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Forming a Math Crew: Supporting Beginning Teachers to Navigate the Tensions and Contradictions of Equity-oriented Mathematics Teaching

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By

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Abstract

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This dissertation was motivated by a deep commitment to creating robust mathematics learning communities for teachers and for students that are grounded in care, dignity, and connection. Designing for learning from this relational perspective requires disrupting dehumanizing aspects of systems of schooling that function to construct difference and reproduce inequity. For teachers committed to such a vision, the first years of teaching can bring many contradictions and tensions, often with little support for how to navigate them. This dissertation examines the learning that can become possible for beginning teachers when they are immersed in a learning community oriented toward the shared commitment of creating ambitious and equitable classroom mathematics communities.

For this study, I invited six beginning elementary school teachers from the same teacher preparation cohort to join me in designing a learning community, named Math Crew by participants. Drawing on the methodology of social design-based experiments, we co-designed a learning ecology with new tools, artifacts, discursive practices, and norms to support robust learning toward our shared commitments. I acted as lead designer, facilitator, and researcher in the community. The design included monthly community meetings and classroom visits from me as the facilitator. Analyses examined learning over time as changes in participation in community conversations and in classroom teaching, and learning in interaction as a collective process mediated by the designed environment of Math Crew.

Findings indicate that being immersed in the Math Crew activity system supported participants to shift from fixing local problems in their classrooms to engaging in relational investigations of teaching and learning that centered students' mathematical experiences. This shift toward relational, student-centered investigation co-evolved and was amplified across community conversations and classroom teaching. Analyses revealed that as participants surfaced and engaged with tensions of equity-oriented teaching, they made visible and contested some of the tacit deficit-focused ways of seeing students, mathematics, and teaching that are prevalent in systems of schooling. As teachers collectively engaged with material representations of schooling, such as district

assessments, they repurposed these artifacts and constructed alternative strengths-based ways of seeing and making sense of the mathematics classroom. Seeing the classroom with this co-constructed inclusive and empathetic vision supported teachers to imagine the classroom from the perspective of their students and to value and connect with students' experiences as mathematical learners. Findings suggest that beginning teachers can take up an ambitious equity-oriented learning agenda when they are part of a learning community that is saturated with new tools and artifacts and that is responsive to the needs and tensions that arise in their daily activity. This dissertation has implications for the design and study of teacher learning as a mediated process afforded and constrained by the complex learning ecologies teachers work within.

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Chapter 1: Introduction

We have learned—through epistemological assumptions, linguistic strategies, and social structures—to deny relationship with others, to literally see others as "not us."

Torres, 2005, p.201

One way in which we close the distance between ourselves and others is through what theologians have characterized as "recognizing the face of the neighbor." Recognizing the face of others creates proximity—a process of fully recognizing the presence of others, which is manifest in our care and love for each other.

Zavala, 2018, p.166

I begin with these quotes because they speak to a central theme of this dissertation: the challenge and the hope of finding new ways to be with each other that close the distance between us and foster rich learning. I consider learning to be social and thus deeply relational. Yet schools often underemphasize the relational aspects of teaching and learning and overemphasize learning as an individual achievement. Current trends in systems of schooling[1] such as the intense focus on measuring and ranking individual performance and the sorting of students into categories such as "Learning Disabled" or "English Language Learner", tend to support us to, in Torres' words, "see others as 'not us.'" This fixation with sorting students produces winners and losers in ways that intersect with social hierarchies and inequities, with the result that students from some nondominant communities continue to be constructed as "struggling" or "failing" (Martin, 2003, 2009). Given the high status of mathematics in the US and the ways mathematics achievement is often conflated with intelligence, math classrooms can be fertile ground for perpetuating the inequities endemic in a schooling culture preoccupied with measuring and categorizing (Martin, 2009; Shah, 2017). Creating learning communities where members "fully recogniz[e] the presence of others" necessitates disrupting aspects of systems of schooling that tend to be dehumanizing and distancing for all the human beings working within them. This dissertation is concerned with the design of robust mathematics learning environments for teachers and for children that are founded on relationships of care, dignity, and connection.

In this introduction, I describe the roots of my commitments to creating more humanizing learning spaces and outline the approach I take to designing mathematics

[1] I use the phrase "systems of schooling" throughout the dissertation to indicate that schooling operates across individuals and institutions and over time as a loose system that affords and constrains the meanings, roles, and positions available within these systems. This is not intended to imply that systems of schooling are monolithic, merely that there are common discourses and practices of schooling that operate diffusely across different contexts.

communities organized to construct relations rather than difference. I offer this dissertation as my current best attempt to translate my commitments into action. My hope is to contribute to the collective effort to disrupt injustice in systems of schooling and to imagine and realize new possibilities for learning.

The theme of closing the distance between ourselves and others is particularly close to my heart because of my own experiences in graduate school as both a student and a teacher. Often, in academic writing we choose to omit the personal side of our stories to conform to the conventions of the genre. I make the deliberate choice to include the personal because to choose not to do so would be to erase a central part of the story and because one of my intentions with this project is to trouble some of the distancing aspects of systems of schooling, including the boundary between the personal and the academic.

My commitments and the conceptions about learning environments that guide this dissertation have been shaped by my experiences as a student and as a teacher. At the end of my first year of graduate school, my husband, Andy, was diagnosed with cancer. After two years of treatment, Andy died, and I became a widow and single mom to our two sons (ages 6 and 8 at the time). Being a graduate student and an instructor in the midst of illness and grief profoundly shaped my thinking about designing environments that support robust learning. In this introduction, I share briefly about my experiences as they relate to my commitment to designing learning spaces that foster connection by supporting us to fully recognize the presence of others.

Learning and Teaching while Grieving

I chose to remain fully enrolled as a graduate student when Andy became sick, during his treatment, and after he died because it gave me a way to stay connected to other people and to academic work that is meaningful to me. Thankfully, my mentors and peers in graduate school were supportive of my decision. Many of my professors and fellow students supported me to participate fully in courses and research groups, and to do so as a human being going through an especially challenging time. For me, it felt important to be open about what was happening in my personal life so that I could show up fully and honestly as a learner. In one instance, a professor let me know that the classroom was not an appropriate place for honesty about personal matters and asked that I not share anything about what was going on in my life outside of graduate school during class time. I chose to withdraw from that course because I knew that being asked to leave part of myself and my experience outside of the classroom doors would constrain my participation, and thus my learning. Aside from that experience, my mentors and professors invited me to participate in the ways that worked for me. I often chose to share about Andy when I introduced myself at the beginning of a new course, crying when I did so. Being vulnerable in this way was intensely uncomfortable for me as it falls outside conventional norms of ways of being in academia. And I did so anyway because being honest felt necessary for me so that I could engage fully in the learning environment as myself for the rest of the semester. Though I suspect my choice made a few people uncomfortable, I was surprised by how many people spoke with me privately to tell me how much it meant to them that I had brought the personal into academic spaces.

Seven months after Andy died, I took on the role of graduate student instructor for a mathematics pedagogy course in a teacher preparation program, teaching a class of 18

pre-service teachers on my own. On the first day of class, I told my students about Andy's illness and death and let them know that I was grieving and also figuring out how to support my two boys through their own grief processes. I explained that I was sharing this with them because it was a central part of my life. It was important to me to collectively create a learning space where we would all be able to show up just as we are without needing to leave behind the reality of our lives. Over the course of the semester, I occasionally talked about Andy and my boys when it seemed relevant to our discussions of teaching and learning. For example, my children were in the 1st and 3rd grades at the time, and I spoke in class about the challenges of sending them off to spend all day in school in the midst of their grief. What mattered most to me, as a mother, was that my boys were part of learning communities that cared for and valued them as human beings. Yet sometimes the focus in their school seemed to be more about measuring their progress on narrow learning objectives than on supporting them to build relationships that would foster rich and connected learning. I offered my own experiences with my children in schools as a way to support pre-service teachers to remember all that they did not know about the complexity in their students' lives and to hold onto the importance of connecting with students as human beings. Over the semester, we worked together to build a community in the pedagogy course that provided care for each member and made space for us to be our full selves, and we talked about how teacher candidates might create similar communities in their classrooms.

What I take most strongly from the experiences of being a student and being a teacher during this difficult time of my life is that we separate the personal from the academic in educational institutions to our own detriment. I could not participate fully as a learner when I was asked to maintain a firm boundary between my personal life and my life as a graduate student. In the spaces where I was able to be my full self, it mattered not only for how I felt in the space, but also for my learning. And the same seemed to be true for the pre-service teachers in my course. After the first day of class, several students shared their own experiences with loss and other personal challenges with me and thanked me for holding space for the complexity of our lives. We did a lot of hard work together that semester, and we continually worked to close the distance between us so that we could bring our full selves to our community. At the end of the semester, many teacher candidates reflected that a central takeaway for them from the math pedagogy course was about what it means to build a caring community that fosters robust learning for everyone. Drawing from these experiences, a deep commitment underlying this dissertation is that we are able to do our best learning when we are members of communities that are founded on relationships of care, dignity, and connection.

Constraints of Systems of Schooling

Various aspects of systems of schooling push against this central aim of creating learning spaces where teachers and students can bring their full selves and feel cared for and valued for their unique contributions. As McDermott (2006) writes,

> A half-century of ethnographic studies has shown that American education is compulsively competitive. In American classrooms, every child not only has to learn, but has to learn better or faster than his or her neighbors (Varenne & McDermott, 1998). Hence American education is well organized to make hierarchy out of any differences that can be claimed,

> however falsely, to be natural, inherent, and potentially consequential in school.
>
> McDermott, 2006, p.12

This emphasis on competition, hierarchy, and difference is inherently distancing, with the purpose being to compare and rank individuals rather than to create communities that build from diverse resources. The types of sorting systems McDermott alludes to are pervasive in our current educational system, from determining which schools are "distinguished" and which are "failing" to the myriad ways that students are sorted into categories and "achievement levels." These systems are predicated on the notion that some schools, teachers, and students have meaningful contributions to make while others do not, a notion that is in contradiction with the aim of creating communities founded on care, dignity, and connection. The organization of learning into units of time, whether with day-by-day pacing guides, grade level standards, or the structuring of learning activities within the school day, is a dominant aspect of schooling. This preoccupation with time lies in contradiction with building communities that support deep learning, as learning does not happen on predetermined timelines. When time pressure is taken as a central organizing feature of learning, connection, care, and dignity can become ancillary, or even unnecessary, aims. A consequence of this focus on hierarchical sorting, with time as a constant pressure on learning, is that implicit norms of schooling can highly constrain acceptable ways of being. Systems of schooling often emphasize narrow learning objectives and frequent measurement toward those objectives. This can lead teachers and students to feel they must leave behind family, personal challenges, first language(s), modes of discourse, or ideas and opinions that are unwelcome as they enter schools. Across these aspects of schooling lies a preoccupation with the performance and improvement of individuals rather than with the creation of communities that leverage diverse resources to engage in rich new forms of collective activity. The central purpose of this dissertation project is to investigate what might become possible when we immerse teachers in learning spaces that provide space and tools to trouble dehumanizing aspects of schooling and to support new forms of activity centered on care, dignity, and connection.

