIM’s goals.

Well, I think there’s been a big push in education for a whole lot less teacher talk and a whole lot more student talk. And AIM was a very big part for me to make that transition. […] I feel there is a push… they may not talk about it the same, but it’s certainly something that I’ve seen… student active learning. Active learning I think is the best way to put it, but not necessarily talk, like math talk or talk about your letters or…

Her view of teaching changing as a whole, and how she sees Project AIM and other PD fitting within and supporting that view of teaching, seemed to be a central tenet of her view.

In the three years after the AIM PD, the political climate for teachers in the state was volatile. Sarah prioritized speaking about the strength and professionalism of teachers. Sarah
is an advocate on behalf of teachers. Here, she eloquently describes how she thinks about teaching:

One of the things that I have done, which is not professional development, but where I have put some of my time and energy, is being a voice for teachers in the state. And I spoke at [a public event at the university] back in May. A lot of times when I see teachers on the television, I do not feel, and feel free to use this because I’m not afraid of anything I say, I should be… But a lot of the times I feel like the teachers don’t represent me. And in this state, teachers [are] not being respected to the degree that they should be. I know that I’m respected and feel valued at my school. So that’s where I’m putting my energy, speaking out for teachers in this state and representing myself in a manner that I would hope would feel good to… so that I represented them well. And I think if you’re going to be a person who’s going to represent in that way, you have to make sure that you’re knowledgeable on what you’re doing. So Project AIM, LTBI [another math PD], and doing things with that have helped, and have helped me gain confidence in you know, being a teacher leader. […] But again, being in those programs at the university allowed me exposure to all the hardworking teachers out there. And there wasn’t one person who was not invested in their profession. And that’s what people don’t see. And that’s what I’ve been trying to share. [My daughter] is an education major. So I feel like for her I have to run my mouth.
Sarah speaks passionately about being a representative voice for teachers. In that role, she wants to ensure that she stays current in her knowledge of the field, which includes constantly looking for additional learning opportunities.

**A Window into Sarah’s Practice.** I observed Sarah implement a lesson dealing with money in January. For this lesson, Sarah planned to build a coins anchor chart as a class. Then she and the class were able to use the chart during the core of the lesson. In this lesson, students were asked to share strategies for purchasing a ‘toy’ from a sheet of paper. Students would then make change for a dollar. In the following image, you can see the anchor chart that Sarah and her class made during the introduction of the lesson.
Figure 8. Change for a Dollar. This anchor chart began a money lesson on making change.

Sarah set up the task in terms of selecting a single toy from a list on a piece of paper. She invited two students to the front of the room and had them act out the process of reading the paper to choose a toy, one student having the dollar to buy the toy, and the other student giving the change back. During the introduction, Sarah wrote in blue marker on the board to track their choices. The pair of students at the front of the room chose a teddy bear, which cost 63 cents. In her introduction of the task, Sarah stated that students would need to find the
partner that makes 100 in order to see how much change to give, as seen in blue marker on the right side of the image. Sarah then said she didn’t know how much change that was yet. She then re-stated the instructions and gave out the required worksheets to the students. (The red marker is from a student explanation later in the lesson.)

Figure 9. Change for 63 cents. This is board work from making change.

From that point most of the students chatted and worked in partners with Sarah circulating the room. Two students were notably disengaged during the entire lesson. After the students had worked on the problem for several minutes, she selected several different strategies to share their answer for how they reached the answer 37.

Though students seemed to understand how to find the missing piece of $63 + \_\_ = 100$, they had more trouble understanding how this idea fit into the idea of making change.
When the students struggled to explain how they knew that was the right amount of change, Sarah asked several questions to make sure that the pair presenting and the other students understood. Further, not all students had enough pennies in their bag to make change simply by counting by ones. One explanation described the use of dimes and pennies, which was displayed on the board in red marker (See Figure XX).

After the completion of the lesson, I asked Sarah about her impressions of how the lesson went. She said that she was not surprised by what she saw, but was pleased that some students seemed to be deepening their understanding. Still, she remained concerned about two students in particular who were disengaged for most of the lesson. Sarah referred to a rewards system she put into place this year to specifically deal with some challenging students in her class, “I’ve put lots of different things in place.” She also mentioned that of her twenty students, she currently had five students being tested for “various things.” She shared that this was because of the structure in her classroom that encouraged first-grade teachers to place students on her roster. Still, Sarah returned to the math talk she heard in the lesson. “I heard students interact and a student asked a question, ‘What’s another way?’” Sarah confirmed that that specific question came from Question Starter cards that she keeps in her classroom. “We don’t have them in our possession today, but that told me that she’s using that.” Overall, though there were some challenging behaviors in the classroom, Sarah was pleased with the math talk emerging.

*Teaching students how to participate in mathematical discourse.* Sarah made clear that she expects that all of her students, across a range of diverse backgrounds, can substantively
contribute to high-quality mathematics discourse. Sarah had this to say about her challenges as she scaffolds the talk of children with learning differences:

Students can put their thoughts on the paper, especially if you give them chart paper and markers, can explain what they are thinking or how they got to a certain conclusion. I find that a lot of limited language children can still share with you how they got, they can show their thinking. It also validates their thinking and I tell you, the hardest thing for kids with math talk: We have become so much less answer-oriented, and so much more process oriented.

Even when students had challenges with expressing themselves verbally, Sarah found that giving students tools to show their work helped students to show their work and validated their thinking.

Establishing norms for math discourse. At the end of the professional development Sarah responded to a prompt asking what she had learned about classroom discourse and its implementation (SIC). When asked, “What key ideas have you learned about mathematics classroom discourse and its implementation, she replied:

The key ideas I have learned include you must plan!!!!! And set a purpose. If you go in and say you want them to talk about math, you must establish the expectations. You must allow them time to formulate their thoughts. You must teach students to value each other's ideas. Lastly, you must have high expectations, but also realistic expectations for them and yourself.
Her response is in line with my observations of her in the classroom at the time of this follow-up study. That is, Sarah gave her students ample opportunities to demonstrate their mathematical thinking. She planned for ways for students to listen to one another’s mathematical thinking throughout the day, both in math time and during morning routines.

**Planning for math discourse.** Sarah described her planning work in terms of how it fit in with her other PD experience with LTBI, which is based on learning trajectories. “AIM was so much more about discourse and LTBI was giving the teacher the opportunity to figure out where children are on their learning trajectories. They used some of the same strategies, such as Think Alouds or Talk Triangle or Think-Pair-Share.” As Sarah processed how she and other teachers experiences these PD experiences, she continued, “People who had never done AIM took away from LTBI more about the math discourse. And whereas we AIM graduates, if you will, already were doing some of those things.” So Sarah was already planning discourse strategies into her instruction after AIM. The additional PD, LTBI, encouraged Sarah and Melody to continue to use the strategies they already had but also to integrate new ideas from a more math content-based professional development. Witnessing their colleagues who had not experienced AIM focus more on the discourse strategies made them realize how many of the discourse strategies they were already implementing into their own work.

**Collaborating with your team to plan math.** Sarah and Melody planned together constantly and consistently in the years following their participation in Project AIM. As they worked together in subsequent years they incorporated ideas from other PD. In the year that I
completed this follow-up study, the two were working tougher to implement math stations. They described a process of collaborating to discuss how to meet the week’s mathematical objectives.

Promoting conceptual mathematical thinking through rich discourse. Sarah describes a controlled, vibrant environment where the guidelines and parameters she provides frees students to share ideas with one another. Sarah reflected on her classroom, describing it as follows:

We’re not LOUD, I mean, this is a louder class than I am used to. But I have learned to be more accepting of that. And you know, given my age, I’m older and so the quiet classrooms are a thing of the past, and they should be. Now, is there a certain way that you know, I always tell them, your volume is at a five, it needs to be a two. So there are guidelines for when it does get loud. But if you balance out that people need to be able to hear themselves think, they need to be able to hear what their partner is saying, so those structures are in place. But you also need to have the abilities and the opportunities to talk math and to, whatever it looks like. Especially given whatever your goals are.

Sarah framed this discussion in terms of changes she had seen in education as a whole. She acknowledged older models of instruction which centered around quiet seatwork, but also embraced newer ideas about instruction that encourage students to be active, vocal participants. The guidelines and restraints that she put into her classroom allowed discussion to flow and become a regular expectation of the classroom.
Supports and Hindrances to Sustainability. Sarah had several supports for her continued sustainability of the Project AIM core values. These included her close and long-term working relationship with Melody, a supportive school that included teacher assistant support, and additional professional development opportunities. Sarah did express some concern for how her teaching may be viewed in light of her teaching effectiveness and subsequent pay implications. Nevertheless, Sarah’s view that the teaching profession is becoming more about student reasoning and her personal conviction that she must continue to improve herself in order to represent the profession well, supported her continued use of the Project AIM core values.

Sarah Summary. It is difficult for me to tell Sarah’s story without Melody. Sarah and Melody are truly a team. In the “formal” moments of observation I could see them working together, checking in on one another during observations. In the “informal” moments such as turning in forms related to this study, they continued to act as one unit. Still, some of Sarah’s aspects set her apart. She maintained a pragmatism about teaching as a career, acknowledging some of the less pleasant parts of the jobs such as being evaluated for effectiveness and how that impacts her salary. She also distinguished herself as one who finds time outside of the school day to stand up for and represent the teaching profession on a state level. In all, the core values of the Project AIM PD had been conventionalized into Sarah’s work.

Melody

Melody, a white female, earned a Bachelor’s degree in Elementary Education and a Master’s degree in Literacy Education. Melody attended the Project AIM PD with Sarah.
Sarah and Melody’s relationship was very close, with evidence of their ties appearing in every aspect of their interviews and classroom observations. The closeness of their relationship was evident in the ways that they reported pushing one another and planning their lessons together. In one informal interaction, Melody shared that financial reasons had led Sarah to consider leaving the classroom in the previous year. Melody grew somber, stating that she did not know what she would do without Sarah as her teammate and friend at the school. At the time of this study, Sarah had continued to teach at the same school with Melody.

Melody believed that each one of her students was capable of participating in challenging tasks. Melody worked outside of school time as the coordinator for an after-school program for underprivileged kids. In this role she planned reading and math game-based lessons for children in a range of grades. Melody also had something to say about the distinction between theory and practice. When I asked Melody if she still referred to any of the documents from the original PD, she pulled out from her desk and pointed to a sheet with the various strategies. When I asked her why she referred to that particular paper, she replied:

It summarizes everything and it’s practical. That’s a big thing for us. I mean, theory… I remember just from my years working on my Master’s. Theories are huge, but for a practicing teacher it all comes down to application. You know, what can I use with this class tomorrow, today, next week? And then I’ll start reflecting on the theory and what I accomplished and what the kids have learned… all of that.
Melody thoughtfully implemented the strategies that she employed in her classroom, and it was clear that she took post-lesson reflection seriously based on our discussions after each of her implemented lessons.

**A Window into Melody’s Practice.** In order to describe how Melody encouraged discourse in her classroom, I share my observations from a lesson she taught in January 2014. On that day, Melody implemented a money lesson that she called “Money at the Movies,” which dealt with counting coins. In this lesson, the students were asked to count and make change for various snack items one might buy at the movies.

Melody began the lesson with a long conversation about attending movies. She shared a fact that she had heard in the car that morning while dropping off her daughters about it being a record-breaking box-office weekend. She then acknowledged that the lesson they were about to do was a little strange, with true movie concession prices much higher than the less than $1 prices in the lesson.

Melody then had students identify the coins in their manipulative bags. As Melody had forewarned me, she had one ELL student struggling across all subjects. At this point in the lesson Melody’s teaching assistant sat with that student and partnered with that student for the rest of the work to primarily focus on coin recognition and value, as indicated by Melody.

Melody extended her introduction to the lesson by quickly reviewing each coin’s name and value. As she transitioned from the game to the main lesson, she asked the students to hold up 30 cents. She paused, watching the students. Then she stated,
**Melody:** Oh, that’s interesting. Huh. T, you have 2 coins. N, you have 3. You were going to make 30 cents. Is one of them wrong?”

**Several students:** No.

**Melody:** Well, why not?”

**Student 1:** The dime equals ten, and she has three, which equals thirty, and…

**Melody:** Hold on. (Selects another student to explain) Student 1 was just telling us about three dimes making thirty. Student 2, can you tell us what’s going on with the two coins?

**Student 2:** Well, he has a quarter, and that’s twenty-five cents. He also has a nickel. And if you add the nickel, that’s five cents, to the twenty-five, then it would equal thirty.

**Melody:** So, both of them are…

**Students:** The same.

**Melody:** The same. Well, actually, why don’t we talk about that. Is it really the same?

**Students:** No.

**Melody:** They’re the same value.

This transcript highlights one example of how she encouraged students to justify their reasoning, how she tried to encourage a wide variety of voices in discussions, and how she reinforced mathematical vocabulary. Melody used that transition to begin the main part of the lesson, describing the different movie concession prices.
In this portion of the lesson Melody supported the students in forming different values using different coins. At one point she had a child come to the smartboard as a record keeper for the different coin combinations students were describing. The record keeper would drag images of the coins onto the screen so that the class could see.
After this portion of the lesson, Melody brought out a worksheet for the students to work through with their coin manipulatives and their partners. She modeled exactly how the students would engage with the worksheet before setting them loose with the worksheet. She constantly encouraged the students to “build” the coin combinations, using their manipulatives, rather than just thinking about the values.

The students then worked in groups through a number of different problems like the one found on the left. One of the problems the students engaged with had the students spending 80 cents, with 20 cents given in change. Melody selected and sequenced student presentations of their solutions, with the following presentation sequence:
Find out how much change Dom got back from a $1.00.
Figure 12. Lesson Sequence Making Change. In the preceding images you see the sequence Melody chose to share student work.