The Creation of Math Crew

My dissertation project grew out of my experience as a math pedagogy instructor for prospective elementary school teachers, described briefly above. During the Master's and credentialing program this pedagogy course was a part of, many of the teacher candidates I worked with developed a deep commitment to creating caring classroom communities organized to value and build on each student's mathematical strengths. At the same time, these aspiring teachers were daunted by the realities of trying to work toward a commitment that was so different from what they saw in many classrooms, where narrow conceptions of mathematics and a preoccupation with identifying and fixing student deficits were often prevalent. In the pedagogy course, teacher candidates often spoke about the challenges of trying to create caring learning communities that value each student's mathematical contributions while working with pacing guides, assessments, and curricula organized around a different understanding of students and of mathematics.

One conversation with a teacher candidate, Kara, who later became a participant in this study, was pivotal in the creation of this dissertation project. For the Master's

projects in the preparation program, students interviewed people who had some expertise in the area of inquiry they had chosen. Several students focused on mathematics for their projects and interviewed me. My interview with Kara, who chose to do her Master's project on differentiation in the elementary mathematics classroom, provided the impetus for this dissertation. When we spoke, Kara had already conducted another interview with a mathematics instructional coach who worked in a local school. In her retelling of that conversation, Kara talked about how the coach explained differentiation in math as a relatively straightforward issue of giving frequent assessments, finding out what students do not know, and then working with small groups of students to fill in these gaps. Kara felt dissatisfied after the conversation but unsure how else she might think about the issue. In our conversation, I spoke with Kara about how the construct of "differentiation" in schools often treats difference as a problem to be solved, but that it is possible to instead think about difference in the mathematics classroom as a valuable resource to leverage to support collective learning. We then spoke at length about what that it might look like to create a community that invited and built on diverse mathematical strengths and how that approach related to the aims of differentiation as meeting the needs of each child in the classroom. Kara told me that she felt relieved after our conversation because it gave her a way of thinking about an issue she knew she would need to address that aligned with her commitment to creating a caring and inclusive classroom math community.

Before I spoke with Kara, I had submitted a proposal to the Institutional Review Board (IRB) for an entirely different dissertation researching an existing equity-oriented professional development program in a local school district. My conversation with Kara helped me realize that I did not want to leave the teacher candidates I had worked with feeling alone and isolated as they tried to create caring classroom communities that value the mathematical strengths of each of their students while working in systems of schooling organized to find and fix deficits. A couple of months before the 2016-17 school year would begin I withdrew my initial IRB proposal and submitted a new proposal outlining a social design-based approach to supporting the transition into teaching for beginning teachers. Instead of researching an existing structure, I chose to work with Kara and other teacher candidates to co-design a learning community (named Math Crew by participants) intended to support teachers to stay committed to and continue to work toward creating classroom math communities founded on care, dignity, and connection, even when working in systems of schooling where that commitment was not widely held. My choice to design Math Crew *with* teachers was a way to hold central the aim of creating a space where we would continually strive to fully recognize each other and to value the unique contributions we each brought to the community.

The deep commitment to creating caring, ambitious, and equitable math learning communities that brought each of us to Math Crew required that we figure out how we might disrupt dehumanizing aspects of systems schooling, while still working within them. In using the term disruption, I intend to draw attention to the fact that escaping these aspects of schooling is not possible, given that we are all participating in these systems at different levels, whether at a university, or in elementary schools and classrooms. Instead, the intention of Math Crew was to construct a learning ecology where we could push on common sense cultural notions of how we design learning environments to try to create a space that supported new ways of being with each other

that honored our full complexity as human beings. Here, I draw on the notion of culture as "a product of people hammering each other into shape with the well-structured tools already available" (McDermott & Varenne, 1995, p.326). Math Crew was designed in the hope that as a community we could collectively create and make use of new tools that would support more humanizing ways of being in schools to foster robust mathematical learning for each student.

Overview of the Dissertation

This dissertation examines teacher learning over time and in interaction in the designed learning ecology of Math Crew. In the chapters that follow, described in detail below, I situate the dissertation in relevant literature, detail my methodological approach to design and analysis, present a series of analyses of learning in Math Crew, and summarize and reflect on the central arguments.

Chapter 2 provides an overview of the theoretical perspectives that motivated and informed the methodological approach taken in this study. I situate the dissertation in prior research on mathematical teaching and learning and on the transition into teaching. I then elaborate the theoretical perspectives that guide the design of Math Crew as a learning ecology, and the study as a whole.

Chapter 3 describes the design and study of Math Crew as a social-designed based experiment intended to support equity-oriented learning for first-year teachers. I provide background and context of the setting, participants, and design of Math Crew to situate the detailed analyses of participant learning that follow. I describe data collection procedures and specify the approaches I take to the analyses of learning presented in the subsequent chapters.

Chapter 4 engages the question: What did teachers learn toward their shared commitment to creating ambitious and equitable classroom mathematics communities? To answer this question, I analyzed changes in participation in teaching activities over time. Analyses of conversations about teaching over the course of the school year revealed a shift from teachers engaging in conversations about teaching by trying to fix local problems to engaging in relational investigations of teaching and learning that centered students' mathematical experiences. I demonstrate that as teachers shifted toward relational investigation, they worked on problems of practice in ways that resulted in enduring changes to their classroom learning ecologies. I show how this learning coevolved and was mediated and amplified through community conversations and classroom teaching, with teachers leveraging resources from Math Crew across these spaces to deepen their learning.

Whereas Chapter 4 focuses on the content of what teachers learned, Chapter 5 pursues the question of *how* teachers' learned to engage in relational investigations of teaching and learning that centered students' mathematical experiences. I find that, in Math Crew, teachers leveraged discussions about the tensions they experienced in their work as opportunities to make visible and to disrupt tacit ways of seeing typical in systems of schooling. In these discussions participants collectively constructed alternative ways of seeing and making sense of the classroom that centered what students *are* doing and why their actions might be understood as sensible in their classroom learning ecology. I examine the nature of the interactional work entailed in constructing this professional vision, identifying discursive practices that functioned to contest deficit-focused ways of seeing and to construct alternatives. I find that developing an inclusive

and empathetic professional vision for mathematics teaching supported teachers to come to know their students as unique mathematical learners and to imagine the classroom from their perspective. I connect this learning to key features of the design of Math Crew as a caring community where teachers surfaced and productively engaged with the tensions in their work with each other in ways that pushed them to new places in their equity-oriented learning.

In Chapter 6, I reflect on the findings presented across the dissertation to consider the implications for the design and study of equity-oriented teacher learning. I explore the limitations of this study and raise questions and suggest directions for future research.

Chapter 2: Prior Research and Theoretical Perspectives

"Its like we had this program, and it was a great program, and then we've been dropped in this mess…All those things you're supposed to be doing, how does one **do** all of that?"

Lauren, 1st year teacher, 2016

This dissertation takes up the problem Lauren describes of supporting beginning teachers from preparation into the first years of teaching, particularly for teachers who are committed to creating classroom mathematics communities that foster deep connection and build from the diverse resources of each student. Lauren's comment highlights two key issues of the transition into teaching: 1) learning to teach is an ongoing process spanning preparation and full time teaching, and 2) ongoing teacher learning takes place in particular settings with different challenges. The design and study of Math Crew was motivated by the need to provide robust support across the transition into teaching that takes seriously learning to teach as an ongoing process embedded in cultural worlds that afford and constrain opportunities for learning.

I begin this chapter by articulating the conceptualization of teacher learning that underlies this study and drawing on research on equity-oriented mathematics teaching and learning to describe the object of learning for Math Crew. I then look to prior research and theoretical perspectives that illuminate the challenges and emerging possibilities of learning toward this vision for beginning teachers working within systems of schooling. I conclude this chapter by connecting these perspectives to the specific methodological approach of this study as a social design-based experiment intended to provide robust support for beginning teachers to learn toward creating classroom mathematics communities founded on principles of care, dignity, and connection.

Conceptualizing Teacher Learning

I conceptualize learning as a mediated process of changing participation in different forms of activity over time (Rogoff, 1994; Rogoff, Baker-Sennett, Lacasa, & Goldsmith, 1995). I consider learning to be "an activity in which heterogeneous meaning-making practices come into contact—explicitly and implicitly, intentionally and emergently—to generate new understandings, extend navigational possibilities, and adapt meaning-making practices to new forms and functions" (Rosebery, Ogonowski, DiSchino, & Warren, 2010, p.324). This social and relational view takes learning to be something that is happening all the time and that is continually shaped and reshaped by participants. In addition, emphasizing *heterogeneous* meaning-making calls attention to a theme throughout this dissertation of conceptualizing diversity as an integral resource for learning rather than as a problem to be overcome. For this study, the conception of learning I describe here applies to children learning mathematics as well as to adults learning to teach.

Taking learning to be a process that is happening all the time as people participate in different activities necessitates clarity in defining learning toward what ends. Beginning teachers learn different discourse, practices, and ways of making sense of students and mathematics as they engage in various teaching activities from classroom teaching to informal conversations with colleagues to staff meetings. The aim of Math

Crew was to support teacher learning toward the goal of understanding students, mathematics, and teaching in ways that align with creating classroom mathematics communities that build on students' diverse mathematical resources to support robust learning for each student.

Toward what ends: Ambitious and equitable classroom mathematics communities

In this section, I draw on research on mathematical teaching and learning to elaborate the shared aim of Math Crew of creating ambitious and equitable classroom mathematics communities. I join other scholars in using the term "ambitious" to refer to math teaching that provides students with opportunities to engage in cognitively demanding math tasks and that considers the ways students make sense of these tasks to be central to instruction (Jackson & Cobb, 2010; Kazemi, Franke, & Lampert, 2009; Lampert, 1990). This kind of teaching is truly "ambitious" because it calls for a different and more challenging role for the teacher than instruction that is centered on the teacher's mathematical ideas. Ambitious teachers must learn how to elicit student ideas about key mathematical content, make sense of those ideas in the moment, and respond to them in ways that support math learning for all students. Taking on this role requires knowledge of the ways students might make sense of the mathematics at hand, as well as a repertoire of teaching practices, such as selecting and designing tasks that reveal student thinking, asking questions to learn more about student thinking, and deciding what to do in the moment when conversations unfold in unexpected ways (Hill, 2010; Kazemi et al., 2009; Lampert, 2001; Sun & van Es, 2015). Ambitious teaching also affords new positions for students by granting them intellectual authority as they grapple with disciplinary content and by holding students accountable to each other and to the discipline (Engle & Conant, 2002). Current research on ambitious mathematics teaching builds on these foundations and moves in new directions to more fully attend to the complexity of students' experiences in math classrooms. For example, the Teaching for Robust Understanding of Mathematics (or TRU) framework posits five dimensions for powerful classrooms, 1) Mathematical Content, 2) Cognitive demand, 3) Equitable access to content, 4) Agency, ownership, and identity, and 5) Formative assessment (Schoenfeld, 2014, 2018). These dimensions take an ambitious and expansive view of mathematical teaching and learning by attending to issues of content as well as to issues of participation and engagement with content such as access, and agency, ownership, and identity. Scholarship on ambitious teaching forms a central foundation of the shared aim of Math Crew of creating classroom communities that value the diverse mathematical contributions and participation of each student as resources to support collective grappling with cognitively demanding mathematical tasks.