This sequence to complete the lesson showed that Melody chose a variety of different strategies to highlight in her summary. In the first two images, she highlighted two ways of making change from one dollar. In the first, the child has represented 2 quarters and five dimes, ultimately crossing out the 2 quarters and three of those dimes, leaving 2 dimes for change. In the second picture, we see another variation of this idea, where the student has broken the dollar up into ten dimes and then chooses to count up to 80 on dimes and circle that amount as the amount for the toy, leaving the 2 dimes change. Finally, she ended with the most abstract method of knowing 100 minus eighty is 20 in order to give 20 cents change.
**Teaching students how to participate in mathematical discourse.** Melody shared that she plans carefully for math and anticipates student mistakes. Still, she shared that sometimes her students surprise her and “we end up going off on a segue.” She further reflected on “how powerful that can be if you can let what you’ve got go, and head down that track and see where it leads you.” Melody’s willingness to let the students lead was evident in her classroom, when Melody actively listened to her students’ strategies and comments. This active listening and small detours may have differed from the day’s lesson plan, but they were in line with the overall way that Melody viewed teaching math.

**Establishing norms for math discourse.** Melody described one of the major challenges she found in establishing norms: convincing students to talk to one another, rather than always speaking to the teacher:

Getting those kids to talk that aren’t talking. Getting them, like when we were in the PD, even adults tend to look at the professor when they’re answering a question. And what you really want them to do, is you want them to look at their peers. So even in this, I keep working on how I can fade into the background more. Like today I sat down at a table and intentionally tried to just fit into the chair, you know. Here, look at each other and talk. And certain years it is easier, depending on the personality of the class.

This description was evident when I observed in Melody’s class. Melody structured her lessons so that students had the opportunity to talk to one another, rather than always
looking to her as the final authority on what they were doing. This was particularly evident in the math stations that she facilitated, where students took the opportunity to give tips to one another between switching stations.

**Planning for math discourse.** One of the largest changes in Melody’s math instruction was the way she plans for math each week using math centers. She described a process where she looks at the five lessons planned for the week according to the county’s curriculum map. She and Sarah plan together using the following process:

We’ll determine which three lessons absolutely need to be whole group and we’ll do those Monday-Tuesday-Wednesday. We’ll think about: Is there a lesson that we can combine? Can we put two lessons in one day? Is there anything that lends itself well to small-group settings? Whether it’s math talk or a math game or technology… We use iPads every week.

Melody reflected on where she found the confidence to employ this type of curriculum rearranging:

I think prior to doing AIM and LTBI, I don’t think I would have had the same level of confidence to play with that. And I don’t think I would have felt as good about looking at the lessons, and kind of anticipating. LTBI really taught us how to anticipate […] where the kids are going to struggle and how you are going to approach that.
In the math centers on Thursdays and Fridays, the students complete four centers. Melody explained, “In between centers we have the kids give advice and do reflections before going to the next center. We do two math centers on Thursday and two math centers on Friday.” When I observed Melody’s classroom I had the opportunity to observe her implementation of the math centers and noticed that the students were very comfortable with the process. Melody did not need to take much time to explain the process, but could focus on explaining the basic idea of what would happen at each of the four centers. I noticed that Melody’s teaching assistant was able to assist in one of the four math centers, while Melody facilitated a mathematics discussion at another.

Collaborating with your team to plan math. Melody wishes she had more time to plan with her teammates. Here, she shared a memory from the PD:

I remember being assigned to different groups and different people, like they would mix us up, and they would say, ‘It’s like the kids, like we do with the kids, we want you to get exposure with working with different people.’ And there were definitely benefits to that, don’t get me wrong, and we’d find out some great resources and oh your school does this. But there was also, if it happened too frequently, there was the frustration of, we don’t get enough time. It’s amazing how little time teachers can get together. We dig the time out more than a lot of our co-workers do. So there’s a huge benefit when I think about it. I think about how much I enjoyed working with Sarah.
Melody articulated how much she enjoyed working with Sarah, and my observations during this study clearly corroborated the close working relationship Sarah and Melody shared. This working relationship extended to the depth of planning they employ each week as they plan their math instruction together.

Promoting conceptual mathematical thinking through rich discourse. During the PD the participants did one particularly difficult task that asked them to sort mathematics problem types. Immediately after completing the task, the PD facilitators led a debrief discussion of the activity. In that debrief, the facilitators suggested that the activity was appropriate for teachers to grow their mathematics understanding, but was not necessarily appropriate for students. Melody, however, identified the activity as one that might be appropriate for her students. She believed the students’ discussion helped them gain a better understanding of word problems:

And I’ve got a great group this year. We actually took the plunge even though AIM told us not to, we took the plunge and one of our math centers, we had the kids sort between change plus and minus we put together, and then collection, two-step, and comparison. And it was really cool because they never got frustrated with each other. They definitely got some things wrong. But it got them talking about what was happening and actually thinking more.

I observed this sentiment in Melody’s classroom. During a small group discussion that Melody was leading, one boy began to describe his own invented strategy for two-digit
addition on the hundreds chart in the middle of a small group discussion. Melody temporarily tabled the boy’s idea to describe a more traditional strategy that had been her objective for the small-group discussion. After she checked in with all of the students to make sure they understood her strategy, she returned to the boy’s strategy.

I was particularly interested in this incident because it seemed to highlight exactly how Melody manages different types of discussions when faced with in-the-moment decisions of teaching. When discussing the incident in her debrief, I asked Melody about the interaction. Melody remarked on how she and other students sometimes think the boy is wrong when his strategy is not typical, but when she takes the time to listen to him she realizes he is doing his own, often correct, sense-making. However, talking through challenging problems was at times confusing to the student’s classmates. As in Melody’s case, sometimes the teacher would favor a strategy or explanation that was more accessible to a greater number of students. Melody explained that she was sure to return to the more difficult-to-understand student explanation so that that student’s thinking was valued and reinforced.

**Supports and Hindrances to Sustainability.** Melody’s strong working relationship with Sarah was one of the most important supports of Sarah’s sustained adoption of the Project AIM core values. Sarah and Melody’s principal described them as "the epitome of lifelong learners," seeking out additional learning opportunities and continuing to change their instruction. Melody also worked in a school that was able to give her a part-time teaching assistant and access to iPads to use in her classroom regularly. Finally, Melody’s
previous education, including a Master’s degree in Literacy Education, meant that her previous learning aligned with the new learning opportunities presented in AIM.

**Melody Summary.** One cannot tell Melody’s story without including Sarah. As Melody told me in reference to Sarah, “She’s my work spouse.” These two teachers had an existing school relationship strengthened by doing the AIM PD together. They had a positive experience with AIM and recruited 17 additional teachers from their school do a year-long math PD together the next year. Their principal described a change in school culture, but shared she was not sure exactly what was changing mathematics instruction at the school. There was alignment between AIM, Common Core roll-out, and new initiatives in the district. Sarah and Melody spoke about the ways that AIM has changed the way they think about and plan for lessons; they felt empowered to make changes to lessons based on their mathematical goals. The AIM core values were conventionalized in Melody’s classroom.

**Summary of the Teacher Sketches**

In this chapter, I described each of the six participating teachers. Each teacher sketch included information about how the teachers sustained the Project AIM core values and the supports and hindrances of that sustainability. The teacher sketches revealed that Margaret did not conventionalize the Project AIM ideas into her work, but the other five participants did. The sketches further revealed that Margaret and Karrie had both moved to different teaching contexts since the completion of the PD, while Nora, June, Sarah, and Melody had largely stayed in the same teaching contexts. In the next chapter I will further explore these relationships with the cross-case analysis.
Chapter 5

In this chapter I present the results from the cross-case analysis in order to answer the research questions:

(1) In what ways do teachers sustain (or not sustain) the core values of a PD in their instructional practices in the years after the PD intervention?

(2) What factors promote (or do not promote) the sustainability of the PD core values in the years after the PD intervention?

The first research question illustrates the different ways in which the teachers are still using some of the core values of the Project AIM PD. In Research Question 2, I examine the factors that emerged from the findings to encourage or discourage sustainability of the professional development ideas in each teacher’s practice. My answer to the first research question is based on emerging themes, organized by the core values. For each theme I refer to quotes and tableaus from the teacher cases. The evidence presented is not an exhaustive list of the data collected, but rather a subset of the evidence that highlights a given theme. Though this is a cross-case analysis, not every teacher will be represented in each theme. In some cases this may be because a theme was only found in one teacher’s work, and in other cases the theme is best represented by choosing just one or two teacher’s highlights of the theme.

Research Question 1: Sustaining PD Core Values

In this section I provide evidence to answer Research Question 1. Recall that I define sustainability as a teacher’s continued use of the ideals promoted in the PD intervention in
ways congruent with developers’ intent after resources and support for such practices have been withdrawn. In order to consider what has been sustained, one must first identify the initial goals of the PD. For this work, I identified five core values of the Project AIM professional development and I looked for evidence of teachers sustaining those core values.

The results of this classification are organized into the five core values of Project AIM identified earlier:

a. Teaching students how to participate in mathematical discourse,
b. Establishing norms for math discourse,
c. Planning for math discourse,
d. Collaborating with your team to plan math, and
e. Promoting conceptual mathematical thinking through rich discourse.

I further shaped the results for each core value based on my sustainability continuum framework. I defined three different phases: recall, emerging fluency, and conventionalized. In recall, the teacher remembered something about the idea, but there was less evidence that the teacher was working on this idea in his or her practice. Emerging fluency suggested that the teacher practiced an idea in some way in her classroom, but that practice was not conventionalized into her work. Finally, conventionalized implied that the idea had been fully integrated into the teacher’s work in some way. Those ways may include generativity, being rich in structure and connections, and driven by the teacher’s own inquiry, as mentioned in the earlier frameworks. Generativity is the ability to make connections to new circumstances by applying PD ideas in her classroom. The concept of rich in structure and
connections refers to having new knowledge obtained in the PD that is highly structured so that new ideas can be aligned and reorganized; there is something particularly compelling about the way that the teacher is integrating perhaps disparate sources of knowledge as they apply to her practice. Finally, in the trait driven by the teacher’s own inquiry the teacher demonstrates that they have made the PD ideas uniquely their own. Themes for each of the five core values were placed within this framework. After discussing the themes, I return to each of the teachers to describe where they are in the continuum.

1a.) Teaching students how to participate in mathematical discourse. One of the defining characteristics of the Project AIM professional development was the premise that student talk does not just happen upon command, but rather must be nurtured and taught. This concept from the PD was very much related to the core values of planning for math discourse and promoting conceptual mathematical thinking through rich discourse. In this section, I describe my findings related to two important concepts from the PD: gradual release of responsibility and strategies. In order to help teachers understand the motivation for students learning to talk to one another, the PD focused on giving control of the conversation to the students through gradual release of responsibility. In order to enact that concept, the program also emphasized a strategy approach, giving the teachers concrete tools that they could immediately try out in their classrooms to encourage talk.
Table 4
Summary of RQ1a Themes

<table>
<thead>
<tr>
<th>Recall</th>
<th>Emerging Fluency</th>
<th>Conventionalization</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Generativity</td>
</tr>
<tr>
<td>Speaking about strategies</td>
<td>• Releasing control</td>
<td>• Using strategies</td>
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**Recall.** All teachers mentioned some of the strategies from the PD. That is, each teacher mentioned at least two of the discourse-teaching tools, called strategies, introduced in Project AIM. They also mentioned in some way that they there was struggle to let students become the mathematical authority in the classroom.

**Emerging Fluency.** There was no evidence of this portion of the continuum for this core value.

**Conventionalized.** In the process of more fully integrating this concept into their work, I observed several themes related to the concept of teaching students to talk to one another. The first concept involves gradual release of responsibility, or releasing control of the classroom conversation. The second theme is related to using strategies. Both strategies described in this section, All Talk and Talk Triangle, were generative. The releasing control and using strategy themes were completely in line with the types of adaptations the PD designers originally intended. Finally, there was an additional theme called mentoring questioning. This theme was related to Karrie’s work as a coach, where she took a set of experiences, including those with AIM, to teach teachers in her building about questioning.
This type of conventionalization would be categorized as driven by the teacher’s own inquiry as it required a particular ownership of the core value.

*Releasing control.* Those teachers who demonstrated generativity in this theme found that it can be hard to give up the mathematical authority in their classroom, but that this process is valuable and worth the effort. When Karrie worked to coach the teachers in her new building, she found that one new teacher, in particular, was having difficulty turning over the conversation to her students rather than leading the conversation. When Karrie went to guest teach in the classroom the teacher had students reciting formulas before she walked in. Karrie reflected that this related to this new teacher’s struggle with letting go of control in her classroom. Karrie carried the value with her, and in her work in a new context endeavored to help new teachers to see the value in the idea.

Nora also mentioned the challenge of giving up control, though she acknowledged the importance of doing so. As she stated, it can be hard to let go and believe that there are times that students will learn better from one another than from the teacher. In Nora, it was evident that she realized that giving up control in the classroom was something that she had to work toward each year in her classroom. It is appropriate that this would be a tension and struggle with each new group of students, who must learn to take on this role of the authority in the classroom over the course of the year. That Nora acknowledges this tension and her work to turn over control to her students shows her sustainability of that core value.

Sarah also described her classroom as one of “controlled chaos,” where she constantly balanced noise level with productive work. She acknowledged the mental shift that this demanded of her as an “older teacher”, but stressed the importance of inquiry-
oriented instruction in her practice. This acknowledgement of the struggle demonstrated that she acknowledged the importance of releasing control to her students, but also balanced that with her previous teaching practices.

Transferring control in a classroom is a process that begins again with each new group of students. By acknowledging the struggle and continuing to engage with this process year after year, these teachers demonstrated their generativity of this core concept.

*Using strategies.* AIM focused on strategies teachers could take and easily implement in their classroom. During her interview, Melody pulled out and pointed to a list of strategies from Project AIM, indicated that these were among the most important things she learned during the PD. As she explained to me, those strategies were the practical classroom application of the theory ideas that she would go and reflect on outside the classroom.

I observed Karrie employ an All Talk discourse strategy when guest teaching in a classroom. As Karrie reflected on the experience afterward, she was amazed but not exactly surprised at how long it took to have each one of the children say something in the lesson. She suggested that if she were in her own classroom, she would not expect the strategy to take as long because it is one she employed frequently. However, when guest teaching in a classroom with less math talk, it takes much more time to build up and teach the students to talk to one another.

Other teachers mentioned using this strategy frequently, as it was a no-prep way to encourage math talk in the classroom. By observing this and other simple strategies in the teacher’s classrooms, I saw that this type of strategy had continued, generative, use in teachers’ classrooms.
Teachers also continued to use strategies from the PD which took more time and prep. During the professional development Talk Triangle was presented as one method to scaffold student talk in small groups. In the PD’s Summer Institute, teachers saw the phrase, “Think about it, most talk happens in small groups…” Teachers were then presented with the ideas that students must learn to work together in small groups and must also learn to listen and speak mathematically. This strategy required more prep and explicitly taught roles related to participating in the discourse of small groups.