Further, I use the phrase "ambitious and equitable" to point to the centrality of a particular conception of equity that guides this study. In line with recent scholarship that interrogates the ways our educational system continues to perpetuate disparate outcomes for different populations of students, I consider equity in mathematics teaching to mean not merely improving access to learning opportunities for all students, but also disrupting dominant hierarchies of power and privilege (R. Gutiérrez, 2008, 2013a; Gutstein, 2003; Leonard & Martin, 2013; Martin, 2003). Research on learning mathematics has drawn attention to the fact that the ways students perceive themselves and are perceived by their peers with respect to mathematics matters for their participation in the mathematical work of the classroom and thus for their learning (Boaler, 2008; Boaler & Greeno, 2000;

Gresalfi, Martin, Hand, & Greeno, 2009; Gresalfi & Cobb, 2011). Research has also increasingly shown that opportunities for students to develop positive mathematical identities are intertwined with larger social inequities. For example, racial narratives have been shown to mediate how students are positioned in the classroom (Nasir & Shah, 2011; Nasir, Snyder, Shah, & Ross, 2013). In addition, preoccupation with achievement "gaps," often named in terms of race, socioeconomic status, or English language proficiency, can perpetuate deficit views of students from nondominant communities, making it difficult for educators to make space for, recognize, and build on the brilliance of these students (R. Gutiérrez & Dixon-Román, 2010; Leonard & Martin, 2013; McDermott, Goldman, & Varenne, 2006). Following this scholarship, I take equitable mathematics teaching to require working toward a more just educational system where students from historically nondominant communities are assumed to have rich and diverse mathematical resources that benefit everyone's mathematical learning, and where teachers deliberately disrupt social hierarchies to create classroom communities in which all students meaningfully contribute to the mathematical work of the classroom.

I use the term "classroom mathematics communities" to highlight the social and relational nature of learning mathematics and the commitment in Math Crew to fostering new ways of being described in the introduction to this dissertation. I consider a central aim of teaching to be to foster social interactions that recognize and value the mathematical contributions of each student as a means of supporting robust collective learning (Lampert, 2001, 2010). This relational approach to teaching and learning is deeply intertwined with the commitments to justice and equity outlined above. Drawing on the work of Philip (2019), I take it as given that "the relational work of teaching includes critically reflecting on and addressing one's own positionality and the ideologies that construct difference and social hierarchy" (p.2). Creating communities that fully recognize the presence of others and invite and value each student's mathematical contributions requires constant critical reflection and ongoing work to counter the hierarchical and deficit-focused discourse and practices pervasive in systems of schooling (McDermott et al., 2006; Philip, 2019; Philip & Benin, 2014).

In ambitious and equitable classroom mathematics communities, students work collaboratively on challenging tasks and engage in mathematical practices, such as looking for patterns, making conjectures, justifying their thinking, making connections across mathematical ideas, and using mathematics to solve non-routine problems. Teachers in these classrooms work towards equitable participation by putting structures in place to remove barriers to participation, such as using particular roles for students in collaborative groups, intervening in small groups when participation is not equitable, and supporting students to develop specific collaborative norms. These teachers work from the assumption that all of their students have strengths that can support collective learning about mathematics. They spend time watching, listening, and getting to know their students as unique mathematical learners. They engage in collective work to challenge and expand their own views about what counts as mathematics and who gets to be seen as mathematically competent. These teachers create opportunities to elicit and highlight the specific mathematical strengths of each student in their classrooms and to support students to build on these strengths to deepen their mathematical learning. Students in these classrooms are supported to come to see themselves as mathematical

thinkers and doers and to see each of their classmates as having important contributions to make to the mathematical work of the class.

The view of mathematical learning outlined above implies an accompanying understanding of the work of teaching. Learning to teach toward this conception of mathematical learning entails not only developing a robust set of teaching practices, it also involves what Philip (2019) has termed "principled improvisation." In this conception of teaching, listening deeply to students with an orientation towards justice, and constantly working to solve "fundamentally unsolvable problems" (Philip, 2019) are taken to be integral to the work of equity-oriented teaching. Teaching and learning is then inextricably tied to a particular place and to specific people, with teaching strategies needing to be constantly adapted and created in response to a complex learning ecology. Conceptualizing the work of teaching in this way calls for a deeper theoretical understanding of the role of "context" in learning to teach. In the next section, I draw on the construct of figured worlds to consider the worlds teachers work within and how those worlds afford and constrain opportunities for learning.

Learning within systems of schooling

Working to create ambitious and equitable classroom mathematics communities while working within systems of schooling involves pushing on existing structures, discourse, and practice that lie in contradiction with this aim. In conceptualizing what is entailed in learning to teach under these conditions, I use the construct of a *figured world* as a "socially and culturally constructed realm of interpretation" that affords and constrains the roles, practices, and meanings available to participants in that world (Holland, Lachicotte, Skinner, & Cain, 1998). Beginning teachers learn to teach within the figured world of schooling. As described by Holland et al., figured worlds "are not so much things or objects to be apprehended, as processes or traditions of apprehension that gather us up and give us form as our lives intersect with them" (p.41). The world of schooling is both gathering up teachers and in a constant process of re-creation as teachers engage with material and ideational artifacts within that world. Artifacts "are the means by which figured worlds are evoked, collectively developed, individually learned, and made socially and personally powerful" (Holland et al., 1998, p. 61).

To help paint a picture of the figured world of schooling, I use color-coded assessment reports as an illustrative example of an artifact that evokes particular understandings of students, mathematics, and teaching. In this figured world, giving students individual assessments of learning objectives, feeding the results into a computer database, and receiving a color coded report of the results is a common practice many teachers across schools and districts are required to participate in. These reports typically depict student assessment performance by numerical score(s), with students categorized into different color-coded achievement levels based on these scores. Many variations of this artifact exist in systems of schooling. The example below shows a sample report from one of the data management systems marketing their products to schools. In this report, student performance on a math assessment is documented over time, with students sorted into color-coded categories based on their overall scores and ranked across different populations.

Student Name	Scaled Score Fall	Scaled Score Winter	Scaled Score Spring	Spring Percentile Rank Class	Spring Percentile Rank School	Spring Percentile Rank District	Spring Percentile Rank National
Runolfsdottir, Juvenal	502 ★	525 ★	516 ★	99	93	89	95
Donnelly, Royce	487 ★	496	510 ★	94	81	81	88
Thompson, Tevin	466 !	498	508 ★	88	76	77	85
Trantow, Shemar	493 ★	503 ★	503	81	74	67	73
Lindgren, Isac	471	499 ★	499	75	67	60	64
Franecki, Lina	496 ★	493	495	69	64	52	54
Wisozk, Gregg	465 !	459 !!	494	63	62	49	52
Rutherford, Royce	445 !!	474 !	491	56	57	43	47
Heaney, Justice	446 !!	472 !	487	50	48	35	40
Kuhn, Micah	459 !	459 !!	484 !	44	40	30	35
Stark, Kari	472	462 !!	480 !	38	38	27	25
Collier, Joelle	448 !!	471 !	479 !	31	36	26	24
Miller, Sydnie	468	468 !!	476 !	25	33	23	16
Langworth, Pete	466 !	475 !	476 !	19	31	22	15
Leannon, Einar	454 !	483	474 !!	13	29	21	12
O'Conner, Madisyn	459 !	467 !!	469 !!	6	19	14	6
Stark, Gregg	452 !	463 !!	466 !!	1	14	12	4

!! high risk ! some risk ★ College Pathway 94% accuracy less than 95% above 85 %ile 31-85 %ile 21-30 %ile 20 %ile & bellow n/a student assessed outside the screening window

Figure 1. Sample Color-coded Assessment Report

The specific example shown above not only sorts students by overall score, but also has embedded another level of sorting of students into "college pathway", "some risk", or "high risk." Artifacts such as this one thus communicate information about what is valued in a given figured world. The commonplace artifact of schooling of color-coded assessment reports evokes mathematical competence as something that can be measured on an individual assessment, students as people to be measured and ranked according to their perceived level of competence, and teaching as the improvement of student performance on individual assessments. These artifacts get taken up in many different ways that impact how the figured world of schooling is "individually learned, and made socially and personally powerful." For example, in one school community, such reports may be taken as hoops to jump through for the district but not as meaningful information about particular students. In a different school community, these reports may be scrutinized at length during staff meetings with the purpose of adjusting instruction to improve student performance. In both cases, the artifact carries with it certain meanings that must be grappled with and made sense of as individuals move within systems of schooling. This artifact is just one example of the myriad ways the construction of difference and hierarchy is built into this figured world.

For teachers who are committed to creating ambitious and equitable classroom mathematics communities, taking up this commitment in their classrooms requires engaging in ongoing learning within the figured world of schooling. As teachers learn to

teach, they engage in heterogeneous meaning-making practices about mathematics, students, and the work of teaching. The cultural artifacts and discourse teachers interact with in their daily lives in schools mediate this learning. When teachers receive information about their class with students labeled as "English Language Learners" or "Learning Disabled", or when they attend staff meetings where colleagues talk about students as "high" and "low", they are learning ways of making sense of students in their school community. Whether or not teachers agree with this discourse and practice, they must constantly bump up against the trappings of the figured world of schooling. Part of the work of learning to teach toward creating ambitious and equitable classroom mathematics communities thus involves navigating the contradictions and tensions of how to work with (or around) school or district practices and policies of the world of schooling that function to reproduce social hierarchy. I consider a contradiction to be "a situation in which inherent factors, actions, or propositions are inconsistent or contrary to one another" (Merriam Webster). For example, for teachers who are aiming to create rigorous, strengths-based classroom math communities, giving students benchmark assessments designed to identify what students do not know is inconsistent with the goal of supporting all students to recognize their own and each others' mathematical strengths. This contradiction can sometimes prompt an experience of tension both for the teacher who may feel pressure to "prepare" her students for a test she may feel is inappropriate for her students, and for students who have to sit through a test that is disconnected from their experiences learning mathematics. These types of contradictions and the feelings of tension accompanying them can be particularly acute for teachers who are working toward a conception of math teaching and learning that is so different from what is currently typical in math classrooms and in schools. In the next section, I turn to the transition from teacher preparation into early career teaching as a pivotal time in the process of learning to teach, as this transition involves moving between different figured worlds and navigating the many contradictions between them.

Moving between Worlds: The Tensions of Supporting Equity-oriented Learning for Beginning Teachers

The transition from teacher preparation into full time teaching is widely recognized as particularly challenging, both because of the overwhelming number of practices a teacher must engage in immediately and because of the disconnect between teacher preparation and full time teaching. A report by Mehta et al. (2015) about what it would take to create a system that supports quality teaching identified that "part of what has been challenging about the American non-system of teacher preparation is that there is no continuity from what one learns in teacher preparation to what is expected during induction, to the ongoing goals of one's school or district" (p. 6). Lauren's comment at the beginning of this chapter speaks to the fact that teachers may experience this "non-system" as dropping off a cliff from preparation into full time classroom teaching (as depicted in Figure 2).