In interviews three years later, Talk Triangle was not a strategy that teachers expressed using frequently. In fact, some teachers gave some specific reasons for choosing pair work instead of groups of three. June shared:

“[W]ith two, everybody has more of a say, than when I’ve noticed with the three’s somebody’s usually left out. … [W]hen we’ve given them the jobs, the talk triangle and that kind of stuff, at least I didn’t do it with this group. At least last year’s group which I thought it would have worked, it was still just a little too difficult for them…”

Sarah further reflected during an interview: “Talk Triangle I don’t use as much because the children argue over, kind of, you know, who gets to talk and whose card it was and…”

Though I did not initially hypothesize based on teachers’ past reactions to the strategy, I saw a modified version of Talk Triangle implemented by both June and Nora at Barnes Elementary. This showed me that although some of the strategies with more prep might not be a frequent “go-to” strategy for the teachers, circumstances still kept the ideas from this type of strategy in teachers’ rotation and use through curriculum and the ways that
the teacher has internalized the strategy. In that way, teachers demonstrated their generativity of some of the more complex strategies promoted in the PD.

*Mentoring questioning.* Karrie’s role as a coach revealed to me how much she had internalized this core value and took some of the Project AIM core values in unanticipated ways. For example, Karrie discussed how she personally grew during the PD in establishing norms for good questioning: Both the types of questions she asked of students and the expected responses, and getting students to ask questions of one another. She also described how she now works with her teachers to help them refine their questioning. Karrie further described the way she is helping third-grade teachers to think about questioning as a tool to elicit thinking and help students learn to talk to one another:

You know, one of the things that I was talking to the third-grade team about yesterday was how you approach questions, like as an expectation rather than an opportunity. Like think about it, if you’re at the end of your lesson and you’re wrapping up. You say, ‘Does anybody have any questions?’ and you’re really hoping the answer is no because you just want to move on. But if you phrase it in a way where you expect questions, “Tell me what questions you have,” that’s different. That means I do believe that questions are valuable. Just helping them think about questions as a teaching tool, not a roadblock or bump in the road.

By speaking with Karrie and observing her guest teach with certain coaching goals in mind, it was apparent that Karrie had found ways to take what she learned in the PD about
questioning and expand it in ways not necessarily imagined by the PD creators. She had conventionalized good questioning in her work in a way that is driven by her own inquiry.

1b.) Establishing norms for math discourse. During the PD teachers engaged with the topic of establishing norms throughout their year of professional development. During the final session of the PD, these teachers had the opportunity to talk about how they would set up their classrooms at the beginning of the subsequent school year to set the expectation that all students would be required to engage in mathematical discourse. During that session, each school team reflected on norms and developed advice for other teachers. In the following table I show the themes related to establishing norms for math discourse. In it, there are four themed related to the conventionalization of establishing norms.

Table 5
Summary of RQ1b Themes

<table>
<thead>
<tr>
<th>Recall</th>
<th>Emerging Fluency</th>
<th>Conventionalized</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Generativity</td>
</tr>
<tr>
<td>Speaking about norms</td>
<td></td>
<td>• Missing home conversations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Respecting diverse populations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Prioritizing small group work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Promoting math talk with routines</td>
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</tbody>
</table>
**Recall.** All of the teachers mentioned norms in some way. Though Margaret spoke quite a bit about establishing norms, she focused more on behavior expectations than mathematical norms.

**Emerging Fluency.** There was not evidence for this portion of the continuum.

**Conventionalized.** The teachers who conventionalized this core value did so with Generativity. In other words, the themes of *missing home conversations, respecting diverse populations, prioritizing small group work,* and *promoting math talk with routines* are all themes that align with teachers who have internalized that core value and are continuing to struggle with the challenges associated with adapting that core value to their classroom contexts.

**Missing home conversations.** The teachers described ongoing challenges in finding ways to focus students’ talk so that it is productive and so that all voices are heard. One theme that emerged from the teachers was that in some cases, a student’s ability to do math talk was really just the student learning to have substantive conversations with others aside from math. At two schools the teachers wondered whether part of students’ struggles with learning math talk have to do with their lack of the conversations at home. The lack of family ‘dinner conversations’ was identified as a possible reason that the teachers were struggling to set up expectations for conversations at school.

June spoke about some of the challenges she faced with her ELL population. She speculated that in addition to the students struggling to learn English, those same students tended to have less educated parents. Based on her conversations with her students’ caretakers and her interactions with her students, she found that most students did not
practice conversations at home in English: “The majority of [the ELL students’] conversations are truly here at school. So, that comfort is not quite as solid as others’.” Therefore, June looked for further ways to scaffold those ELLs’ language and conversation skills. June’s persistence in scaffolding these AIM ideas showed her generativity in continuing to build those norms in her school context.

_Respecting diverse populations._ Teachers also discussed affect issues involving shy students and ELLs’ participation in math talk. Sarah made clear that she expected that all of her students, across a range of diverse backgrounds, could substantively contribute to high-quality mathematics discourse. Sarah had this to say about her challenges as she implemented scaffolds for the talk of language learners, “I find that a lot of limited language children can still share with you how they got, they can show their thinking. It also validates their thinking and I tell you, the hardest thing for kids with math talk: We have become so much less answer-oriented, and so much more process oriented.” Sarah clearly expected that all of her students were able to participate in mathematical conversations and she looked for ways to support their participation, which demonstrated her generativity of this idea.

_Prioritizing small group work._ I found that an emphasis on small group work was still evident in the teachers’ work. Melody expressed a challenge associated with directing and guiding students’ conversations: “[T]he loudest kids are always the kids who are going to tend to get their voices heard. And it tends to be the same kids when they are in a whole group setting.” Melody described her awareness of this issue and her constant struggle to have more voices heard.
Small group work comes with challenges. When asking Margaret what some of her main takeaways were from AIM, she mentioned the challenges of teaching students to work in small groups. June described some of the strategic work she does when teaching her students to work in groups. She purposefully chose pairs so that she could more strategically work with some of the individual student behaviors in her classroom. June used “Thinking Teams” and included a poster on her wall, mentioned before, to describe the sorts of actions that are expected of students during Thinking Teams. Particularly for some of the students in her classroom who were learning social skills through their IEPs, June at times would go into great detail to describe behaviors such as who should hold the pencil as students learned turn-taking.

Similarly, Nora incorporated small group work in her classroom. Through her use of other adults in the room, assigned roles in groups, and her own active monitoring of student work, she was able to keep students math-focused as they engaged in tasks.

Small Group is when every student has an opportunity to speak. The teachers showed generativity in that they recognized the importance of small group work. They also recognized that small group work is a learned activity and put provisions in place so that students would learn to work together in these small groups.

Promoting math talk with routines. Another theme of this core value was the importance of routines. Sarah found the structures and guidelines she put in place to be an appropriate way to keep the conversations on track and focused on the greater goal of enhancing the students’ mathematical understanding. When I interviewed Karrie, I found a similar disposition about how to set up expectations for how math would be discussed in the
classroom. In our conversation, Karrie began by describing a method she uses with her students to train them to think through what is happening in story problems. She went on to describe the importance of establishing these expectations as routine:

**INT:** And the way you describe [facilitating story problem discussions] is so natural. And that goes back to what you were saying, that you don’t have to plan in the same way that you used to. Or that’s what it reminds me of. It just seems so… you describe this so fluently.

**Karrie:** Right. And it’s like, the kids expect it. I mean, you do it five times, then the kids are used to the structure, they know what’s coming next, and so they’re better prepared to engage with it.

In this theme promoting math talk with routines, the teachers described the importance of setting the expectation for math talk, the need to slowly release control of the conversation from being more teacher-driven to more student-driven, and the need to set up the student expectations that they will be in these routines throughout the school year. This theme highlighted the teacher’s generativity in taking an idea from the PD and applying it to their school context appropriately.

1c.) **Planning for math discourse.** This core value originated with Project AIM’s emphasis that rich discourse happens through careful planning. This core value was reinforced throughout the professional development by frequently asking teachers to work together with their school teams to plan discourse-rich lessons. The types of planning emphasized in the Project AIM PD included: planning for a mathematical goal, planning for the type of discussion, and planning with grade level team members. For this core value I describe only each teacher’s individual planning for mathematical goals and types of discussions. I save the evidence related to team planning for the next core value.
During the course of the Project AIM PD participants had the chance to speak about careful planning and further had the opportunity to begin transformation of their own work by purposefully planning lessons outside of the PD hours. I observed one teacher who recalled aspects of planning and showed emerging fluency in planning and five teachers who demonstrated conventionalization. An overview of those results is shown in the following table:

**Table 6**

Summary of RQ1c Themes

<table>
<thead>
<tr>
<th>Recall</th>
<th>Emerging Fluency</th>
<th>Conventionalized</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Generativity</td>
</tr>
</tbody>
</table>
| Planning with time restrictions | • Choosing appropriate tasks  
• Setting mathematics goals  
• Setting discourse goals | Planning based on a combination of AIM and other PD | Mentoring others to plan well |

Those teachers who conventionalized this theme focused on the ways that their professional learning, including their professional learning from AIM, changed the way that they planned for mathematics. As a whole, they spoke about how they were better able to plan since they could think about their instruction in terms of specific goals. There were three themes that I categorized as generativity: *choosing appropriate tasks, setting mathematics goals*, and *setting discourse goals*. With these three themes, teachers demonstrated that they were still looking at specific aspects of Project AIM and applying those ideas to their work.
In the theme of planning based on a combination of AIM and other PD, some teachers demonstrated a highly structured approach to planning that was inextricably linked to other PD they attended: they were able to integrate ideas from both the AIM PD and other PD in a unique way. Finally, the theme of mentoring others to plan well was categorized as driven by the teacher’s own inquiry. In this theme, there was adaptation of AIM that required a deeper level of adoption and adaptation.

**Recall.** Each of the teachers, when asked, demonstrated that they recalled planning as an aspect of the AIM PD.

**Emerging Fluency.** All of the teachers described planning with time constraints as a challenge for planning well for math discourse. For Margaret, this seemed to be a particular barrier to frequently planning for activities. Margaret enthusiastically described a lesson where she asked students to act out a story problem:

> They loved it! I think they understood it better. And one of my children, he said, ‘Oh I get it now.’ Yeah, I loved hearing that. I need to do more of that.” When asked what kept her from doing more of that type of activity she responded, “Not enough time to plan lessons, and to really think, thoughtfully, about how this is what I want them to learn. How am I gonna get there? Yeah, just not enough time.

For this theme, lack of time was named as an insurmountable barrier to being able to plan high-quality, discourse-centered lessons. Lack of time to plan with teammates was an obstacle mentioned by several teachers and will be addressed in the discussion of the next core value.
Conventionalized. I observed many ways that the five teachers who had conventionalized this core value planned for discourse to enact rich mathematics discourse. These themes emerged: choosing appropriate tasks, setting mathematics goals, setting discourse goals, planning based on a combination of AIM and other PD, and mentoring others to plan well.

Choosing appropriate tasks. Several teachers mentioned the importance of task selection when planning to enact discourse. June described the challenge she found in choosing good tasks when some students were used to being able to work through tasks without thinking: “So that’s kind of what I’m thinking about [when choosing a task]. It’s what’s going to push them to get wrong answers at times and really have to use their precision […] to justify.” June described further that she critically examined problems labeled as ‘challenge’ problems to see if they were truly high-demand tasks.

Melody went into more detail to describe how AIM changed the way she looked at curriculum materials given to her. Similarly to June, Melody was more critical in her selection. She chose tasks in order to help her accomplish her goals for the day:

I think before AIM, I would really read that script follow through what I could, accomplish what I could. Versus after AIM and the other math programs that I’ve done, like I said, look at it with a skeptical eye, and pick the pieces that are going to accomplish that goal. I’ve learned to set a mathematical goal.
Melody described how she plans for and thinks about her mathematics instruction differently. Her ability to plan carefully did not constrain her when it was appropriate to follow the students in a surprising direction. Her ability to plan tasks carefully helped her anticipate some of the common errors that she might see while also being flexible when appropriate.

In each of those examples, the teachers demonstrated that they had taken an idea from the AIM PD and continued its use with generativity to adapt it to their own unique circumstances.

*Setting mathematical goals.* I also saw evidence of the teachers choosing their mathematical goals differently after AIM. In the following transcript, Karrie described one of her main take-aways from AIM:

> And so, the standards are so big. And they’re like 500 skills within that standard. And I don’t need to focus on all of that. Like, we don’t need to conquer that whole standard today. But I want to focus on one specific thing that I want them to get today. That has really helped me focus, and it has really helped me ask better questions.

In other words, AIM changed the way Karrie thought about planning for a daily lesson’s math goals. She displayed generativity in the way she internalized a key component of how AIM described planning and then continued to plan in that way.

*Setting discourse goals.* Sarah said that AIM changed the way that she approached teaching math. When discussing her pre-AIM teaching she said: “I’ve always worked with
children working with groups. But [AIM] gave me more focus and made me more thoughtful.” Sarah further explained:

And then realize that you don’t only have the goal of them learning how to solve the word problems or identifying the numbers or identifying the question, but you had to have a goal for how they’re going to go about it. Not just pencil and paper. But how, a goal for their conversations. And therefore you want certain conversations to happen, and to get them to think more deeply, you have to plan better. And so I definitely plan in a different way. I enjoy planning math. It’s… I like teaching math.
And so I plan for conversation.

Sarah’s discussion about her planning showed that rather than just generally planning for math, AIM and other professional development had given her specific discourse goals to plan for. She talked about enjoying the process of planning for the math lessons. This was evidence of her generativity of this theme.

**Planning based on a combination of AIM and other PD.** Karrie had a very powerful statement about how her planning changed after AIM. As described in her sketch, she reflected that attending AIM gave her the tools she needed to really understand what it means to plan for talk:

I definitely use the strategies. You know, some more than others. I had had that CGI experience, so I definitely believed in talk if that makes sense. I think it just gave me a lot of how to be more successful facilitating talk for the kids. I think that was what has really changed, who had control, maybe, during math… And of course teachers
still have control, but I was just willing to give up a lot more. I didn’t have to facilitate so strongly…

In her statement, Karrie integrated her previous experiences with Cognitively Guided Instruction with the concrete tools that she learned in AIM, then applied those experiences to plan differently.

Melody also demonstrated this theme. When Melody described her planning, she began by describing her and Sarah’s use of Math Centers. Though she and Sarah worked together closely, she was able to articulate how she had changed her ways of thinking about mathematics planning individually. She further explained how her experiences in AIM and additional professional development changed the way she thinks about planning. Recall this quote about how she planned for math a week at a time:

Sarah and I will look through the five lessons [the district pacing guide planned] for the week. And we’ll determine which three lessons absolutely need to be whole group and we’ll do those Monday Tuesday Wednesday, and we’ll think about, is there a lesson we can combine? Can we put two lessons into one day? Is there anything that lends itself well to small group settings? Where it’s math talk or a math game or technology. We use ipads every week, something there? And we take those five days and kind of manipulate and play with them. And I think prior to doing AIM, and LTBI, and I don’t think I would have had the same level of confidence to play with that. And I don’t think I would have felt as good about looking at the lessons, and kind of anticipating. LTBI really taught us to anticipate what are going to be the
problems. Where are the kids going to struggle, and how are you going to approach that.

Sarah’s description of her planning not only assumed that she was confident picking and choosing what was important to discuss, it also described how she was able to confidently decide how she would structurally implement planning by describing different learning goals for different types of instruction.

Both of these teachers were able to articulate how they were able to combine other learning experiences with their AIM learning experiences to continue to enact quality instruction. This demonstrates how they were able to sustain connections that are rich in structure and connections.

*Mentoring others to plan well.* Finally, Karrie’s work as a coach showed ways that she was able to take AIM values and extend them to new and different contexts. As Karrie reflected on her work coaching other teachers to enact rich discourse she stated,

One thing that I have really been encouraging my teachers to do is to plan [talk] in their lesson plans. Like, write down we’re going to do this. Because if they don’t do it intentionally, it’s not going to happen organically. You have to do it intentionally, particularly when you’re learning from it and you’re getting comfortable with it.

Karrie further reflected on what it means to plan for the occasions that she now guest-teaches in other classrooms:
In this unique role of Math Coach, I often find it difficult and frustrating to “guest teach” in classrooms that have not yet developed the level or culture of discourse that I am accustomed to. While I wish to retain high expectations for what students “can do,” I often find myself over-planning because my memories from my own classroom do not match the management style and classroom culture that I walk into.

In her role as a mathematics coach and guest teacher Karrie planned for the typical things she would have had to plan for in her own classroom in addition to finding ways to compensate for the fact that these students were not her own. As a professional she was constantly refining and improving her work. This included finding ways to continually modify and improve her planning in this new leadership role. Much of what she described used AIM ideas to cement her own values, but then the ways that she enacted those values in her coaching role were driven her own inquiry.

1d.) Collaborating with your team to plan math. Many of the teachers mentioned specific changes to their planning due to Project AIM and other professional learning. By requiring teachers to attend with school teammates and then having dedicated times for teachers to plan together with their school colleagues, AIM continually reinforced the importance of team collaboration.

The evidence of sustained, conventionalized adoption of this core value can be clearly seen in two of the teachers in particular. Changes in their planning were intricately linked to how their team planning for mathematics changed. As they mentioned in their focus group, this and then subsequent professional development that they attended together were some of
the key factors for this change. Because this core value was so dependent on team interactions, I present the results in terms of the teachers’ current experiences. I structure the evidence in terms of the teachers in the continuum:

Table 7

<table>
<thead>
<tr>
<th>Recall</th>
<th>Emerging Fluency</th>
<th>Conventionalized</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Generativity</td>
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<tr>
<td></td>
<td></td>
<td>Being Rich in Structure and Connections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Driven by the Teacher’s Own Inquiry</td>
</tr>
<tr>
<td>Speaking about collaborative planning</td>
<td>Functioning as a team but not math-focused</td>
<td>Working together as a team</td>
</tr>
</tbody>
</table>

Though all teachers stated that they valued team collaboration, they expressed a number of challenges in continuing those practices from the PD. Both the Sarah-Melody and June-Nora pairs represent long-standing teaching team collaboration that function well together. Sarah and Melody work very closely together due to their close proximity, and they have several shared professional learning opportunities. June and Nora also work well together, but the strength of their union seems to rely more on how they fit into their larger grade-level team and school.

These pairs seem to stand in contrast to the two “single” teachers described in this study. They did not stay with their other team mates after the conclusion of AIM, which meant that team collaboration was not continued from what was started in AIM. In particular, Margaret suffered from the lack of team support, and her descriptions of the teams she had worked within since the completion of AIM did not imply strong math planning ties.
**Recall.** Margaret, who had worked in several different teams since AIM, stated that her current team struggles to plan. Margaret described some of the challenges associated with planning for mathematics with a team, including being asked to plan in isolation on behalf of her entire team:

But now we’re trying to find our groove this year. We’re not a new team, we’ve been together for, you know, a little while, but our reading specialist wants us to, she was like urging us to, like each person plan a subject. She said a lot of schools are doing that now. A lot of grades at our school are doing that, and we’re getting into it. We’re not there yet. I mean, we’re doing it. I mean, I’m planning the math, but I’m not planning the math. I’m just taking it off [the district curriculum guide’s lessons] and plugging it in to Google Drive. And then it’s never really getting, there’s not an elaborate plan.

Margaret also described some of the challenges she had faced in planning with her team because of moving schools and teams frequently, with teaching assignment changed just before the start of a new job or school year. She remembered that planning math together with teammates was important, but she did not do it.

**Emerging Fluency.** In the focus group June and Nora were clearly collegial and comfortable with one another. They had worked together for many years, and June nurtured Nora into the profession when Nora moved to the school. June and Nora exchanged pleasant stories about their work and other experiences they have had together as colleagues. Based
on their conversations, it was clear that they were happy with the way their larger grade-level team (a total of four teachers that year) functioned together.

*Functioning as a team but not math-focused.* June and Nora stated that the school focus is on literacy so they have much less time to plan for math as a team. It was less clear how this pair continued to plan math together. Though they both described how much they appreciated having time to plan math together during the Project AIM PD, they expressed desire to have time like that again rather than demonstrating that was a value that they had been able to maintain after the PD. Indeed, both teachers were in very different places in the pacing guide and Nora, June’s grade-level chair, acknowledged that June tends to get behind the pacing guide by spending multiple days on some lessons. Nora further highlighted the differences in their two classrooms by pointing out the high number of special needs students in June’s class and how that population demands some different structures and support. When asked specifically about math planning, they said that most of their math discussions came at informal, “playground talk” moments.

In conclusion, while June and Nora enthusiastically planned together during the Project AIM PD and still expressed a desire to have more focused time to plan for math, there was not enough evidence to support the idea that June and Nora had conventionalized this Project AIM core value in their work. They did plan together well and stated that they continued to have some playground conversations, so their implementation of this core value is more strong than recall, but it was not at the level of being conventionalized.

*Conventionalization.* In this section I describe two types of conventionalization related to team collaboration. In the first, Sarah and Melody exemplify working together as a
team, as a well-functioning team in the same vein as imagined in the professional
development, best categorized as generativity. They also articulate the ways in which they
weave together ideas from AIM and LTBI in order to inform their planning together.
Whereas Sarah and Melody describe a more typical, well-functioning team, Karrie’s
conventionalization of the team planning core value is more that she adapts to any team, best
categorized by driven by the teacher’s own inquiry. After collaborating with her team
planning partners in the PD and after the completion of the PD in different contexts, she now
facilitates and grows other grade-level teams in their mathematics planning.

Working together as a team. Sarah and Melody worked together intensely throughout
AIM, carpooling and constantly collaborating. Their close working relationship deepened
with additional PD. The two have continued their close relationship and still planned
together. When asked about the ways that AIM and a subsequent PD, LTBI, has influenced
her team collaboration, Melody mused:

I was like, I don’t know how I’m gonna talk about math for an hour [in this
interview.] It just seems like it’s been so long ago. It’s funny. Like I didn’t realize
how much of it probably does stem from doing AIM and doing LTBI and getting all
that time that we had to think about what we were teaching and how we were
 teaching it. And time to reflect and then go and talk with other people who did the
same thing. You know, that’s stuff we don’t get the time to do.

When further interviewed about their collaboration, Sarah and Melody discussed their give
and take as they plan together for mathematics. They also discussed how much work it is to
plan for math centers, and how they hoped that they could recruit another grade level team member to work with them.

Adapting to any team. In contrast, Karrie’s path had been less linear with regard to team planning. Karrie described fond memories of planning with colleagues during the Project AIM PD year. Since that time, Karrie taught two different grades before landing in her instructional support role. Karrie described positive relationships with her grade level peers in those varying teaching assignments, but there was not enough evidence to say how close those connections were or how she planned with those teams. There was evidence of how Karrie nurtured the grade-level teams with which she worked to plan mathematics together. There was also evidence that Karrie worked well with a reading resource teacher with whom she shared an office in her current role. Consequently, Karrie demonstrated her conventionalization of the Project AIM core value of valuing team planning in terms of driven by her own inquiry. That is, she internalized the core value and applied it to her new coaching context.

1e.) Promoting conceptual mathematical thinking through rich discourse. During the PD, participants engaged in several activities that required them to spend time discussing difficult mathematics problems. One of the purposes of this type of activity was to help the participants see that talking about the mathematics helped all of them to have a greater understanding of the mathematics.

All six of the teachers in this study stated that they valued student discussions in math. Built into AIM were several opportunities for teachers to try out these ideas in their own work, giving each teacher who completed outside-of-PD activities the opportunity to
begin to transform his or her work. By the end of the PD, some of the teachers may have even conventionalized this into their work. At the time of this study I observed some sustainability in one teacher’s work. In five of the six teachers, I observed that their adoption of the AIM core value of promoting conceptual mathematical thinking through rich discourse had been conventionalized in their teaching.

Several themes emerged from the data related to this core value. These themes aligned themselves within the sustainability continuum as conventionalized. In Table 8, I summarize the observed continuum and the themes that emerged:

Table 8
Summary of RQ1e Themes

<table>
<thead>
<tr>
<th>Recall</th>
<th>Emerging Fluency</th>
<th>Conventionalized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Generativity</td>
</tr>
<tr>
<td></td>
<td>Trying activities that support student talk</td>
<td>• Making decisions in the moment that support student thinking</td>
</tr>
</tbody>
</table>

For the remainder of the section, I describe in greater detail my observations of the ways in which the teachers demonstrated their current use of this Project AIM core value. There was some weak sustainability of the PD, categorized as emerging fluency, in the theme
of *trying activities that support student talk*. There were four themes that demonstrated conventionalization of this core value. Two core values were Generative, exactly in line with the original intent of the PD: *making decisions in the moment that support student thinking* and *believing students learn from one another*. One theme, *adapting challenging tasks to promote discourse*, is about how a series of professional learning experiences, including AIM, meant that teachers felt empowered to adapt and try out different math tasks. Finally, *developing scaffolds to support students’ discussions* is related to developing activities that help students to develop metacognitive skills and further helps teachers to develop students’ metacognition.

**Recall.** There was no theme in this portion of the continuum.

**Emerging Fluency.** In this category I observed the theme of trying activities that support student talk. Margaret, when asked, stated that she valued student discussions as a way for students to share their thinking in her classroom. Throughout my interview conversations with her, she expressed interest in doing more discussions, as they are a way for students to learn from one another. Yet most of her comments were focused more on how she found other teacher’s math work interesting than how she was able to try these things in her own class. Margaret did try some discussions and explanations in her classes.

Margaret demonstrated that she did have math discussions in her classroom, but facilitating those conversations was challenging. She recounted an episode of student explanation that she claimed did not really help the student receiving the explanation. I also observed in her classroom students explaining their work on the board who appeared uncomfortable in that role while their classmates did not listen well.
This example from Margaret’s classroom led me to believe that though she recalled and occasionally tried out the core value of promoting conceptual mathematical thinking through rich discourse, she was not yet able to facilitate those sorts of conversations in her classroom on a regular basis and this was not conventionalized in her practice.

**Conventionalized.** Those teachers who had conventionalized most of the other core values (with the possible exception of 1d team collaboration) also believed mathematics discourse to be important to having students think deeply about mathematics. These teachers made rich discourse a priority. The teachers who conventionalized this belief maintained discourse as an expected, integral component of their math classrooms. In the following sections I present some of the themes that emerged relating to their conventionalization.

*Makes decisions in the moment that support student thinking.* I observed this sentiment in Melody’s classroom. During a small group discussion that Melody was leading, one boy began to describe his own invented strategy for two digit addition on the hundreds chart in the middle of a small group discussion. Melody temporarily tabled the boy’s idea to describe a more traditional strategy that had been her objective for the small group discussion. After she checked in with all of the students to make sure they understood her strategy, she returned to the boy’s strategy.

I was particularly interested in this incident because it seemed to highlight exactly how Melody manages different types of discussions when faced with in-the-moment decisions of teaching. When discussing the incident in her debrief, I asked Melody about the interaction. Melody explained that she was sure to return to the more difficult to understand
student explanation so that that student’s thinking was valued and reinforced. This type of teacher move demonstrates generativity of this core value.

*Believing students learn from one another.* Several teachers expressed to me the belief that students learn from one another. June created an expectation of talk in her classroom. Creating this culture was supported because she worked in a school where student discussions were an expectation across all subjects. This was evident as June described her classroom and the way that she supported the talk that was expected in her school:

> Everything is team focused. […] Lots of cooperative learning and in here I call them thinking teams. So, when you’re working in your thinking team what should you be doing? On topic, you know, we have our math thinking team ideas of okay, talk about on topic. And justify your answer, use different strategies, ask questions. […] If you don’t agree say ‘mmmmkay, I think it could be this….’ We have it just spelled out this is what you do in your thinking team.

June’s description showed some of the specific expectations that she implemented and continued to reinforce throughout the semester. See the Thinking Team poster from Chapter 4 for a reminder of how June made an anchor chart visible to her students so that they would know exactly what to expect and do when they were speaking with one another.