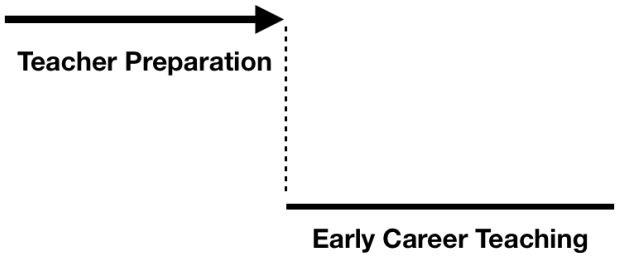


Figure 2. The Disconnect between Teacher Preparation and Early Career Teaching.

In conceptualizing what is challenging about this transition, I return to the idea of figured worlds, considering this issue as a problem of moving between the figured world of university-based teacher preparation and that of the world of schooling (Feiman-Nemser, Schwille, Carver, & Yusko, 1999; Horn, Nolen, Ward, & Campbell, 2008; Nolen, Horn, Ward, & Childers, 2011). Most prospective teachers were educated in K-12 classrooms where learning mathematics was viewed as memorizing and practicing procedures received from teachers, rather than as a mediated process of developing competence with mathematical practices and concepts in interaction with materials and people. Though teacher preparation programs tend to emphasize research-based constructivist and sociocultural theories of learning, pre-service teachers often conduct their student teaching in field placement classrooms with the same type of instruction they experienced as students, organized around a more passive "transmission" view of learning (Cochran-Smith & Villegas, 2014, Gutierrez and Vossoughi, 2010). Once teachers are in their own classrooms, this disconnect persists. While beginning teachers often receive some form of early career support, that support is rarely coordinated with their preparation, and thus is often poorly aligned with the commitments and practices teachers developed during their preparation (DeAngelis, Wall, & Che, 2013; Ingersoll & Strong, 2011; McGinnis, Parker, & Graeber, 2004). The problem of falling off a cliff from teacher preparation into the first years of teaching can thus be thought of as a problem of being immersed in one figured world during a University-based teacher preparation program and then being dropped into the figured world of schooling, often with little explicit support for navigating the tensions that arise from this movement between worlds.

Complicating the navigation of the figured world of schooling for beginning teachers is the fact that the teaching force is overwhelmingly white and female while the K-12 student population is not. There is increasing evidence of the ways that race and culture matter for students' experiences learning mathematics (e.g. Martin, 2000, Nasir, 2016). Understanding classrooms as racialized spaces is particularly important when teachers are working to build more equitable classroom math communities where all students are supported to make meaningful contributions to the mathematical work of the classroom. Recognizing the ways that inequity is rooted in the social and the historical and continues to be perpetuated in schools for students from historically nondominant communities can be particularly challenging for white teachers who likely have not had to engage with these issues on a personal level (Philip & Benin, 2014). Yet these understandings are critical for teachers who seek to disrupt the ways that the figured world of schooling constructs difference and social hierarchy in order to create ambitious and equitable classroom math communities. Coming to see the mathematical strengths that each student brings to learning, even if those strengths may not be readily apparent in

the classroom, and working to remove barriers to learning for students from nondominant communities who may be positioned by other students and by past schooling experiences as less capable, are integral aspects of creating these types of math communities.

The challenge of moving between worlds that each operate from very different principles sets up a daunting agenda for supporting teacher learning. Though research and practice is increasingly attending to the transition into teaching beyond teacher preparation programs, many current approaches and scholarship tend to look at overall impact and at structural dimensions of support for beginning teachers rather than focusing on how support mediates teacher learning. I give a broad overview of this area of scholarship, focusing on what has been learned about structures of support, and highlighting some of the questions that still remain to be answered.

Much of the current support for new teachers comes in the form of one-on-one mentorship, typically termed "induction" (Ingersoll & Strong, 2011). Programs differ in frequency, duration, and types of support, with the common thread being providing some form of mentorship from a more experienced teacher in the first year(s) of teaching. These programs tend to be administered by school districts or states and are typically not connected to specific teacher preparation programs. There is substantial variation in induction support from duration and frequency to mentor selection and training. Thus, findings from large scale studies into the outcomes of induction have been somewhat mixed (Glazerman et al., 2010). Overall, most studies find that participation in an induction program seems to be generally correlated with increased student achievement scores, and that this correlation is stronger when teachers receive more frequent or longer lasting induction support (Fletcher, Strong, & Villar, 2008; Glazerman et al., 2010; Ingersoll & Strong, 2011; Rockoff, 2008; Thompson, Paek, Goe, & Ponte, 2005). In addition, several studies of district or state induction programs have found that beginning teachers who received some form of induction support report higher levels of job satisfaction and commitment to remain in the profession, with this effect also being stronger with induction programs that provide longer and/or more frequent support (Kapadia, Coca, Vanessa, & Easton, John, 2007; Rockoff, 2008). Studies that have looked at classroom practice and induction have had somewhat mixed findings, in large part because the expected classroom outcomes of induction have often been ill defined (Ingersoll & Strong, 2011).

Some smaller scale studies have looked more closely at particular aspects of mentorship, finding that attention to different possible alignments between new teachers and mentors can support more robust teacher learning. These alignments include more practical concerns such as shared content areas (Luft et al., 2011) as well as issues such as shared commitments towards a particular vision of teaching and to ways of seeing students' diverse resources, (Achinstein & Barrett, 2004; Feiman-Nemser & Carver, 2012; Ingersoll & Strong, 2011). This line of research has also highlighted the importance of considering the ways that school contexts matter for how beginning teachers are able to carry forward their developing vision of teaching into their own classrooms. In addition to maximizing the mentor-teacher relationship, research suggests it may be productive to consider ways that early career support can provide opportunities for beginning teachers to participate in learning communities with like-minded educators (Luft et al., 2011), and when necessary, to create these types of communities across different schools (McGinnis et al., 2004). Across the research and design of induction

programs, the focus has largely been on structural features such as the frequency and duration of support, the selection and training of mentors, and the alignment or misalignment of mentors and school settings. To date, very little of the research on beginning teacher support has focused on program design in relation to *what* exactly teachers might be learning and *how* this learning might best be supported (Bullough Jr, 2012; Ingersoll & Strong, 2011). To reimagine how we might better support the transition into teaching in line with the conceptualization of learning underlying this dissertation, I turn to research on teacher learning for pre-service teachers and in-service teachers that examines learning as an ongoing process that is mediated by the cultural worlds teachers work within.

Research and Design of Teacher Learning as a Culturally Mediated Process

To inform my methodological approach to providing more connected and robust support for beginning teacher learning, I look to research on teacher learning grounded in conceptions of learning as a mediated process that is afforded and constrained in particular cultural worlds. I focus on two emergent lines of research that attend to what teachers are learning and how their learning is mediated: empirical studies of how teacher learning communities afford and constrain opportunities for learning, and empirical studies of teacher learning over time as teachers attempt to disrupt aspects of the figured world of schooling.

One emerging trend in research on teacher learning over the past couple of decades is the study of how opportunities for learning toward ambitious and equitable teaching are fostered or inhibited as teachers engage with their colleagues in conversations about teaching. These studies have begun to paint a picture of the types of activities that can support heterogeneous meaning-making practices toward a particular vision of teaching. Much of the research in this area has focused on how teacher communities make available particular ways of understanding students' mathematical learning. This line of research has uncovered how conversational routines, interactional norms, and resources and networks of support can afford generative ways of understanding students as sensible actors embedded within complex learning ecologies, or reproduce deficit views of students (Horn, 2007; Horn & Little, 2010; Louie, 2016, 2017). Findings highlight the ways that dominant discourse and practice of schooling mediate teacher meaning-making and require active disruption. These studies have also pointed to specific conversational routines, such as replays and rehearsals of actual teaching, as collective activities that can support teachers to reason about and make connections between teaching choices and underlying principles of ambitious and equitable teaching (Horn, 2005; Horn & Little, 2010). Scholarship on teacher learning in community has also highlighted the importance of interactional norms that either open "problems of practice" up for deep reasoning about teaching or close conversations to further analysis (Horn & Little, 2010; Little, 2002). Drawing on this research, the design of Math Crew, elaborated in the methods chapter of the dissertation, takes seriously the need to support deep investigation that is connected to a robust vision for teaching through ongoing conversational routines, attention to the resources made available in activity, and to the co-construction of productive interactional norms.

Another area of scholarship that helps to elaborate both *what* teachers need to learn as they attempt to take up equity-oriented teaching in systems of schooling and *how* that learning can be supported, is research that attends explicitly to the problem of

teachers moving between different figured worlds. This emerging field of research examines how teacher learning is mediated over time in cultural worlds, offering examples of how to support teacher learning that disrupts dominant ways of understanding students and the work of teaching. Studies have highlighted the political work necessary to navigate tensions in ways that uphold teachers' commitments to ambitious and equitable teaching, preserve their positions in schools, and maintain their personal integrity (Anderson, 2010; R. Gutiérrez, 2013b; Stillman, 2011; Willey, 2013). Teacher educators can serve as important resources for supporting beginning teachers to engage with these tensions productively when there are opportunities to surface and engage with tensions as they emerge in the daily work of teaching (Anderson & Stillman, 2013; Gutierrez & Vossoughi, 2010; Stillman, 2011). The UCLA UC Links/*Las Redes* partnership serves as one example of how a design approach to teacher learning can create opportunities to productively engage with tensions. In this program, pre-service teachers worked with elementary school students in an after-school club every week. Concurrently, they also took a course in which they made sense of their interactions with students, connected those interactions to theories of learning and development, and raised tensions that arose as they navigated these two different worlds (Gutierrez & Vossoughi, 2010). The Critical Friends Group formed from a teacher preparation cohort to provide a space for first year teachers to engage in structured collective inquiry about their teaching practice offers an in-service example of creating space to navigate tensions (Windschitl, Thompson, & Braaten, 2011). The Critical Friends Group created a space for teachers to bring artifacts from the world of schooling and to make sense of them with like-minded colleagues, supporting teachers to expand their understanding of how student actions related to their teaching practice. These examples are part of a growing body of work that treat the tensions teachers encounter as they move between different figured worlds as important opportunities for meaning-making rather than as obstacles to be overcome (e.g. Bannister, 2015; Stillman, 2009; Stillman & Anderson, 2011). Across this emerging scholarship, learning to teach is taken as an ongoing process that is mediated by tools and by material and ideational artifacts made available in a given cultural world. In the concluding section of this chapter, I outline the methodological approach I take to the problem of better supporting the transition into teaching toward creating ambitious and equitable classroom mathematics communities, and relate it to the themes of engaging with tensions and attending to the ways learning is mediated across a learning ecology.

A Social Design-based Approach to Supporting the Transition into Teaching

Drawing on the conceptualization of teacher learning as an ongoing mediated process that takes place within cultural worlds, and of the transition into teaching as a pivotal time of moving between different worlds, I return to the theme from the introduction of this dissertation of creating learning spaces across this transition that are grounded in care, dignity, and connection. I begin by returning to the construct of figured worlds, focusing on the making of new worlds that disrupt dominant worlds and offer new possibilities. Holland et al. (1998) highlight the role of play and imagination as central in the creating of new worlds that disrupt what is taken for granted as common sense: "In play, more than in other human activity, aspects of the natural world, and by extension, of social worlds that have come to seem natural, are suspended and made subject to pretense" (p.236). The authors go on to connect this to the making of new worlds, writing, "It is the opening out of thought within the activity of play, what we might call the cultural

production of virtualities, that allows for the emergence of new figured worlds, of refigured worlds that come eventually to reshape selves and lives in all seriousness." (p.236). For teachers working within systems of schooling, disrupting the pervasive emphasis on constructing difference and social hierarchy necessitates recognizing and questioning the highly constrained ways of being in schools that have come to be seen as "natural." Creating a new figured world of mathematical learning that operates from principles of care, dignity, and connection requires imagining and playing out new forms of interaction that support very different ways of making meaning of mathematics, students, and the work of teaching. This dissertation takes up the issue of better supporting the transition into teaching through a social design-based methodology that is centered on working with teachers to help create a new figured world of ambitious and equitable mathematics teaching and learning.

Social design-based experiments (SDBEs) grounded in Cultural-historical Activity Theory (CHAT) offer a way to think about human activity that attends to the complexity and the cultural nature of learning to teach toward an equity-oriented vision for math classrooms while working within systems of schooling (Gutiérrez & Jurow, 2016). Deeply rooted in sociocultural theories of learning, CHAT attends to multiple aspects of an *activity system* that mediate learning. In activity systems, people draw on tools and artifacts, take up particular roles and positions, engage in specific cultural practices, and observe various rules and norms. All of these aspects of the system are dynamic and constantly being negotiated by members of a community as tensions and contradictions arise in their activity (Cole & Engeström, 1993). This approach to understanding human activity provides a way of conceptualizing the challenges teachers face in trying to enact a vision of teaching that differs from dominant practice by considering how their learning is mediated across different figured worlds. Taking tensions and contradictions to be an inherent part of activity systems and also a potential resource for learning centers the dilemmas that beginning teachers face when working to create new types of classroom math communities. CHAT is also explicitly oriented to the task of supporting new ways of being with each other: "the acid test of the theory is its success in guiding the construction of new, more humane forms of activity" (Cole, 1998, p.292).

Social design-based experiments build on this foundation to consider how we might apply these principles to the design of learning environments. SDBEs take justice and equity as central organizing features across the design process; "social transformation is sought by creating a significant reorganization of systems of activity in which participants becoming designers of their own futures is an essential aim" (Gutiérrez & Jurow, 2016, p.2). In SDBEs, participants are actively involved in co-constructing the supports they need to navigate the tensions they encounter (Gutiérrez & Jurow, 2016). This approach to design is well suited to supporting teacher learning across figured worlds as it attends to the deeply cultural nature of learning to teach through the creation of activity systems saturated with new tools, artifacts, norms, and routines to mediate learning toward a shared aim. Another guiding principle of SDBEs is historicity, which entails making sense of one's own position over time as well as the histories of communities and institutions. For Math Crew, the focus on historicity is well aligned with the commitment to uncovering the ways that interactions in the math classroom are rooted in historical inequities that tend to privilege narrow views of mathematics and

mathematical competence and to exclude diverse ways of knowing and being. In SDBEs, the focus on the system rather than on individuals provides a way of centering a conception of learning as an ongoing mediated process within cultural worlds throughout the design process, and offers a way of conceptualizing the making of new worlds through design.

Summary

As I have elaborated in this chapter, learning to teach is an ongoing process that is mediated by the figured worlds teachers work within. The transition from teacher preparation into early career teaching represents a pivotal time in this ongoing process as it involves moving into the figured world of schooling. As teachers move into full time classroom teaching they become immersed in a figured world that emphasizes constructing difference and social hierarchy in ways that tend to reproduce historical inequities. Supporting equity-oriented teacher learning across this transition then requires attending both to what teachers are learning toward and how that learning is mediated by the worlds teachers move within. This dissertation takes a social design-based approach to this problem with the intention of immersing teachers in new spaces that "generate new understandings" and "extend navigational possibilities" (Rosebery et al., 2010) toward the aim of creating mathematical learning spaces grounded in care, dignity, and connection. In the next chapter I describe this methodological approach in detail, providing background on Math Crew participants and the contexts they were working within, an extensive elaboration of the design of Math Crew as an activity system, and a description of the analytic methods employed to study ongoing teacher learning as a mediated process.

Chapter 3: Methods

With the aim of learning more about how to help beginning teachers navigate the tensions of working to create ambitious and equitable classroom mathematics communities, I invited several members from the same teacher preparation cohort to join me in creating a teacher learning community to provide support during the first year of teaching. In this chapter I elaborate the methodology underlying this social design-based study. I begin by describing the research setting, participants, and school contexts. Next, I describe the design of our learning community, named Math Crew by participants. I then detail the data collection procedures used throughout the study. I conclude by describing the methods I used to reduce and analyze the data to investigate teacher learning over time, teacher learning in interaction, and how design supported this learning.

Research Setting and Participants

Setting

Math Crew participants were all part of the same 18-month Master's and Credentialing program for prospective elementary school teachers. This program (pseudonym Elementary Teacher Preparation or ETP) is a highly regarded teacher preparation program at a large public University on the west coast of the United States. ETP works to recruit a diverse pool of teacher candidates and holds social justice as a core ideal of the program. The math pedagogy course these teacher candidates took with me was the only course in ETP about teaching mathematics. For the cohort that became part of Math Crew, ETP courses tended to focus either on issues of social justice in education or on pedagogy. In the math pedagogy course I taught, I attempted to infuse issues of justice and equity throughout the course. This course formed an important foundation for the commitments of Math Crew. I begin this section with a brief description of the course, focusing on the aspects of the course most relevant to Math Crew.

Math pedagogy course. I taught this course as sole instructor in the spring of 2016 after serving as a graduate student assistant in the same course for the previous two cohorts. A central theme of the course, as I chose to design it, was to support teacher candidates to develop expansive conceptions of mathematics and mathematical competence along with a repertoire of teaching strategies for creating and sustaining ambitious and equitable classroom mathematics communities. The course met for three hours per week. The typical organization of these sessions was to spend the first half of class working on mathematical tasks in small groups and reflecting on the experience, and to spend the second half of class delving into topics of teaching such as lesson planning or orchestrating mathematics discussions. I chose to spend a substantial part of the three hours doing mathematics because I wanted teacher candidates to experience being part of an ambitious and equitable mathematics community as learners. This focus felt especially important for elementary school teachers as many did not have positive experiences with mathematics in their own K-12 education.

Throughout our semester together, we discussed the ways that mathematics classrooms tend to exclude certain students in ways that perpetuate existing inequities. Through readings, video, and reflection we considered mathematics classrooms as racialized spaces that often sort students in ways that tend to preserve existing

hierarchies. We worked together to create an inclusive mathematics community in the course that was organized around inviting and valuing the mathematical strengths of each participant rather than identifying their deficits. Teacher candidates drew on their experiences learning mathematics both in their K-12 education and in the course to consider how they might create ambitious and equitable math communities in their classrooms and to develop a repertoire of teaching ideas aligned with this vision. In the course, a frequent topic of discussion was the issue of how to enact a vision of mathematics teaching that felt so distant from what teacher candidates saw in their student teaching placements, all while also navigating pacing guides, curricular constraints, and high stakes assessments.

Participants

I invited seven of the teachers from Kara's cohort to join me in creating a teacher learning community to provide support during the first year of teaching to maintain and continue to work toward ambitious and equitable math teaching. I selected these seven teachers because they would be teaching in local K-5 classrooms during the 2016-2017 school year and I had evidence from their participation during the pedagogy course that each was committed to equity-oriented mathematics teaching. All seven initially accepted. One participant, who was teaching kindergarten in a classroom with 27 students, attended the first meeting and then decided to withdraw from the study, saying that she was too overwhelmed to continue. The remaining six participants participated in the study for the 2016-2017 school year. Table 1 shows these participants and their schools and districts.

Table 1. Participants[2]

Teacher	Grade Level	School	School District
Selina	1st grade	Connections Community School	Hamilton Unified School District (HUSD)
Marie	1st grade	Rise Up Charter School	Charter School in Hamilton
Kara	3rd grade	Connections Community School	Hamilton Unified School District (HUSD)
Maritza	4th grade	Glenshire Elementary School	Logan Unified School District (LUSD)
Tina	5th grade	Cleveland Elementary School	Sullivan Unified School District (SUSD)
Lauren	5th grade	Taylor Elementary School	Hamilton Unified School District (HUSD)
Facilitator: Mallika			

[2] All teacher, school, and district names are pseudonyms

Profiles of Participants

Math Crew participants taught in different schools and districts with a wide range of student populations, varying levels of school and district involvement in mathematics and in the classroom, and different mathematics curricula. Participants experienced some similar tensions and contradictions across these different contexts and some that were unique to their context as they worked to enact their vision of equity-oriented math teaching. In this section I provide background about participants and their schools and districts, focusing on the aspects of the school and/or district activity systems most relevant to teachers' participation in Math Crew.

Selina and Kara both taught at Connections Community School in Hamilton Unified School District located the large city of Hamilton. Connections Community School serves a mostly low-income (~75%) predominately Latinx (>90%) student population and has a bilingual program. Selina taught math in Spanish to her first graders and is herself a native Spanish speaker. Kara taught math in English to her 3rd graders and is a native English speaker. Most students in both classrooms spoke Spanish at home. Kara also had two students who were native Arabic speakers, one of whom was a newcomer who spoke almost no English at the start of the school year. Selina and Kara considered the principal of Connections to be generally supportive. She adopted a relatively hands-off approach with her new teachers, visiting classrooms rarely. Selina and Kara both had on-site induction mentors and both teachers spoke about their participation in induction as an obligation that was not particularly supportive toward what they were trying to accomplish in their classrooms. Weekly professional development meetings at Connections tended to focus on literacy. The only math-related staff meeting during the year involved looking at assessment data from district math assessments. HUSD used the Houghton Mifflin Math Expressions curriculum with some interspersed collaborative tasks designed by groups of teachers in the district. HUSD also required that teachers administer "benchmark assessments" every trimester. Teachers scored these assessments and entered them into an online system.

Lauren also taught in HUSD, in a 5th grade classroom at Taylor Elementary School. This school serves a student population that is slightly over 50% white with the remaining students relatively evenly split between African-American, Latinx and Asian. The school has a very small (less than 5%) population of students who have a home language other than English. Approximately one quarter of students are classified as low-income. The principal at Taylor was very involved with the new teachers at her school and visited Lauren's classroom many times over the course of the year, particularly in the beginning of the school year. Lauren considered her to be generally supportive and also mentioned at times that she sometimes felt overwhelmed by the frequency of her visits. Lauren completed one semester of student teaching at Taylor during the ETP program and thus was already somewhat familiar with the school context and had some relationships with colleagues. Her cooperating teacher from student teaching also acted as her induction mentor during her first year of teaching. Lauren found this relationship to be supportive toward what she was hoping to accomplish in her classroom. As Lauren was also teaching in HUSD, she administered benchmark assessments every trimester and entered the scores but because her school was considered "high performing" by the district, Lauren reported that no one at Taylor or in HUSD paid much attention to the scores.