This belief in student justifications was also apparent in the way Nora described her philosophy toward her students learning math:

> We are starting number sense now. You know, that’s so important in second grade, the major work that we do, and I wanna make sure that every kid understands it. But
sometimes you have to kinda let that go and hope that maybe they will understand it better when they’re hearing conversation and hearing their peers share. You have to, kind of, take away some of the control from me and give it to the kids.

In summary, both June and Nora held a strong belief that discourse was part of how their students learned math. This belief demonstrated generativity in how they have taken the PD ideas and continued to implement them in their contexts.

*Adapting challenging tasks to promote discourse.* Melody demonstrates how she tried ideas in her classroom to promote discourse on a consistent basis. During the PD the participants did one particularly difficult task that asked them to sort mathematics problem types. Immediately after completing the task, the PD facilitators led a debrief discussion of the activity. In that debrief, the facilitators suggested that the activity was appropriate for teachers to grow their mathematics understanding, but was not necessarily appropriate for students. Melody, however, identified the activity as one that might be appropriate for her students. She believed the students’ discussion helped them gain a better understanding of word problems. Melody felt confident to look at her overall mathematics goals and how they fit within the curriculum, to adapt ideas she sees in one context into another context.

This confidence in her ability to rearrange the curriculum showed that her familiarity with this idea was rich in structure and connections. She felt confident, based on her experience with AIM and subsequent PD, to make these sorts of changes. Sarah also expressed that a combination of the various PD’s that she had attended made her feel capable of making those types of instructional decisions.
Developing scaffolds to support students’ discussions. Finally, there was something unique about the way that Karrie worked to scaffold student discussions. This was particularly true of the way that Karrie taught story problems, both to students and what she modeled for the teachers she worked with. Karrie described, and I then observed her use of, a strategy for talking through story problems with her students. This strategy allowed students to build their own self-questioning and ability to articulate the essential information associated with each story problem. When I observed this lesson in which she guest-taught, Karrie appeared relaxed and confident in using the set of steps. Further, she expressed that she was working with teachers in her building in order to help them implement these types of supports. Teachers expressed that they were having trouble with students simply jumping to a set of steps that may or not make sense, so this type of protocol was one tool Karrie was giving them to help students’ sense-making.

This evolution showed Karrie’s deep beliefs that students have the power to engage deeply with story problems and that teachers can scaffold this work so that students can learn to do so well. In the way that Karrie first developed this set of scaffolds on her own, refined the process with her own students, and then taught this to other teachers, she internalized this core value and then conventionalized it through being driven by her own inquiry.

**Summary of Research Question 1.** In responding to this research question I described the ways in which teachers sustained the professional development ideas, answering: In what ways have core values of the professional development been sustained or not in participating teachers’ instructional practices three years after the intervention? I did so by identifying themes from the data and mapping those themes according to a learning
progression for each of five Project AIM PD core values. These results are summarized in the following table:
### Table 9
Summary of Research Question 1 Themes

<table>
<thead>
<tr>
<th>Recall</th>
<th>Emerging Fluency</th>
<th>Conventionalized</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Generativity</td>
</tr>
</tbody>
</table>
| 1a.) Teaching students how to participate in mathematical discourse | Speaking about strategies | • Releasing control  
• Using strategies | | Mentoring questioning |
| 1b.) Establishing norms for math discourse | Speaking about norms | • Missing home conversations  
• Respecting diverse populations  
• Prioritizing small group work  
• Promoting math talk with routines | | |
| 1c.) Planning for math discourse | Planning with time restrictions | • Choosing appropriate tasks  
• Setting mathematical goals  
• Setting discourse goals | Planning based on a combination of AIM and other PD | Mentoring others to plan well |
| 1d.) Collaborating with your team to plan math | Speaking about collaborative planning | Functioning as a team but not math-focused | Working together as a team | Adapting to any team |
| 1e.) Promoting conceptual mathematical thinking through rich discourse | Trying activities that support student talk | • Making decisions in the moment that support student thinking  
• Believing students learn from one another | Adapting challenging tasks to promote discourse | Developing scaffolds to support students’ discussions |
In order to conclude this section, I return to the six individual teacher cases in terms of the Research Question 1 framework. I recorded when each of the teachers’ practices showed up in the themes presented from the five core values. In the following table, I present a frequency count of how many of the core values were evident in each field. For example, Margaret demonstrated recall in three of the core values and emerging fluency in two of the core values:

Table 10
Teachers’ Core Values on the Sustainability Continuum

<table>
<thead>
<tr>
<th></th>
<th>Recall</th>
<th>Emerging Fluency</th>
<th>Conventionalized</th>
<th>Generativity</th>
<th>Being Rich in Structure and Connections</th>
<th>Driven by the Teacher’s Own Inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Margaret</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Karrie</td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Nora</td>
<td>1</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>1</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarah</td>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melody</td>
<td></td>
<td></td>
<td>5</td>
<td>2</td>
<td></td>
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</tr>
</tbody>
</table>

In looking at the teachers’ practice three years after the PD finished, I noticed that the teachers were still implementing many of the core values in similar ways, which I identified as themes. These themes emerged under the umbrella of conventionalized, implying that many of the teachers had strongly adopted those core values and were implementing them in a way that adapted them to the current contexts. Still, there were some differences in how the teachers conventionalized their work. For example, five of the six teachers demonstrated that their current work represented generativity. However, being rich in structure and connections
also appeared, particularly in ways where teachers were meaningfully implement their work from AIM with some other professional learning experience. And finally there was some evidence of a teacher taking ownership of the idea from Project AIM in a truly unique way, driven by her own inquiry. After examining the preceding table and reflecting on the teachers in terms of this framework and Research Question 1, I placed each teacher along the sustainability continuum.

Table 11
Teachers on the Sustainability Continuum

<table>
<thead>
<tr>
<th>Recall</th>
<th>Emerging Fluency</th>
<th>Conventionalized</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Generativity</td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Margaret</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nora</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarah</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melody</td>
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</tbody>
</table>

Margaret, despite recalling several ideas about the PD and occasionally trying them out in her classroom, did not fully adopt those ideas into her work. Her sustainability was a weak version, not fully realizing the PD’s goals and ideals of practice.

Five of the six teachers had conventionalized the PD ideas into their practice. It is important to note that all five of these teachers demonstrated sustainability, implementing the PD ideas in ways congruent with the PD developer’s initial intent after support for the PD had been withdrawn. However, there was nuance and variability in the ways that the teachers conventionalized those ideas. These were demonstrated and can be parsed by considering the
three distinguishing characteristics as described by Franke et al. (2001). Nora and June demonstrated generativity by continuing to implement the core values, weaving the AIM ideas into their school culture and other learning experiences. Sarah and Melody also demonstrated generativity by integrating AIM ideas into their current classroom instruction. However, they had more evidence of the characteristic being rich in structure and connections. They had an additional math PD experience shortly after AIM that impacted their instruction. Both Sarah and Melody demonstrated that they were able to pull together both of those math PD experiences to meaningfully implement ideas from both of them into their current practice. This made their overall instruction stronger and helped them conventionalize their AIM work.

Finally, Karrie demonstrated that she had conventionalized the Project AIM ideas in all of the ways mentioned for Nora, June, Sarah, and Melody, but she also described ownership of ideas in a way that was uniquely her own. For example, she described, and I witnessed her work in, four of the five core values in a way that I would describe as driven by her own inquiry. From the way that she mentors other teachers in their questioning to how she adapts to any team, Karrie shows that she adapts the AIM ideas in a way that is unique to her.

**Research Question 2: Factors that Aligned to Promote or Hinder Sustainability**

In the last section I detailed themes related to the teachers’ continued use of Project AIM core values. In this section I continue my analysis by describing factors that impacted sustainability. This will answer the second research question, “What factors promote (or do not promote) the sustainability of the PD core values in the years after the PD intervention?”
Recall from the teacher cases in the last chapter that I shared quite a bit about the unique circumstances of each of the teachers. Each of the teachers had factors that seemed to help or hurt her ability to sustain the PD ideas. For example, Margaret and Karrie both changed schools after the PD, and Sarah and Melody worked closely together, seeking out new mathematics PD opportunities. In order to organize all of these factors, I present them at the teacher level, teacher-team level, and with factors beyond the teacher and teacher-team levels. I describe all of the factors that emerged, even if the factor only emerged for a single teacher. I identify factors that promote or factors that do not promote sustainability for each level and then provide a summary of influencing factors for each teacher.

2a.) **Teacher level factors.** I identified eight teacher level factors that seemed to promote sustainability of the professional development ideas and four factors that did not seem to promote sustainability.

*Factors that promote sustainability at the teacher level.* Several teacher level factors emerged that appeared to promote sustainability. These factors described the set of experiences that supported each teacher’s sustainability. For example, several of the teachers were described as seeking out additional learning experiences. The factors that tended to promote sustainability were:

- Completing additional PD before intervention
- Completing additional PD after intervention
- Strongly adopting PD ideas
- Seeking out additional learning experiences
- Attending with cohesive professional development cohort
- Perceiving high-quality PD
- Completing all outside PD assignments
- Displaying mathematics confidence
Completing additional PD before intervention. Karrie had a year-long CGI PD with her teaching colleagues the year before she participated in PD. She named this as an experience that caused her to believe that talk was important, while AIM gave her the tools to carry out that belief.

Completing additional PD after intervention. Most notably, Sarah and Melody recruited a large number of teachers from their school to participate in another math PD after completing Project AIM. This mattered because it meant that Sarah and Melody were able to grow their mathematical excitement and expand the group of teachers with whom they could collaborate for mathematics.

Strongly adopting PD ideas. Karrie described her experience with the Project AIM PD in a way that showed that she had a deep understanding and adaption of the types of understandings intended by the PD. She conventionalized those ideas into her own work. The following quote describes how Karrie understood her experiences with the PD: "[M]aybe it was the power of the facilitators, maybe that’s what it was, but I think with the CGI experience, I had a good, like I had a lot more knowledge after that, but I wasn’t really prepared to act on it. And so through Project AIM I was able to implement it.” Karrie was prepared to accept the Project AIM PD values and fully adopted them in her teaching.

Seeking out additional learning experiences. Nora was a second year teacher when she participated in AIM, and at that early phase in her career she began work on her Master's in Education. She went on to complete the degree and moved into a leadership position as grade chair. Melody and Sarah’s principal described them as the epitome of “lifelong
learners.” As driven learners, these teachers seemed poised to continue their learning and adapt it as necessary to their contexts.

**Attending with cohesive professional development cohort.** These teachers attended every session of the Project AIM PD. This cohort from the PD might be considered unusual because each of the 26 teachers who participated persisted and finished. Therefore all of the teachers in this study came from a PD cohort which was cohesive.

**Perceiving high-quality PD.** Karrie found one of the reasons she carried on and AIM changed her was due to the quality of the original PD, including the embedded nature of practicing strategies outside of class. Karrie pondered what might have caused the change, and part of what she pointed to was the quality of the PD.

**Completing all outside PD assignments.** Each of the teachers completed all of the professional development outside assignments. Those assignments included planning with other teachers, recording a video of their own teaching, and completing an artifact package related to an implemented math lesson. This implies that all of the teachers in some way participated in active learning throughout the PD.

**Displaying mathematics confidence.** Several of the teachers expressed an increased confidence with their mathematical content knowledge for teaching. This was evident in several ways, including their confidence in critically examining and adapting the curriculum they were given.

**Factors that do not promote sustainability at the teacher level.** There were some factors that appeared to hurt sustainability. For example, one teacher expressed that she was
not confident in her mathematics ability. Two other teachers were concerned about personal
teaching evaluations. The factors that did not promote sustainability were:

- Not strongly adopting the PD ideas
- Obtaining alternate initial teacher licensure
- Not displaying mathematics confidence
- Expressing concern about evaluation of effectiveness if teaching looks
different than expected

*Not strongly adopting the PD ideas.* At the end of the PD, despite all participating in
all of the sessions and work, Margaret did not completely adopt the core values. For example,
in Margaret's write-up of her Artifact Package at the end of the PD, she did not appear to
have been as able to enact math discourse as others. When asked at the end of the PD how
here artifact package lesson had encouraged discourse, she replied, "It didn't."

*Obtaining alternate initial teacher licensure.* Margaret described her initial licensure
in agricultural education and acknowledged that she missed some classes, such as math
content classes, that may have been helpful to her in her teaching, in particular in the type of
math teaching described and prescribed by the PD.

*Not displaying mathematics confidence.* Recall Margaret's statement about her first
elementary education position, as a math intervention teacher. She reflected that being
chosen for the position was “hilarious, you know, because I’m not… I don’t have a math
background, and it was like a job that was available. It was a blessing because I probably
learned as much as the children did from my [teaching] partner, who is amazing.” This lack
of confidence appeared to hurt her ability to sustain many of the AIM ideas.
Expressing concern about evaluation of effectiveness if teaching looks different than expected. Sarah and Melody described some concerns about the nature of evaluation in the teaching profession. Sarah stated that she had to consider how her teaching effectiveness may be evaluated if she is teaching in ways consistent with the PD but not necessarily in ways that the evaluator may be looking for.

Summary of factors that do or do not promote sustainability at the teacher level.

The summary of who was influenced by these factors is found in the chart below:
Table 12
Teacher Level Factors

<table>
<thead>
<tr>
<th>Teacher Level</th>
<th>Margaret</th>
<th>Karrie</th>
<th>Nora</th>
<th>June</th>
<th>Sarah</th>
<th>Melody</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promote</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completing additional PD before intervention</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completing additional PD after intervention</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Strongly adopting of the PD ideas</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Seeking out additional learning experiences</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Attending with cohesive professional development cohort</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Perceiving high-quality PD</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Completing all outside PD assignments</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Displaying mathematics confidence</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Do Not Promote</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not completely adopting the PD ideas</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtaining alternate initial teacher licensure</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not displaying mathematics confidence</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expressing concern about evaluation of effectiveness if teaching looks different than expected</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
This summary chart highlights the fact that there were many factors to promote sustainability on the teacher level in the original cohort of the PD, with all of the teachers fully attending the PD and completing all of the outside activities.

2b.) Teacher-team level factors. On the teacher team level I identified three factors that seemed to promote sustainability and three factors that did not appear to promote sustainability.