Marie also taught in the city of Hamilton, in the same neighborhood as Connections Community School, at Rise Up Charter School. The student population is over 95% Latinx and over 90% are classified as low-income. Approximately 60% of students were classified as English Language Learners. Marie had completed a full year of student teaching at Rise Up and was thus quite familiar with the school community. Marie had the most structured support of the teachers in this study. She had an induction mentor and a literacy coach, as well as a very involved principal, all of whom visited her classroom regularly. Marie reported in interviews that she found the amount of coaching and feedback she received to be somewhat overwhelming and not always supportive toward the type of classroom community she was hoping to create. Rise Up used TERC: Investigations for their math curriculum, which the staff had chosen to begin using the year before Marie started teaching there. The school had recently received a large grant to be used for "personalized learning." With this grant, computer-based programs became a regular part of classroom instruction. In Marie's classroom, students worked each day on an online math program in which students moved through skill levels as part of their math instructional block. By the end of the school year, she had organized her classroom so that her students were divided into three groups that rotated through different activities. One group did a math lesson with her, one group worked on the online, leveled math program, and one group played games. Students rotated through each activity each day. Rise Up placed a heavy emphasis on "data-driven instruction", requiring teachers to administer school-mandated assessments and holding frequent discussions of assessment data during professional development meetings.

Maritza taught in Logan Unified School District, in a medium sized city that uses an options and lottery system to attempt to balance demographics across schools. Maritza did one semester of student teaching at Glenshire and was happy to get a job there. Glenshire serves a student population that is approximately 35% white, 24% Latinx, 20% black, 13% mixed, and 6% Asian. The school had a dual immersion program in Spanish that was being phased out. Maritza's class of 4th graders was the last group of students in the immersion program. Maritza was a native Spanish speaker and sometimes taught in Spanish, though not for mathematics instruction. She had only 14 students for the first half of the day (including math) who remained in the immersion program, and then another 14 not in the immersion program who came to join for the second half of the day. The 14 immersion students had been part of the same cohort since kindergarten. LUSD used Eureka Math for their curriculum and required that teachers administer district math assessments every trimester aligned with this curriculum. Teachers scored the assessments and entered them into an online system and the school and district seemed to take these assessments seriously. Maritza had an induction mentor who worked for the district and although this relationship started off with some challenges, Maritza reported that it improved over time. Maritza happened to live down the street from me and so we ran into each frequently in our neighborhood, which provided some opportunities for informal talk about math teaching. Maritza was also the only parent participant in Math Crew (not including me as facilitator). She has three children (ages 3, 5, and 8 at the time of the study), two of whom were attending the same elementary school as my children. As a parent of school-age children, Maritza sometimes brought a somewhat different perspective on teaching. She also had different constraints on her time than the other participants.

Tina taught 5th grade in Sullivan Unified School District, at Cleveland Elementary School, in a large city. This school serves a student population that is over 85% Chinese and Chinese American with the remaining students relatively evenly split between African-American, Latinx and White. Approximately 90% of students are classified as low-income. The school has a high (~64%) population of students who have a home language other than English with the predominate language being Cantonese. Tina identifies as Chinese American and grew up in the same community as her students. SUSD chose to write its own math curriculum to align with the Common Core State Standards for Mathematics. Tina liked this curriculum and used it consistently. SUSD also required that teachers administer "benchmark assessments" every trimester. Teachers scored the assessments and entered them into an online system. The assessments and scores did not appear to be a big focus at the school, though Tina occasionally spoke about her concern that she was "behind" on the pacing guide and wouldn't have time to get to everything on the assessments. Tina had an induction mentor who was a teacher at her school site. This teacher had taught many of Tina's students in an earlier grade and Tina appreciated being able to discuss her students with her. Tina described Cleveland as being very focused on literacy and reported that all school professional development centered on reading and writing. She reported that they did not talk about math at all as a staff during the 2016-17 school year.

As I considered myself a participant as well as facilitator and researcher in Math Crew, I include relevant background about me in this section as a seventh participant, as well as some reflection on my positionality and identities within this study. I came to this work as a former classroom teacher. My first teaching experience was teaching middle school math and science for two years in the Los Angeles Unified School District (LAUSD) through Teach for America. I received only five weeks of training over the summer before taking on the full responsibilities of classroom teaching. I was (not surprisingly) wildly unprepared for the job. I taught in a school that served primarily Latinx students, with a large majority of students classified as low-income. My alternative path into teaching and lack of preparation helped me appreciate the importance of a traditional preparation program. It also helped me see the ways that a strong preparation program is necessary but insufficient to support rich ongoing teacher learning. During my two years teaching in LA I encountered many dilemmas as I tried to support rigorous and connected mathematical learning for each of my students while using textbooks that emphasized procedural fluency and hearing widespread deficit discourse about my students. I had extremely limited opportunities for collaboration in LAUSD so I often felt isolated as I tried to navigate these dilemmas. After teaching for two years, I moved back to the Bay Area (where I had grown up) for a job at a charter school in Oakland serving a very similar student population to the students I worked with in LA in the hopes of finding a more collaborative community. I taught at this school for three years and during that time I had many more chances to collaborate with colleagues. And I still struggled with many of the same dilemmas about curricula, assessment, and dominant discourse about students from nondominant communities. I taught from 2000 to 2006, when the No Child Left Behind Act (passed in 2002) was just beginning to have a serious impact on discourse and practices in schools. Assessment and "accountability" increasingly became part of the language around me and a focus of professional development. After these experiences in the classroom, I worked as a mathematics

instructional coach in schools and districts across the bay area serving a wide range of student populations. My work as a coach gave me a much broader view of the inequitable impacts of systems of schooling on different communities. For example, the schools I worked with which served primarily black and brown students were subjected to such intense levels of scrutiny and control supposedly in the service of equity, while the more affluent and whiter schools had much more autonomy. These experiences in classrooms as a teacher and an instructional coach shaped my commitments to creating more just and caring mathematics classrooms and to working in partnership with teachers.

Researcher positionality

I had a unique position in the Math Crew community in many ways and this position deserves some attention. Before we formed our learning community, I had been an instructor for all of the participants and thus in a position of authority and power. The intention of Math Crew was to create a space where I was not in a position of authority, and instead expertise was distributed across the community. However, given our previous history, participants saw me as an expert and this persisted across the study. Over time, participants came to also appreciate and value the expertise they each brought to our community. This shift took ongoing work, as will be described in the following section on design. My prior role as instructor and my position as "expert" may have impacted my interviews with teachers. I chose to have a colleague conduct the focus group interview mid-way through data collection to mitigate this issue. I chose to conduct closing interviews myself because the relationship I had built with teachers and the knowledge I had of their classrooms and their participation gave me important background for the conversation. However, this choice may have influenced what teachers said about their learning, given that they may have been trying to please me in some way.

In addition to the difference in position I was the only participant not in the classroom. This afforded me the luxury of time to attend to the logistics of organizing and facilitating our community. It also meant that I did not have to contend with the same constraints and tensions that participants dealt with every day. I tried to attend to this limitation in my experience by listening carefully for the issues that were coming up in classrooms so that I could stay as connected as possible with the realities of teachers' daily work. A limitation of my own background was my lack of proficiency with speaking Spanish. I studied Spanish for several years in school and can understand conversational Spanish reasonably well but I do not speak the language well and my understanding of academic Spanish is limited. These limitations were evident when I visited Selina's classroom as she taught entirely in Spanish. My observations and interactions with students were constrained by my lack of Spanish fluency and my field notes of Selina's teaching were limited by my partial understanding of her math instruction. I noted this limitation to Selina and asked her questions after class when I didn't follow something that happened that I thought might be important. However, this limitation affected the data I collected and the support I was able to offer Selina in her classroom.

Another aspect of my position and identity that deserves attention is my identity as mixed; my mother is a South Asian immigrant and my father is white. In Math Crew, Selina and Tina identify as teachers of color, Kara, Lauren, and Marie identify as white, and Maritza identifies as mixed. Part of my experience of being mixed is that for as long as I can remember, I have been aware that different people read my racial identity in

different ways. White people tend to assume I am white, sometimes even when they know that my mother grew up in India. People of color often assume that I am not white. I have recently begun to become more aware of the ways this aspect of my identity mediates how I participate in different spaces. I have tended to talk about race and racism very openly with people of color and to keep quiet about race in whiter spaces unless a white person initiates the topic. This held true in Math Crew. In one-on-one conversations with Maritza, Selina, and Tina, we discussed race openly when it seemed relevant to the work we were engaged in. Kara introduced race into our conversations and so we also spoke openly about race and racism. In these conversations, we discussed our own identities and positions as well as students' identities and positions and how those might mediate learning. Marie and Lauren did not initiate conversations about race and I chose not to bring race or racism into our conversations, even when it seemed relevant to our discussions of teaching and learning. As will be discussed in the discussion chapter of the dissertation, my occasional silence on matters of race was consequential in that it limited opportunities for learning in Math Crew.

Math Crew Design

In designing Math Crew I drew on principles of social design-based experiments with the aim of constructing an activity system for first-year teachers that would support learning toward creating ambitious and equitable classroom math communities. The design of Math Crew spanned a designed teacher community and the classroom communities of each participant with the intention of creating parallel spaces that function very differently from what is currently typical in schools. In this section, I first provide an overall framing of the project of Math Crew as creating transformative learning communities for both teachers and students. I then elaborate five design principles that were used to guide design choices across both the teacher activity system and the intended classroom activity system[3].

Math Crew was formed to support teachers to maintain and continue to work toward a shared commitment to creating ambitious and equitable classroom math communities. A shared ethos of our community that grew out of our experience together in the math pedagogy course was supporting rich and transformative learning entails creating learning spaces founded on relationships of care, dignity, and connection for all community members (Paris & Winn, 2013). These types of spaces remain the exception in systems of schooling that tend to be organized around very different goals. As was described in Chapters 1 and 2 of the dissertation, creating caring communities that treat each member as a valuable contributor requires attention to disrupting various dehumanizing aspects of schooling such as hierarchical systems of sorting, the way time functions as a constraint on learning, and the emphasis on learning as an individual project of self-improvement. An assumption underlying the design of Math Crew was

[3] "Intended classroom activity system" is used to denote the fact that while each teacher worked within their own classroom activity systems, collectively we designed an intended classroom activity system aligned with our shared commitment to creating ambitious and equitable classroom math communities. This is not to say this classroom existed in totality in any of the participants' classrooms, instead it represents a collective articulation of our shared commitments.

that in order for teachers to create caring communities in their classrooms, they also needed to be part of communities that cared for and valued them as teachers.