Factors that promote sustainability at the teacher-team level. Given the selection criteria for choosing participants, I expected that to see teachers who had been together with their former team members to benefit from continue to benefit from those relationships. This teacher group continuity did prove to be a positive factor, along with two others that I had not anticipated. The factors that tended to promote sustainability were:

- Teaching with same group of colleagues
- Teaching in close physical proximity of grade level colleagues
- Displaying a strong team relationship during PD

Teaching with same group of colleagues. This result was not surprising, as it appeared in the literature (Fishman et al, 2011). Nora, June, Sarah, and Melody all benefited from continuing to teach with someone from the Project AIM PD after the completion of the PD.

Teaching in close physical proximity of grade level colleagues. Close proximity of classrooms was a more surprising teacher level factor. It was clear through their conversations and by observing Sarah and Melody that having their classroom doors right across from one another had a large impact on how they functioned together as a teaching
pair. This proximity allowed them to check in one another frequently and informally rather than having to always carve out times for planning.

*Displaying a strong team relationship during PD.* During the PD the seating arrangements of the teachers were frequently changed in order to encourage teachers to work with teachers from other schools. Sometimes, walking into the room and seeing an alternative seating chart on the board was met with groans or minor annoyances. Melody reflected on the experience this way, “It’s amazing how little time teachers can get together. We dig the time out more than a lot of our co-workers do. So there’s a huge benefit when I think about it. I think about how much I enjoyed working with Sarah.”

Sarah and Melody would frequently work even past the conclusion of a PD session to make sure that they had the opportunity to work on the assignment together. In the reflection, Sarah laughed at the memory, declaring, “You would feed us, and we would go, ‘We’ve gotta get this done!’ Because, when we get to school we’ll be… we won’t have time.” Melody chimed in, “That is why we stayed late!”

*Factors that do not promote sustainability at the teacher-team level.* Not all teachers continued to work with their school teams and that did not aid those teachers in their sustainability. Furthermore, even those teams who stayed together still found that they had barriers to working together. The factors that did not promote sustainability were:

- Leaving PD peers
- Managing lack of time to plan math with colleagues
- Prioritizing literacy rather than math
Leaving PD peers. The first factor was predictable based on the literature. When teacher teams did not stay together it was harder for teachers to continue with practices from the professional development. In Margaret’s case, moving away from the team with which she participated in AIM was not helpful to her.

Managing lack of time to plan math with colleagues. The next factor was lack of time to plan with math colleagues. All of the teachers stated structural reasons in their school schedules that revealed challenges for planning with their colleagues. Sarah and Melody, in spite of challenges in finding time, did find ways to meet with one another to plan their math centers.

Prioritizing literacy rather than math. The last challenge was associated with a team focus on literacy rather than math. All of the teachers expressed how limited the time was to meet together to work and plan as a team. Nora and June, in particular, stated that their team focus during that time tended to be on literacy rather than math. When I spoke with them they expressed an interest in spending more time with math, but that was not the current focus.

Summary of factors that do or do not promote sustainability at the teacher-team level. The summary of those factors for each of the participating teachers is found in the chart below:
Table 13
Teacher-Team Level Factors

<table>
<thead>
<tr>
<th>Teacher-Team Level Level</th>
<th>Margaret</th>
<th>Karrie</th>
<th>Nora</th>
<th>June</th>
<th>Sarah</th>
<th>Melody</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promote</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching with same group of colleagues</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Teaching in close physical proximity of grade level colleagues</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displaying a strong team relationship during PD</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Do not Promote</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaving PD peers</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managing lack of time to plan math with colleagues</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Prioritizing literacy rather than math</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

It was unsurprising to see Sarah and Melody with more factors that promote sustainability at the team level. It was also unsurprising to note that Margaret had more factors that did not promote sustainability at that level. It was somewhat more surprising to note that Nora, June, and Karrie all displayed an equal balance of factors that promote or did not sustainability at the teacher team level.

2c.) **Beyond factors.** This broad category takes into account a large variety of factors that are largely outside of the control of the teacher and not directly implied by the Teacher Team level factors. I identified nine factors that promote sustainability and seven factors that did not.
Factors that promote sustainability at the level beyond. These factors were derived from teacher’s perceptions and my observations. In this category I found a number of influences that supported teacher sustainability, but did not seem to fit neatly into the category of teacher level or teacher-team level. For example, alignment of PD goals with the teacher’s current work were often a direct result of the PD designer’s intent. Other factors, like administrator or parent support, supported at least one teacher’s sustainability but was more individual to each teacher’s context.

- Perceiving administrator support
- Finding Parent Support
- Aligning PD goals with school goals
- Aligning PD goals with district goals
- Aligning PD goals with curriculum
- Employing teaching assistants
- Supporting the school financially
- Perceiving partnership during PD development year
- Encouraging autonomy in the work environment

Perceiving administrator support. Sarah and Melody, especially, expressed support from their administrator. For example, after they attended AIM their administrator encouraged them to share about their experiences with the professional development at a staff meeting. With their administrator valuing their mathematics professional learning, Sarah and Melody were supported to continue to engage with the PD ideas.

Finding parent support. I observed additional adult assistance in Nora’s classroom when a parent came in to work with her students as another facilitator during math. I observed this parent to have a good sense of how to assist students in the math tasks that they were engaging with. For example, the volunteer was asking probing questions so that the child would think more deeply about a problem he was working on rather than just telling the
child how to do the problem. When I asked Nora about the parent volunteer, her response was that she was pleased and grateful for the help. She also expressed her confidence in her parent volunteers, stating that she knew that they helped her students. With this support, Nora was able to continue to enact the mathematics discourse in her classroom that she had come to value and implement from AIM.

**Aligning of PD goals with school goals.** The PD goals included encouraging discourse to promote conceptual understanding for mathematics. This closely aligned with Nora and June’s school’s paideia emphasis. Their museum school, with its seminars across all subjects, also valued discourse to promote conceptual understanding.

**Aligning of PD goals with district goals.** The PD developers designed the PD in alignment with the types of math instruction prescribed by the county district. Further, county math coaches, who are district employees, gave substantive feedback that shaped and better aligned the PD with the district goals.

**Aligning of PD with curriculum.** The PD was specifically designed to align with the district curriculum. That is, the textbook specifically required teachers to implement “Math Talk.” The PD valued math talk and gave the teachers tools to implement that type of instruction. Therefore, teachers were learning strategies that directly helped their daily math teaching.

**Employing teaching assistants.** One factor that supported sustainability in Melody and Sarah’s classrooms were classroom were having TAs in the classroom. Melody and Sarah’s school had a PTO organization that supported the school by fundraising each year in order to pay for part-time assistants in each second-grade classroom. Both Melody and Sarah
were enthusiastic and grateful for this support in their classrooms, praising their teaching assistants. Further, they said that having a teacher assistant in the room allowed them to plan purposefully with who would be able to work with students for different math learning objectives.

Supporting the school financially. I observed an advertisement for a carnival, sponsored by the school's parent-teacher organization and other community partners. Sarah and Melody praised the parent-teacher organization, as they raised significant funds for their school to fund such things as part-time teaching assistants. When speaking informally about one of the community sponsors of the carnival, an orthodontist, Sarah joked that the orthodontist could afford to donate back to the school with all of the money she had paid for her children's braces.

Another example was the Parent-teacher organization at June’s school paying for her and a team of teachers to attend a summer arts-initiative professional development.

Perceiving partnership during PD development year. The teachers in this study participated in the Project AIM PD during the development year. Because that was the first full implementation of the PD, the PD facilitators were very receptive to the needs and suggestions of the teachers, and they appreciated that sense of partnership. Several teachers remarked about that feeling of collaboration.

Encouraging autonomy in the work environment. Several of the teachers stated that they felt supported in trying out instruction in ways that would be best for their students. For example, Nora and June were in different places in the math pacing guide, but they felt comfortable doing so because of their administrators. As another example, Melody stated that
they “have a very thorough, set, almost scripted program that we can follow” for math instruction. She shared, “The principals that I have worked under have never required it, [but] there are principals that do.”

**Factors that do not promote sustainability at the level beyond.** There were a number of factors in this nebulous “beyond” category that did not promote sustainability. These related to structural problems such as time constraints and class size and challenging interactions with students or parents.

- Navigating challenging student groups
- Navigating challenging parent interactions
- Handling time constraints
- Accommodating increased class size
- Managing testing expectations
- Perceiving student homes to be without “dinner conversations”

**Navigating challenging student groups.** Participants indicated that examples of challenging student groups included: Classroom management issues and varying classroom personalities from year to year. Margaret was consistent in prioritizing managing the behavior issues in her classroom. Sarah described the personality of her class for the study year as one where she had some trouble managing and focusing the students’ conversations in general, not just in math. Because of these challenges, she mentioned that this year her math discourse goals were different and perhaps not as well-developed as in previous years.

**Navigating challenging parent interactions.** Recall Margaret's quote concerning dealing with parents, "Yeah, I have prayed a lot this year. More than ever. I have prayed for these little students and I pray for me and I pray for me and their parents. Because, you
know, it doesn’t need to be a fight between me and Momma. Like, I don’t want your child not to be able to do good in math."

*Handling time constraints.* Each of the teachers expressed challenges associated with planning for quality math discourse. This was largely related to not having much dedicated time to plan for math. Several teachers expressed that if they wanted to plan for math, they had to carve out time. This is in contrast to a school structure that may give teachers more dedicated time to plan.

*Accommodating increased class size.* Nora and June struggled with class size. They previously had five second-grade teachers at their school. When one teacher left, she was not replaced. With only four second-grade teachers and approximately the same number of students, the teachers’ class sizes had increased. Each expressed concern over the general challenges of teaching a large class, and more specifically facilitating rich conversations when balancing so many young students’ voices.

*Managing testing expectations.* Sarah and Melody expressed concern over how to implement quality math discourse, as this type of conceptual thinking may not directly align with more procedural problems on common tests.

*Perceiving student homes to be without dinner conversations.* All but one teacher expressed concern over how it seemed that students had fewer conversations outside school to encourage them to think critically. They expressed that this made having those conversations in the classroom more difficult, as sometimes students were learning to have conversations primarily at school.
Summary of the factors that do or do not promote sustainability at the level beyond.

After identifying these factors that do or do not promote sustainability, I summarized each of the teacher’s factors for the factors beyond level. A summary of the factors beyond is presented in the table below:
<table>
<thead>
<tr>
<th>Factors Beyond</th>
<th>Promote</th>
<th>Do not promote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceiving administrator support</td>
<td>Margaret</td>
<td>X</td>
</tr>
<tr>
<td>Finding parent support</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Aligning PD goals with School Goals</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Aligning PD goals with District Goals</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Aligning PD goals with Curriculum</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Employing teaching assistants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting the school financially</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceiving partnership during PD development year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encouraging autonomy in the work environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navigating challenging student groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navigating challenging parent interactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handling time constraints</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Accommodating increased class size</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Managing testing expectations</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Perceiving student homes to be without ‘dinner conversations’</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Table 14

Level Beyond Factors
These factor summaries provide an insight to the overall influence of the different teachers involved in this study as a whole. However, with so many factors to consider in this chart and the preceding ones, I chose to develop summaries.

**Teacher sustainability factor summaries.** One natural extension of this type of summary is to summarize the three categories for each of the participating teachers. To develop each summary I counted the number of factors that promote sustainability and the number of factors that do not promote. When the count for both types of factors was equal, I described the level as Neutral. I call these *teacher sustainability factor summaries*. Once I evaluated each of the six teachers, four teacher sustainability factor summaries emerged.

Both Nora and June shared the same summary, which follows:

<table>
<thead>
<tr>
<th>More Factors that promote</th>
<th>Teacher</th>
<th>Teacher Team</th>
<th>Beyond</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Neutral</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>More Factors that do not promote</th>
<th>Teacher</th>
<th>Teacher Team</th>
<th>Beyond</th>
</tr>
</thead>
</table>

Figure 13. Nora and June’s Sustainability Factors Summary.

This summary gives a snapshot of the factors that influenced each teacher’s ability to sustain the Project AIM professional development ideas. Nora and June each had more teacher-level factors that promoted sustainability, including a strong belief in her own mathematical ability and a strong adoption of the professional development core values at the conclusion of the PD. Their teacher-team factors were neutral. Though they continued to teach together after the PD, they did not plan for math together regularly. Finally, both had had more positive factors in that large beyond category. Those factors to promote
sustainability included the paideia emphasis of the school building, so fostering student talk aligned well with the Project AIM PD focus.

Sarah and Melody also shared the same teacher sustainability factors summary. Like Nora and June’s summaries, they each had more teacher factors to promote sustainability and more factors beyond to promote sustainability. However, Sarah and Melody’s close working relationship also meant they had more factors to promote sustainability at the teacher-team level. Their summary follows:

<table>
<thead>
<tr>
<th>More Factors that promote</th>
<th>Teacher</th>
<th>Teacher Team</th>
<th>Beyond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>More Factors that do not promote</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 14. Sarah and Melody's Sustainability Factors Summary.

Karrie’s summary was quite different than the others. She had many factors to promote sustainability at the teacher level, but her circumstances had shifted her teacher-team and beyond factors in the years since the conclusion of her time with the AIM PD, leaving them neutral. Some of her factors to promote include her administrator support and working well with school teams, but she also had negative factors such as no longer working with colleagues from the PD and moving grades, resulting in overall neutral factors. Her summary follows:
Finally, Margaret had more factors that did not promote sustainability across all three of the levels.

In Margaret’s case, there were more factors in all three levels that did not promote her success in sustaining the PD ideas. Despite completing the same PD that the others did, she did not fully adopt the ideas at the end of the PD. When I checked in with her for the purposes of this study, there were too many external factors that were keeping her from being successful in implementation.

**Summary of Cross-Case Analysis**

In this chapter, I began my cross-case analysis by answering the first research question, “In what ways do teachers sustain (or not sustain) the core values of a PD in their instructional practices in the years after the PD intervention?” In order to answer that
question, I presented themes that were categorized as recall, emerging fluency, and conventionalized for each of the five core values from the PD. This framework for reporting the findings illustrated to what extent the teachers continued to use the AIM ideas in their teaching.

In the second portion of the chapter I answered RQ2: What factors promote (or do not promote) the sustainability of the PD core values in the years after the PD intervention? I described factors that promoted or failed to promote teachers’ sustainability of the PD ideas. I compiled three sets of factors that promoted or failed to promote teachers’ sustainability at the: teacher level, teacher team level, and beyond. Finally, I compiled a summary of each of teacher’s factors, called teacher sustainability factors summaries. In the next chapter, I make suggestions for various stakeholders based on these results.
Chapter 6

In this study I sought to describe the ways in which teachers sustained professional development ideas three years after the completion of the PD. To do this I developed a way of describing teachers’ sustainability in terms of the PD’s core values. I also developed a continuum, based on previous sustainability work, to describe to what extent and in what ways teachers were sustaining those core values. In doing so, I described the sustainability of these teachers and presented a possible framework that others may choose to adopt for studying sustainability.

Discussion

One teacher in this study had a weak form of sustainability, while the other five teachers had conventionalized the PD ideas in their everyday practice. These five teachers’ conventionalization presented itself in three defining characteristics: generativity, being rich in structure and connections, and driven by the teacher’s own inquiry. The nuance of these three characteristics highlights the fact that sustainability can present itself in many ways.

In answering Research Question 2 I described factors that contributed to or did not contribute to sustainability. In the review of the literature I found five categories of factors that influence sustainability of PD. With those categories in mind, I was able to look for those factors that have already been identified. Furthermore, I integrated those ideas from the literature along with what emerged from the data, organizing them to provide a framework for describing sustainability of PD at the teacher, teacher team, and beyond levels.
Teachers’ perception of the usefulness of the intervention. This feature was identified as influential in the literature and I also found it to be influential for the teachers of this study. For the teacher who only displayed weak sustainability, her focus was on other things besides the mathematics discourse from Project AIM. The five teachers who had conventionalized the PD described ways in which they were able to practically apply the strategies from the PD to meet their course goals.

Alignment of the PD with current practice. Just as others found, the teachers in this study who conventionalized the PD saw a direct link with the PD ideas to the type of work they wanted to implement in their classrooms. In this study, the factors that supported sustainability included aligning PD goals with curriculum and strongly adopting PD ideas. This was particularly evident in Karrie’s case, a teacher who found so many links between the PD and her philosophy of teaching that she was able to transfer the PD ideas to a variety of contexts.

Alignment with other stakeholder’s expectations of instruction. This investigation found a number of factors that supported sustainability when the PD’s ideals aligned with other stakeholders’. Such factors included aligning PD goals with district goals, aligning PD goals with school goals, and perceiving administrator support for implementing the PD. However, a lack of alignment also revealed itself to be problematic, with factors that did not support sustainability including prioritizing literacy rather than math and expressing concern about evaluation of effectiveness if teaching looks different than expected.

Iteration and adjustment. This category from the literature refers to a particular philosophy about learning from the original PD. The Project AIM PD subscribed to this type
of learning. As a result, much of the PD included this philosophy of trying out ideas, reflecting on them, and continually striving to improve. Based on the ways that the five teachers conventionalized the PD core values, it appears that this philosophy from the PD was continued even after the PD. For those teachers who did conventionalize those ideas, some factors that supported this sustainability were completing additional PD after intervention and perceiving partnership during PD development year.

**Ongoing colleague support.** The final category of factors from the literature concerning sustainability centered on colleague support. This study confirmed that such factors as teaching with the same group of colleagues and displaying a strong team relationship during the PD supported sustainability. On the other hand, leaving PD peers did not promote sustainability. Yet colleague support alone does not predict sustainability; Karrie, in particular, highlights the fact that teacher-level factors may be strong enough to overcome negative other factors.

These five categories of factors that influence sustainability from the literature were confirmed in my study. My study extends and suggests another way of organizing these factors in a teacher, teach-team, and beyond categorization. Based on the factors that do or do not promote sustainability, I identified four teacher sustainability factors summaries. These summaries highlight the different contexts and influences that each of the teachers experiences during and after the PD. In the next section, I combine those summaries with the ways in which teachers displayed sustainability to construct sustainability profiles.
Teacher Sustainability Profiles

The purpose of this study was to examine how teachers continued with PD ideas after the supports of the PD had gone away. A group of practicing teachers, with varying initial experiences, came together to complete a professional development experience together. Each of the teachers in this study completed the entire professional development and all associated assignments outside of the meetings. In this explanation I use the analogy of flight. Each of the teachers came in with their own unique experiences, then engaged in a similar set of slingshot experiences within the PD that propelled them to the moment when they were released to fly on their own.

This follow-up study provided further insights into sustainability. To follow the analogy, it gave insights into each teacher’s flight after the PD. By combining the findings from both research questions, I suggest four Teacher Sustainability Profiles: Glider, Tandem Glider, Self-propelled, and Flight Mismatch.

Glider. A glider aircraft has an elegant and well-engineered vessel that is well-equipped to fly after being propelled into the air. For a teacher to be a glider she must have a strong enough set of teacher-level factors that promote sustainability. These strong personal factors are supported by positive external factors related to sustainability. To recall Coburn’s definition, “Sustaining new instructional approaches is not simply about continuing to do the same thing. It requires that teachers and others make continual adjustments to new conditions and needs at the same time that they maintain the underlying pedagogical approach” (2012). That is, Gliders must be able to skillfully navigate the positive and negative factors that they
encounter, but they also have strong external factors (favorable winds and weather conditions) that buoy their flight.

Both Nora and June conventionalized the Project AIM core values, with work and actions that displayed generativity. They also had the same teacher sustainability factors summary, with more factors that promote sustainability for the teacher and beyond levels. They had some factors that promote sustainability and some factors that do not promote sustainability in their teacher-team level, so that was an overall neutral category for each of them. For external factors, they had more positive factors than negative factors.

Because of their conventionalization of the PD core values and their strong supporting factors, Nora and June are Gliders. They have strong teacher factors which support their ability to adapt to change and sustain high level discourse. Their external conditions are generally favorable to sustainability, with alignment between the AIM PD and school and district goals.

**Tandem Glider.** I use the term Tandem Glider to highlight the idea that a Glider may also have something very compelling about their partnership with others. For a teacher to be a tandem glider, she must have the factors of a glider: positive teacher level factors, positive external factors, and the additional trait of a strong work partnership that nurtures and supports sustainability.

A Tandem Glider is a subset of the Glider grouping. If a teacher is a Tandem Glider, he or she is able to navigate on his or her own, but he or she also has strong external factors that support their flight. In moments of weakness or struggle, the Tandem Glider has strong
team support that can fill in gaps for the partner or even take over and fly for a while, if needed.

Both Sarah and Melody conventionalized the work of Project AIM in their teaching practice, as evidence by defining characteristics of generativity and being rich in structure and connections. Sarah and Melody adapted AIM to their context, sought out additional math PD to support their and their school’s growth, and then deftly integrated ideas from those experiences to support high-quality mathematics learning in their classrooms. Sarah and Melody also had the same Teacher Sustainability Factors Summary, with strong factors that promote sustainability across the board.

Sarah and Melody are both Tandem Gliders. Their unique and strong working relationship, the strength of their teacher team, is what sets them apart from Nora and June. Sarah and Melody have many favorable factors to support sustainability, and have managed to continue to implement PD ideas in a meaningful way. Furthermore, when one is struggling, the other knows that she has that support to carry her along or perform such tasks as plan lessons or conference about a challenging student situation.

**Self-propelled.** A self-propelled airplane has its own engine or propulsion system. It also has a solid flying structure and is well-prepared for long-term flight, including external conditions that may not always be favorable. For a teacher to be self-propelled she must have a strong set of favorable teacher-level factors that promote sustainability. She may or may not have strong external factors that contribute to her overall success. Her teacher level factors are so strong that she can adapt to a wide variety of situations.
It may be true that some teachers labeled as Gliders have strong enough teacher level factors that, given adverse external situations, they would reveal themselves to be Self-propelled. In order to be self-propelled, there must be some indication that the teacher has had to take a very different path of sustainability than the PD had initially envisioned or supported. I place no higher emphasis or value on the label of Self-propelled as opposed to Glider. Gliders do very good work at navigating their circumstances, and most PD designers would hope for the teachers they work with to have similar, favorable circumstances that Gliders enjoy.

Karrie had conventionalized the Project AIM PD in her work. There was evidence of her work in all three of the defining characteristics of conventionalization, but her work was largely categorized as driven by teacher’s own inquiry. In some ways it seems natural that Karrie’s sustainability would be in this form, given the fact that Karrie’s teacher sustainability factors summary indicated she had few factors to support sustainability at the teacher-team level or the beyond level. Despite having neutral other factors, Karrie’s teacher level factors were more positive.

Based on her strong conventionalization and her unique teacher sustainability factors summary Karrie is Self-propelled. As a self-propelled learner, the circumstances she encountered forced her to take ownership of the core values and adapt them in very unique ways for her circumstances.

**Flight Mismatch.** In this category, the aircraft goes through the same set of preparatory exercises, but that slingshot experience does not appear to match what the participant would need in order to fly. This could be due to a number of reasons, but negative
factors in any of the teacher level, teacher team level, or external factors could contribute to this state.

Margaret showed the weakest form of sustainability, often only recalling some of the PD’s core values. Further, her teacher sustainability factors summary reflected more factors that did not promote sustainability for each of the three identified levels.

Margaret had a Flight Mismatch. There was some disconnect between her and the PD that meant she never appeared to conventionalize the ideas. In addition, there were not enough factors after the PD that would have allowed her to further try out those ideas and conventionalize them into her practice.

**Future Research**

Based on the Teacher Sustainability Profiles, I propose further research to develop an instrument to make this classification system more precise. In order to do this, one would need to survey many more teachers and identify different stages along the sustainability continuum and additional factors that promote or do not promote sustainability. In addition, more teacher participants would allow for a greater variety of teacher sustainability factors summaries beyond the four that have already been identified. I would be interested, in particular, to see more summaries where there were neutral or negative teacher factors, but strong teacher team level and/or external factors. For example, I suspect that there may be a category called Piggyback where a teacher has fewer factors to promote sustainability at the teacher level, but more positive factors at the other levels. I would imagine that the strength of that teacher’s external factors and teacher team level factors may carry that teacher, allowing him or her to conventionalize many PD ideas.
In related research, I would like to further study how to identify and further support those teachers who, at the end of the professional development, display a Flight Mismatch.

**Implications of the Results**

As a result of my findings, I make some suggestions for their use for professional development facilitators, school administrators, and teachers. In particular, I return to the findings from Research Question 2, which describe the factors that tended to promote or did not promote sustainability in order to inform these recommendations.

**For professional development designers.** PD designers may look for ways to ensure that as many as possible of the factors that promote sustainability are built into the structure of the professional development. This may include such factors as:

- Including administrators in designing the PD so that teachers feel confident in administrator support in their teaching
- Aligning PD with a teacher’s work expectations, such as the standards they are expected to teach
- Creating online communities to extend additional PD after the conclusion of the PD intervention.

**For professional development facilitators.** PD facilitators can build on PD designer’s work by further aligning “out of classroom” factors to PD as much as possible. For example:

- Require teachers to attend PD in groups and work together in groups.
• Invite administration to attend certain PD sessions so that they are aware of what teachers are doing, particularly in light of teacher assessment tools such as school walk-throughs.

• Make sure that the PD itself is closely aligned with what teachers are expected to do in their schools already, so that the work of the PD does not just feel like ‘one more thing.’

For school administrators. School administrators can support their teachers by listening to what they share about emerging practices in education. Other suggestions include the following:

• Support teachers who want to attend high-quality PD.

• Find ways to build planning for math into the daily schedule so that teachers can work together on a regular basis.

• Place teachers in rooms that are close in proximity, and give them space to collaborate.

• Check in with the PD facilitators about how your teachers are doing.

• If you find a teacher with a “Flight Mismatch,” identify a few tangible actions that you could take to help that teacher, such as finding a way to team her up with another teacher who could support her.

• Consider pairing a “Self-propelled” teacher with a struggling teacher as a mentor.

For teachers. Some possible suggestions for teachers seeking out PD:
• Teachers should look for PD that closely matches what they are expected to teach.
• Consider attending PD with other teachers from your building.
• Choose to attend PD that is offered over time.

Conclusion

Because of the intense focus on PD and the amount of time and money invested into studying quality PD, this study provides a much-needed additional way to study PD effectiveness. Many PD effectiveness measures focus on pre- and post- measures, but this study adds to the growing literature about Sustainability. This study set forth to provide rich descriptions of teachers’ practices by examining teachers’ work through lesson cycles, completed three years after the completion of the PD.

In addition to describing those teacher actions by examining how deeply and in what ways the teachers have sustained PD ideas, this study identified factors that did or did not promote sustainability. Once I identified those factors, I proposed Teacher Sustainability Profiles that may serve as an early warning system for professional development facilitators to identify teachers who may need additional support in order to sustain the professional development ideas.

These profiles describe one way to quickly take a snapshot of the type and extent of teachers’ sustainability after the completion of PD. This type of profile also gives a snapshot of the types of factors that influence that sustainability. If expanded, this work has the potential to enable researchers to summarize a large amount of teacher information in a small
package, enabling them to conduct longitudinal studies on sustainability in a time and cost-efficient way.
References


Lisbon, Spain.


Appendix A
Artifact Package
Artifact Package Submission Checklist

Purpose: The purpose of this activity is to gather an artifact package from you just like you submitted during the AIM PD. The artifact package will be for a lesson that you are teaching during the school year. Please choose a lesson that you feel is representative of the discourse that occurs in your math classroom.

Instructions

Email the following to Christine (cmtaylo5@ncsu.edu) within one week of implementation of your lesson, and no later than DATE. If possible, please email all of the documents at the same time.

- A copy of your lesson plan, labeled LastNameFirstInitial_ArtPack_LessonPlan. You are welcome to provide this in any form that is convenient: Word doc, a picture of a handwritten plan, etc.

- A copy of the problem assigned to students (original and modified version, if applicable). Label the file as LastNameFirstInitial_ArtPack_Task. You are welcome to provide this in any form that is convenient: Word doc, a picture of a handwritten problem, etc.

- The three documents supplied to you, with your answers filled in. The files should be called LastNameFirstInitial_ArtPack_Before, LastNameFirstInitial_ArtPack_After, and LastNameFirstInitial_ArtPack_StudentWork; and

- The sample of student work (photocopy, or photograph) Please label the file as LastNameFirstInitial_ArtPack_WorkSample. Please mark out student name(s) on the work sample. (If you include images of the student work in the LastNameFirstInitial_ArtPack_StudentWork document supplied to you, there is no need to send a separate document titled WorkSample.)