The design of our teacher learning community as a space where teachers would feel cared for and valued led to some choices that may seem unrelated to learning about teaching mathematics but were intentional and (as will be argued in Chapter 5), consequential for learning. Our community meetings took place on Friday evenings at my home. I provided food and beverages for participants and we would often spend some time socializing in the kitchen before we sat down at my dining table to begin our meetings. My children (ages 7 and 10 at the time of the study) as well as Maritza's three children were present at these meetings. According to the children, they had their own "Math Crew" in my basement while we met upstairs. Their Math Crew mostly seemed to consist of eating pizza and watching movies. We would occasionally need to pause what we were doing in our meetings while Maritza or I helped one of our children with whatever they needed. I made the design choice to hold meetings at my home with children present both out of necessity (as a single parent, meeting in the evenings would have been near impossible unless my children could be there) and as a way of caring for our community. The first year of teaching tends to be incredibly challenging and overwhelming. Welcoming participants and their children into my home and providing food and drink for them was a way for me to show Math Crew teachers that I recognized the difficulties they might be facing and would do what I could to attend to their needs, even if they fell outside of the specific learning goals we had decided to engage in together. These choices also provided concrete reminders that our community was working to disrupt some of the trappings of typical learning spaces where acceptable ways of being are often highly constrained.

Design principles

To support the goal of creating parallels between our adult activity system and the intended classroom activity system, Math Crew was designed to allow for travel across our teaching community and participants' classrooms. Our two central support structures were monthly teacher learning community meetings and classroom visits from me as facilitator, with tools, artifacts, and people traveling across these spaces. In the next section I describe five design principles aligned with the aim of creating a caring community to support teachers toward creating ambitious and equitable classroom math communities and elaborate how these principles were designed for across the Math Crew teacher activity system and the intended classroom activity system. These design principles were attended to throughout the activity system; in the tools and artifacts used, the implicit and explicit norms of interaction, and the ways we distributed our work in the community. The five principles that guided the design of Math Crew are: 1) Enlisting participants as co-designers, 2) Maintaining a shared orientation toward strengths, 3) Making space for deep investigation, 4) Taking an expansive view of mathematical activity, and 5) Treating tensions and contradictions as resources for learning.

Design Principle 1: Participants as co-designers

A central feature of the theory of change underlying social design-based experiments is that design should be undertaken in collaboration with participants so as to be responsive to their needs as they emerge in activity (Engeström, 2011; K. D. Gutiérrez & Jurow, 2016). As Math Crew was intended to provide a space for beginning teachers to navigate

the tensions of equity-oriented math teaching, involving beginning teachers in the design initially and throughout the study was a way to ensure that our community would meet participants' needs as they arose. This design principle also served to disrupt traditional hierarchies that position first-year teachers as having a lot to learn and not much to contribute. Enlisting participants as co-designers was an important part of creating an adult community that valued each member as having something meaningful to contribute.

This design principle was attended to both in the initial creation of the community and in our ongoing work together. Math Crew came into existence as a response to the needs Kara expressed during her Master's interview and so, from the inception, was designed with the needs of participants at the center. In our first meeting we collectively generated and discussed ideas for how we might spend our time together. In this discussion, I asked participants if they wanted to do mathematics as they had done in the pedagogy course and teachers embraced this idea as important to them. Marie suggested a routine of having teachers share a positive story about their classroom math community each month. The group received this suggestion enthusiastically, commenting that they needed to be reminded of what was working in their classrooms instead of always dwelling on the negative. We began this routine at the next meeting and kept it throughout the year. Other routines, such as choosing and discussing focal students and sharing teaching dilemmas developed over time as new questions and needs arose in monthly meetings and classroom visits.

Enlisting participants as co-designers did not mean that we all had the same role in the community. As researcher and the only member of the community not in the classroom, I acted as facilitator of the group. In this role, I took care of meeting logistics, offered a tentative agenda each month, facilitated our monthly community meetings, chose math tasks, and invited participants to share specific stories or artifacts from their classrooms. When I visited classrooms I would check in with teachers about the issues that were coming up for them and use this information to inform how we spent our time together. I invited different participants to bring in student work and classroom stories to share as resources for everyone's learning based on what I had observed in their classrooms and the emerging needs of the community. Throughout the year, I checked in with participants in one-on-one conversations and in monthly meetings about how we might adjust what we were doing to better meet their needs. Over the course of the year, classroom visits came to look different for each participants based on their needs (this is described in more detail in the data collection section of the chapter). The intention across these design choices was to create a space where participants would have a hand in shaping and reshaping our work together so that it could be as responsive as possible to their emerging needs and where each participant felt that their contribution was valued.

Design Principle 2: A shared orientation toward strengths

A focus on both teacher and student strengths was intentionally designed for across the tools and artifacts, interactional norms, and division of labor of Math Crew. The routines we established in our monthly meetings consistently emphasized strengths. For example, when teachers brought student work to the group, we began the conversation by looking for and naming the strengths we could see in the work, and then talked about how to build on these strengths. The routine Marie suggested during our first meeting of sharing a positive teaching story was another way of focusing on what was working in classrooms rather than what was not working. When we did math together, sometimes we

would discuss the mathematical strengths teachers' had noticed in each other to practice the language of noticing and naming strengths. An emphasis on strengths was also carried into classroom visits. When I visited classrooms, I asked teachers which students they wanted me to observe more closely, and I took detailed notes about these students' mathematical strengths. After the visit, I sent participants an email describing specific student strengths I had observed, naming practices I had seen them use as teachers to make space for these strengths, and suggesting ways they might build on these strengths moving forward (an example email is included in the data collection section of this chapter). Establishing these norms and routines for how we talked about students and about teaching took intentional facilitation work during the first few meetings and visits (such as bringing the conversation back to strengths if teachers started to talk about what students were not doing) and eventually became the shared responsibility of all participants.

The focus on strengths was integral to creating a caring community where teachers could bring their honest dilemmas and trust that the group would help remind them what might be possible in their classrooms. Knowing that we would all orient toward building on what was working helped to support participants to critically reflect on their own teaching in ways that were not about evaluation as a "good" or "bad" teacher but instead approached teaching as ongoing inquiry. Choosing to look for and build on strengths was also a way of disrupting hierarchy in the classroom and of inviting more expansive ways of being for students. By practicing noticing and naming a wide range of mathematical strengths in students and in each other, participants deliberately pushed on narrow notions of mathematics and mathematical competence to create a more inclusive and equitable conception of mathematical learning.

Design Principle 3: Making space for deep investigation

Across the teacher activity system and the intended classroom activity system, the design of Math Crew aimed to support deep investigation. In our teacher community, we designed routines and activities that would support us to take time to investigate issues of teaching and learning and to ground our investigation in the details of the classroom. For example, when teachers brought student work from their classrooms, we looked carefully at students' inscriptions, working together to make sense of what students had produced and how it related to the mathematics. When teachers told positive stories or shared dilemmas about their classrooms, they often brought artifacts to use in the discussion such as student work or teaching tools they had used. In addition, in the telling of these stories, teachers included details about students' histories in the classroom, their mathematical participation across different activity structures, and how they interacted and were positioned in the classroom community. The artifacts and detailed descriptions provided rich information about the classroom learning ecology for us to use to deepen our investigations of teaching and learning.

A focus on deep investigation was something that was initially designed for, and that deepened over time in the community. In January we added the structure of teachers choosing three to four focal students to focus on for Math Crew. This structure supported deeper investigation by allowing for ongoing conversations over time about the same students. Choosing focal students then led to the new routine of discussing a teaching dilemma. In January, Tina emailed me about a dilemma she had with one of the students she had chosen and I invited her to bring her issue to the next community meeting (this

dilemma will be discussed in detail in Chapter 4 of the dissertation). After discussing Tina's dilemma, the group decided to continue the routine for the rest of the school year. The new routine of discussing dilemmas provided more opportunities for deep investigation as teachers explained a problem of practice and the community engaged with the problem. Across all of the routines described above, we observed the implicit norm of conversations being done when we collectively decided the conversation was done. None of these routines had specific times attached to them and as facilitator I chose not to end conversations until no one else had anything more to contribute to the topic. This meant that conversations took varying lengths of time depending on the topic(s) at hand. Allowing time for these conversations supported deeper investigation and helped to create a space where everyone's contribution was valued.

Deep investigation was also a part of the intended classroom activity system. When we articulated our shared commitments in our first community meeting, teachers offered "space and time to work" and "discussion and investigation-based meaning-making" as aspects of the classroom math communities they were hoping to create. Planning meetings before classroom observations provided opportunities for teachers to think with me about how to support students to deeply investigate the big math ideas they were currently working on. Doing math in Math Crew gave teachers experience with deep mathematical investigation, to make sense of key math ideas for themselves and to reflect on what supported their process of mathematical sense making. This aspect of deep investigation was closely intertwined with the design principle described in the following section about mathematical activity.

Design Principle 4: Expansive views of mathematical activity

Another principle that was designed for across the teacher activity system and intended classroom activity system was to take an expansive view of mathematical activity. This principle is integral to creating ambitious and equitable classroom math communities in that narrow conceptions of mathematics and mathematical competence have long functioned to sort and exclude some students from engaging with rigorous mathematics. In choosing to take an expansive view of mathematical activity, we sought to disrupt these narrow and exclusive conceptions and to consider mathematical activity as a complex experience. This experience includes multiple facets from the challenges of making sense of specific content, to the relative social positions of the people doing mathematics, to participants' prior experiences and histories doing mathematics.

In our teacher activity system, choosing to work on mathematical tasks at every meeting except the first and last meetings was a way to stay connected to the experience of engaging with mathematics from this more expansive view. Reflecting on the experience as learners gave participants opportunities to connect aspects of the tasks and the structure of their interactions to inclusion and exclusion in the classroom. Investigating the mathematical strengths in teachers' own mathematical work as well as in student work created opportunities to practice recognizing a broader space of what counts as mathematical competence than is typical in schools. Looking for mathematical strengths in the classroom during classroom visits provided opportunities to practice this in real time as students worked on mathematical tasks. These varied opportunities to take an expansive view of mathematical activity across both the teacher activity system and the intended classroom activity system gave teachers the chance to become immersed in a way of thinking about mathematics that contrasted with their own K-12 math experience.

Design Principle 5: Tensions and contradictions as resources for learning

The fifth design principle of treating tensions and contradictions as resources for learning was designed for across activity systems as well as being an impetus for the project itself. The central aim of Math Crew to create caring communities that value the contributions of each member differed substantially from the primary aim of systems of schooling, which tend to instead be concerned with learning as individual performance and improvement. Thus, contradictions and tensions were an inevitable part of teachers' experiences in their school sites. Drawing on social design-based experiments, Math Crew was designed as a space where participants could bring these issues as they arose in their activity to collectively figure out how to navigate them.

The routine of bringing a teaching dilemma to the group was an explicit attempt to provide space to take up the tensions teachers experienced in their work. In addition to this routine, we established the explicit norm in our community from our first meeting of checking in about the issues that were emerging at their school sites. This usually happened informally before we started the first item on our agenda. In the first few meetings I would ask if any issues were coming up at their school sites related to math that they wanted to discuss. Over time, I did not need to extend this invitation as participants would spontaneously share stories about the tensions they experienced both at the beginning of our meetings and throughout our other routines. Planning meetings before classroom visits followed a similar trajectory of me asking about tensions during the first couple of meetings and then participants spontaneously sharing them as they arose in conversation. Across these different activities, when tensions or contradictions were raised, as facilitator, I supported participants to spend time thinking about the issue and considering various possible responses that aligned with our shared commitments. We worked together to treat these moments of tension not as problems to solve or barriers to complain about, but instead as opportunities to reconnect with our shared commitments and to support each other to maintain these commitments in the face of whatever challenges arose (the role of moments of tension in learning will be discussed further in Chapter 5 of the dissertation).