Please contact Christine with any technical questions related to turning in these documents. She will work with you.

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Please contact Christine with any technical questions related to turning in these documents. She will work with you.

Do not use without permission.
Artifact Package
Before the Lesson Planning

Purpose: The purpose of this document is to gather an artifact package from you just like you submitted during the AIM PD. The artifact package will be for a lesson that you are teaching during the school year. This is one of three documents that you will receive to complete for the Artifact Package. Please reference your instruction sheet or contact me with any questions.

Instructions

• Prior to teaching the lesson, type your answers to the questions below in the space provided. Please label this document LastNameFirstInitial_ArtPack_Before.
• Please email a copy of the written lesson plan that was either given to you or one that you created yourself. Label the file LastNameFirstInitial_ArtPack_LessonPlan (example: SmithK_ArtPack1_LessonPlan.doc).
• If not already part of the written lesson plan, email a copy of the original version of the task(s) that you will assign to students as part of the lesson. Additionally, if you altered the task, include the modified version. Please label the problem(s) LastNameFirstInitial_ArtPack_Task
• Email to Christine (cmtaylo5@ncsu.edu) on or before DATE.

1. Lesson details
   a. Length of class period: _______________
   b. Number of students in class: __________
   c. Date(s) the lesson will be implemented: _______________
   d. Topic of the lesson: ________________________
   e. Is there anything you feel we should know about your classroom or teaching situation to help us better understand how you planned and carried out the lesson?

2. What are the mathematics learning goals for the lesson? What mathematical content and practices (from the Common Core) do you hope students will learn?
3. What do you think your students already understand about the mathematical ideas included in this lesson? In what ways does this lesson build on what your students already know about the content?

4. What are the mathematical discourse goals for the lesson in terms of explaining, questioning, listening, and modes of communication?

5. How will the mathematics task(s) for this lesson support students’ engagement in discourse (i.e., explaining, questioning, listening, using modes of communication)?

6. What discourse strategy (or strategies) do you plan to implement? What are your reasons for choosing those strategies?

7. Describe the support or guidance that you plan to provide to help all students engage in discourse in the lesson.

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Artifact Package
Student Work Analysis

Purpose: The purpose of this document is to gather an artifact package from you just like you submitted during the AIM PD. The artifact package will be for a lesson that you are teaching during the school year. This is one of three documents that you will receive to complete for the Artifact Package. Please reference your instruction sheet or contact me with any questions.

Instructions for submitting student work samples
- Mark out the student name(s) on the work samples.
- Scan the student work and email it. Please label the file as LastNameFirstInitial_ArtPack_WorkSample, or insert images of the student work directly into this document.
- Please label this document LastNameFirstInitial_ArtPack_StudentWork.
- Email to Christine (cmtaylo5@ncsu.edu) on or before DATE.

Select a sample of student work (from one student or one group of students) that you think has the potential to promote student discourse around the important mathematical ideas in the lesson. The sample can be one that was shared with the whole class, or one that would have been helpful to share with the whole class.

1. Why did you select this piece of work? What ideas in particular would you want the student(s) to highlight in their work?

2. What questions would/did you ask about this work to make sure the important ideas were highlighted?
Artifact Package
After the Lesson Reflection

Purpose: The purpose of this document is to gather an artifact package from you just like you submitted during the AIM PD. The artifact package will be for a lesson that you are teaching during the school year. This is one of three documents that you will receive to complete for the Artifact Package. Please reference your instruction sheet or contact me with any questions.

Instructions
- After you teach the lesson, type your answers to the following questions in the space provided. Please label this document LastNameFirstInitial_ArtPack_After.
- Email Christine (cmtaylo5@ncsu.edu) on or before DATE.

1. Date(s) the lesson was implemented: ___________

2. Briefly describe the segments of the lesson. Please include:
   - What students were working on and how they were grouped (e.g., in small groups, individually, whole-class),
   - What you did during each segment, and
   - The approximate number of minutes for each of the segments you describe (e.g. students worked on question #1 individually for 5 minutes and then in small groups for 20 minutes).

Example
Students sat at their desks in groups of 3 or 4. I introduced the teddy bear problem to the class (5 minutes). I handed out blank paper to each of the groups and asked if there were any questions. Students worked in their groups to find the answer to the teddy bear problem using the blank paper. I circulated around the room answering questions (20 minutes). When the groups had finished with their drafts, I gave them poster paper. The students decided together in their groups how to organize their final copies and put them on the poster paper (10 minutes). I hung the posters on the wall and asked students to walk around the room and examine all of the posters (5 minutes). We then had a class discussion about the groups’ posters and how they were similar and different (10 minutes).
3. Did you implement the lesson differently than you had planned? If so, what changes did you make and why?

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you implement the lesson differently than you had planned? If so, what changes did you make and why?</td>
</tr>
</tbody>
</table>

4. Describe any support or guidance you gave to students to help them engage in discourse (i.e., explaining, questioning, listening, using modes of communication) in the lesson.

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe any support or guidance you gave to students to help them engage in discourse (i.e., explaining, questioning, listening, using modes of communication) in the lesson.</td>
</tr>
</tbody>
</table>

5. Describe the nature of the discourse students were engaged in during the lesson. What evidence did you see and/or hear in terms of students explaining, questioning, listening or using modes of communication?

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the nature of the discourse students were engaged in during the lesson. What evidence did you see and/or hear in terms of students explaining, questioning, listening or using modes of communication?</td>
</tr>
</tbody>
</table>

6. In what ways did students’ engagement in the discourse help develop their understanding of the mathematical ideas of the lesson?

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>In what ways did students’ engagement in the discourse help develop their understanding of the mathematical ideas of the lesson?</td>
</tr>
</tbody>
</table>

7. Were your mathematics learning and discourse goals for the lesson met? How do you know?

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were your mathematics learning and discourse goals for the lesson met? How do you know?</td>
</tr>
</tbody>
</table>
8. Is there anything else you would like to share that you feel has not been covered by the questions we’ve asked? If so, please share.
Appendix B
Teacher Semi-structured Interview

Hello, thank you for participating in this study. First, let’s go over the informed consent paper that you have signed. Do you have any questions about this study or the informed consent paper? – Okay, with your permission, I would like to record our discussion today. If, at any point, you would like me to turn off the audio recorder, please let me know and I can do that.

Professional background

1. Over two years has passed since the completion of your participation with Project AIM. Please describe any professional learning experiences you have completed since that time? (Includes university courses, in-house PD, mathematics coaching, etc.)
   - Have you taken the opportunity to lead any professional learning opportunities since that time? What did those look like? How did those opportunities arise?
   - Describe any overlap or relationship between your Project AIM PD experiences and the professional learning experiences you experienced after.

Classroom implementation

2. Try to recall your experience during the 2011-2012 school year. How did Project AIM influence your teaching? ---and planning?
   - Were these things that you did before the PD, or were they new from the PD?
   - As you look back, are there any aspects of Project AIM that you are still using? (Describe their use in an example.)
3. Please describe a typical math lesson prior to AIM. During AIM? Since AIM?
4. What, if any, structures did you put into place at the beginning of the year in school years since the AIM PD to encourage math talk?
5. What have you noticed about your students’ learning as you make these changes?
   - Students with IEPS, ELLs?
6. What are the main challenges you face in trying to implement the type of mathematics instruction you learned about in Project AIM?

Outside the team level influences (Team level influences discussed during focus group)

7. How would you describe the administrative support you have received to implement what you learned in Project AIM?
8. Please describe changes that have happened, if any, in the school culture because of your experience in Project AIM.
9. What external factors helped or hurt you in implementing Project AIM ideas in your classroom?

PD Specific influences

10. How would you describe Project AIM to another teacher friend who has never heard of it?
11. Do you still refer to any of the documents from the PD? Which ones, and why?
12. Which of the following documents do you recall or have you used since the completion of the PD? In what way?
   - Discourse types
   - Lesson cycle
   - Lesson planning document

Conclusion

13. Do you have any other impressions of Project AIM or math talk thoughts to share?

Do you have any questions about the research study or your next steps? (Teachers will be about to collect an artifact package for a math lesson, so they may have questions about the directions.)

Thank you, I look forward to getting your artifact packages soon. In the meantime, please feel free to email or call me at any time if you have questions.
Appendix C
Lesson Observation Cycle
Before the Lesson Planning

Instructions
- Prior to teaching the lesson, type your answers to the questions below in the space provided. Please label this document LastNameFirstInitial_ObservLesson1_Before.
- Please email (address below) a copy of your written lesson. It can be a plan that was either given to you or one that you created yourself. Label the file LastNameFirstInitial_ObservLesson1_LessonPlan (example: SmithK_ArtPack1_LessonPlan.doc).
- If not already part of the written lesson plan, email a copy of the original version of the task(s) that you will assign to students as part of the lesson. Additionally, if you altered the task, include the modified version. Please label the problem(s). LastNameFirstInitial_ObservLesson1_Task
- Email to Christine (cmtaylo5@ncsu.edu) at least two days before your observed lesson.

1. Lesson details
   f. Length of class period: ______________
   g. Number of students in class: __________
   h. Date(s) the lesson will be implemented: __________
   i. Topic of the lesson: ___________________________________________________________________
   j. Is there anything you feel we should know about your classroom or teaching situation to help us better understand how you planned and carried out the lesson?

2. What are the mathematics learning goals for the lesson? What mathematical content and practices (from the Common Core) do you hope students will learn?

3. What do you think your students already understand about the mathematical ideas included in this lesson? In what ways does this lesson build on what your students already know about the content?
4. What are the mathematical discourse goals for the lesson in terms of explaining, questioning, listening, and modes of communication?

5. How will the mathematics task(s) for this lesson support students’ engagement in discourse (i.e., explaining, questioning, listening, using modes of communication)?

6. What discourse strategy (or strategies) do you plan to implement? What are your reasons for choosing those strategies?

7. Describe the support or guidance that you plan to provide to help all students engage in discourse in the lesson.
Lesson Observation Cycle
After the Lesson Debrief Protocol

1. What are your overall impressions of the lesson you just taught?

2. What mathematical content and practices (from the Common Core) do you think the students learned? How do you know?

3. Was there anything that surprised you about the lesson? Did you change your actions or plan as a result?

4. What went well during the lesson? What would you have changed?

5. What sort of discourse do you believe you and your students engaged in during that lesson? Why do you think that is the case? What evidence do you have to support that?

6. What discourse strategy (or strategies) do you plan to implement? What are your reasons for choosing those strategies?

7. How do you think the discourse in the lesson impacted student learning, if at all? What evidence do you have to support that?

8. Were you able to implement the discourse strategy (or strategies) that you had planned? Why or why not? Describe the effectiveness of the strategies.

9. Describe how you think the math task you selected supported (or did not support) the students’ engagement in discourse.

10. How will today’s lesson impact your planned lesson for tomorrow?
Appendix D
Teachers Semi-structured Focus Group
(This is a sample protocol. As this is the final data collection instrument for this study, additional questions may emerge from the previous steps of data collection.)

Thank you for agreeing to participate in this focus group. Today you and your school team partner (or former school team partners) will be participating in a focus group. Because this is a focus group, please be aware that your responses cannot be entirely anonymous. If you have any questions about the process, please let me know. – With your permission, I would now like to record our conversation. At any point, if you would like me to turn off the audio recorder, please let me know.

Team Information
1. Please describe your “team background” since the completion of the Project AIM PD in the 2011-2012 school year. That is, please tell me about your teaching assignments, whether or not you have continued to teach together, etc.
2. Please describe the other teams that you reside within, or have resided within, during and since the completion of the PD. (Did your whole grade-level team attend AIM together? Has your grade-level team changed since then? What other grade level teams have you participated in?)
3. Please describe any professional learning experiences you have completed since that time as a team? (Includes university courses, in-house PD, mathematics coaching, etc.)
   - Describe any overlap or relationship between your Project AIM PD experiences and the professional learning experiences you experienced after?
4. What sort of team planning did you do prior to AIM? (Please describe how often you planned, when you planned, what typical planning sessions looked like, time spent on Math versus other subjects....)
5. What was team planning like during the Project AIM Professional Development? (Please describe how often you planned, when you planned, what typical planning sessions looked like, time spent on Math versus other subjects....)
6. What time and space did you have to plan together before Project AIM? (Please describe how often you planned, when you planned, what typical planning sessions looked like, time spent on Math versus other subjects....)
7. What time and space did you have to plan together during Project AIM?
8. What time and space did you have to plan together since Project AIM ended?
9. What time and space do you have to plan together now? How do you decide how to use current team planning time now? Why?
10. What sort of influence have you had on teachers who did not attend Project AIM PD? Why do you think that is so?
11. Do you have anything else to add about your experience participating with others in Project AIM?
Thank you for participation in this focus group. If you have any questions, please do not hesitate to call or email me.
Appendix E
Principal semi-structured interview protocol

Hello, thank you for participating in this study. First, let’s go over the informed consent paper that you have signed. Do you have any questions about this study or the informed consent paper? – Okay, with your permission, I would like to record our discussion today. At any point, if you would like me to turn off the audio recorder, please let me know.

Note: The topics of the questions will remain in line with these questions though they may change based on field experience.

1. What aspects of Project AIM made an impression on you during the 2011-2012 school year?
   o Describe what you noticed when you observed classrooms of Project AIM teachers,
   o Describe how these were the same and/or different from what you observed in their classrooms before Project AIM.
   o Do you still notice those things? If so, what has contributed to sustaining those aspects of their teaching? If not, what has gotten in the way?

2. Did you as an administrator (fellow teacher) provide any support to Project AIM teachers, e.g. allocate planning time in their schedule, collaborate using Project AIM materials, etc.
   o How does Project AIM align with the school’s goals for math instruction?
   o Describe any formal or informal structures that you’ve implemented in order for Project AIM teachers to share their practices with others.

3. Did you notice any staff besides the AIM participants discussing the project?
4. What were some of the benefits of having teachers participate in the project?
5. Were there any drawbacks to having teachers participate? Explain.
6. Describe any lasting effects from the project, if any, that you have noticed.
7. Do you have any other impressions of Project AIM or math talk thoughts to share?

Thank you for your participation. If you have any questions about this study or further thoughts to share, please do not hesitate to contact me by phone or email.