Math Crew monthly community meetings

In this section I first provide an overview of the structures used at monthly community meetings, and then describe one meeting in narrative form. This is intended to give a sense of the activities and participation structures in a typical meeting and to provide context for the analyses of learning in these meetings that I present in Chapters 4 and 5. Table 2 shows the ongoing routines used in community meetings.

Table 2. Math Crew Routines

Routine	Description	Number
Doing Math Together	I would bring a math task I selected and teachers would work in groups of 3 or 4 on the task. Some discussion of the math and the connection to the classroom would follow (e.g. how design features of the task either opened or closed opportunities for different types of student participation).	6
Examining Student Work	I would invite a teacher to bring a selection of student work and the group would identify strengths in the	3

	student work and then have a broader discussion about teaching prompted by the work (e.g. how to modify given curricular materials).	
Positive Stories about Classroom Community	Marie suggested the ongoing routine of have one teacher share a positive story about her classroom community at each meeting. This rotated each meeting so that each teacher shared one story over the course of the year.	6
Discussing focal students	During our January meeting, I asked participants to choose 3-4 students who they were curious about who we would focus on both in community meetings and classroom visits. At this meeting, participants discussed these students with a partner, and in each subsequent planning meeting and classroom visit we would also discuss these students.	1 + classroom visits
Classroom Dilemma	One teacher would bring a dilemma about one of her focal students and ask for the group's help with the dilemma. Kara suggested making this an ongoing routine after the first instance in February, when I asked Tina to share a dilemma we had been discussing over email.	3

Sample Math Crew meeting

In this section I provide the agenda of the November community meeting followed by a narrative description of this meeting as a typical example of a monthly meeting. All six teachers were present at this meeting. This is intended to give the reader a general sense of how these meetings unfolded.

Agenda:

- Checking in/Logistics
- Positive Story from Maritza
- Revisiting Shared Commitments
- Math Task
- Student Work from Lauren
- Developing Shared Language of Math Strengths

We spent the first five minutes of this meeting going over the agenda and talking about logistics for my upcoming classroom visits. We then started with the routine of telling a positive story from the classroom. It was Maritza's turn to share (this routine rotated in alphabetical order of first name). Maritza told a story about a change in participation of one of her fourth grade students. Pablo had not participated very actively during math for the first couple of months of the school year. In the week before this meeting, during one of my classroom visits, Maritza and I had noticed an important mathematical idea Pablo shared in his small group. We conferred and figured out together how to highlight Pablo's idea in a whole class discussion at the end of the lesson. After that experience, Maritza had noticed much more active participation from Pablo during partner work and

whole class discussions. Maritza had a parent conference with Pablo's mother a couple of days later and his mother had commented that he had come home and told her about how well he was doing in math. After Maritza related this story, we discussed it together, with participants commenting on how helpful the classroom visits were for supporting them to notice students' strengths that they might not otherwise have seen. Maritza also raised a question about a resource specialist who came in to support Pablo and a few other students during math time. The group discussed how Maritza might work with this teacher so that students would have space and time to think, while also receiving her support. This conversation lasted for about 16 minutes.

After Maritza's story, we revisited the shared commitments we had created during our first community meeting in September and brainstormed ways to hold on to these commitments. Our list of shared commitments, which was posted at every meeting, is shown below:

> Everyone meaningfully contributes to the mathematical work of the classroom
> - Students see math as creative, with multiple ways to approach it
> - Students develop a love of math/ a positive relationship with math
> - Different math strengths are valued
> - Everyone listens to and values every student's ideas
> - Students express more confidence and willingness to persevere
> - All students have access to the tools and scaffolds needed to communicate their thinking

We spent about 13 minutes sharing and discussing ideas for how to keep working toward these commitments. Participants offered many ideas including adapting math tasks to support more conversation, using Number Talks to provide ongoing opportunities for students to share and discuss different each others' ideas, and including more partner and group work so that students have lots of opportunities to discuss their ideas.

After this conversation, I divided teachers into two groups of three to work on a math task. I designed a task that would connect to the student work Lauren would be sharing later in the meeting, related to decimal addition and subtraction. The task is shown below:

> Juan has $2.74 in his pocket. He wants to buy a graphic novel that costs $4.50. How much more money does he need so that he can buy the book? Draw this situation in as many ways as you can (your drawings should help you think about a solution). Look for and discuss connections between the different drawings you create. Show your thinking as clearly as possible so that another group can make sense of what you did without you being there to explain it.

Participants spent about 20 minutes working on the problem in small groups. They shared and discussed different representations and made connections between these representations. I listened as each group worked, occasionally asking a question to prompt further discussion when I noticed a lull in the conversation. I then brought the two groups back together and asked them to swap papers so they could each make sense of

the other group's representations. We discussed connections across the posters, with participants noticing that both groups created some representations that involved adding up and some that involved counting back. I asked them to think about the specific strengths they had noticed in each other's work. Participants shared their ideas and collectively refined each other's language with the aim of making the strengths specific enough to give a sense of what the person had done and general enough that they might apply to other tasks.

After this discussion of the math task and of strengths, Lauren shared some student work from her fifth grade class. Her students had been solving similar types of problems with decimals. She explained the task and then showed us the posters her students had created. We looked at one poster at a time and discussed what strengths we could see in the student work. We spent 15 minutes examining the posters, looking closely at student representations, naming student strengths, and commenting on similarities and differences between student strategies and the strategies teachers had used on the math task they had just completed.

We concluded the meeting with a 15 minutes conversation about how teachers might support students to notice and name each other's mathematical strengths. Teachers offered various ideas about what they might try in their classroom. For example, Lauren suggested doing a debrief at the end of class similar to what we had just done with the math task, in which students have a chance to share the strengths they had noticed in their classmates. Tina responded by commenting that she had been writing up student strengths and then reading them during debriefs and that she was now thinking about "transferring that responsibility" to her students. We also discussed which math strengths might be most important to emphasize for their students to help students see math more expansively. After this discussion, I concluded the meeting by appreciating them for the hard work they were doing, and let them know that I felt inspired when I visited their classrooms.

Classroom visits

In addition to community meetings, the other central structure of Math Crew was visits by me as facilitator. The table below shows the different possible activities we engaged in related to these visits.

Table 3. Classroom Visit Routines

Routine	Description
Planning Meeting	I met with each teacher before the second classroom visit for about 30 minutes. We began the meetings with participants telling me a bit about how things were going in their classrooms and sharing anything they wanted my support with. We then talked about the lesson they would be teaching for my observation, making adjustments to the plans based on what they wanted to work on. After the second visit, teachers chose whether or not they wanted to meet before my observation (further details included in the data collection section of this chapter)
Observation	When I visited teachers' classrooms, I asked the teacher if there were any students she would like me to keep a closer eye on during my visit. I then walked around the room, taking notes on what

	students were doing and what the teacher was doing and interacting with students. Sometimes the teacher would come over to confer with me during the lesson about something she had noticed or a question she had about the lesson or a student.
Informal debrief	I tried to always find a few minutes to informally talk to the teacher after my visit. This sometimes involved walking with them (and sometimes with their students) to the next activity (e.g. recess or lunch) and sometimes involved chatting in the classroom. During these conversations I shared some positive things I had noticed from students and often spent some time reassuring the teacher that the lesson had gone better than she thought. I chose not to record these conversations as I worried that would undermine the purpose of providing some reassurance and connection after an experience of vulnerability of opening up their teaching practice to me.
Follow up emails	After each classroom visit, I sent teachers an email with notes from the visit including specific student strengths I had noticed, moves teachers had made to make space for these strengths, and some thoughts about how they might build on these. I tried to send these notes within 24 hours of my observation, though a few times it took a bit longer.

Summarizing Math Crew design

Our overarching commitment to creating learning spaces that foster relationships of care dignity, and connection, along with the five design principles described above, guided the initial and ongoing design of Math Crew. These principles worked in concert to create parallel activity systems that disrupted some of the dehumanizing aspects of systems of schooling and sought to create caring and inclusive learning spaces. To provide a more holistic look at design, I include representations of the teacher activity system and the intended classroom activity system that summarize the principles and activities described above.

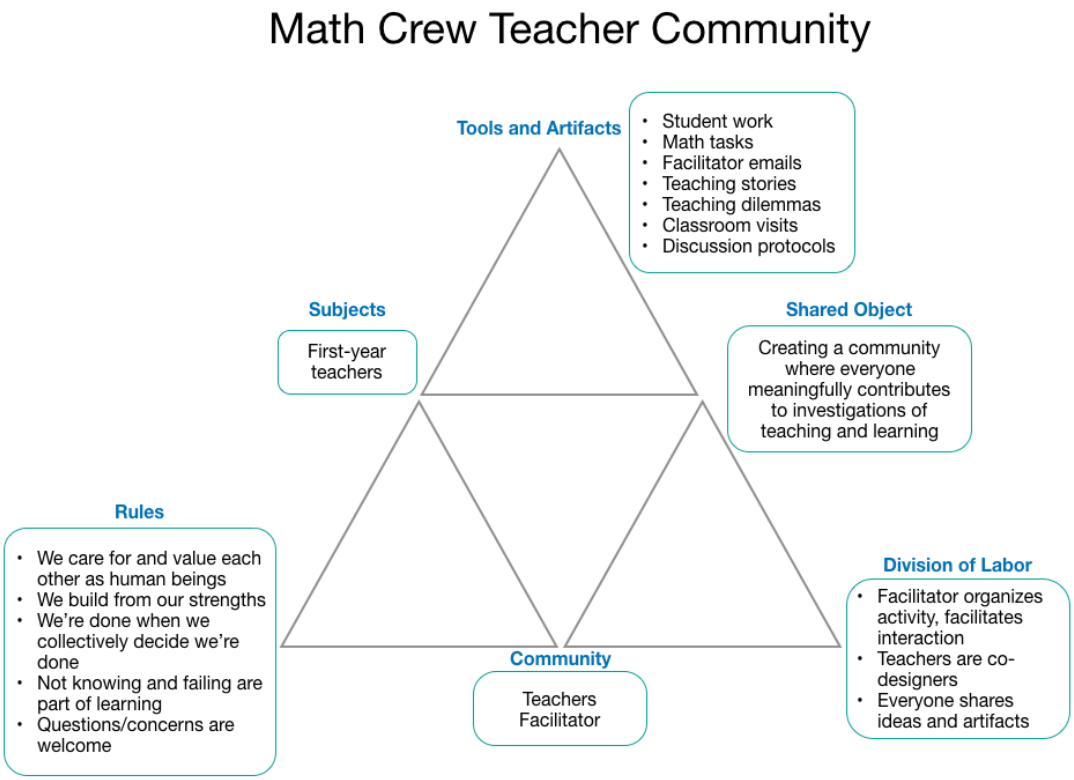


Figure 3. Math Crew Teacher Activity System

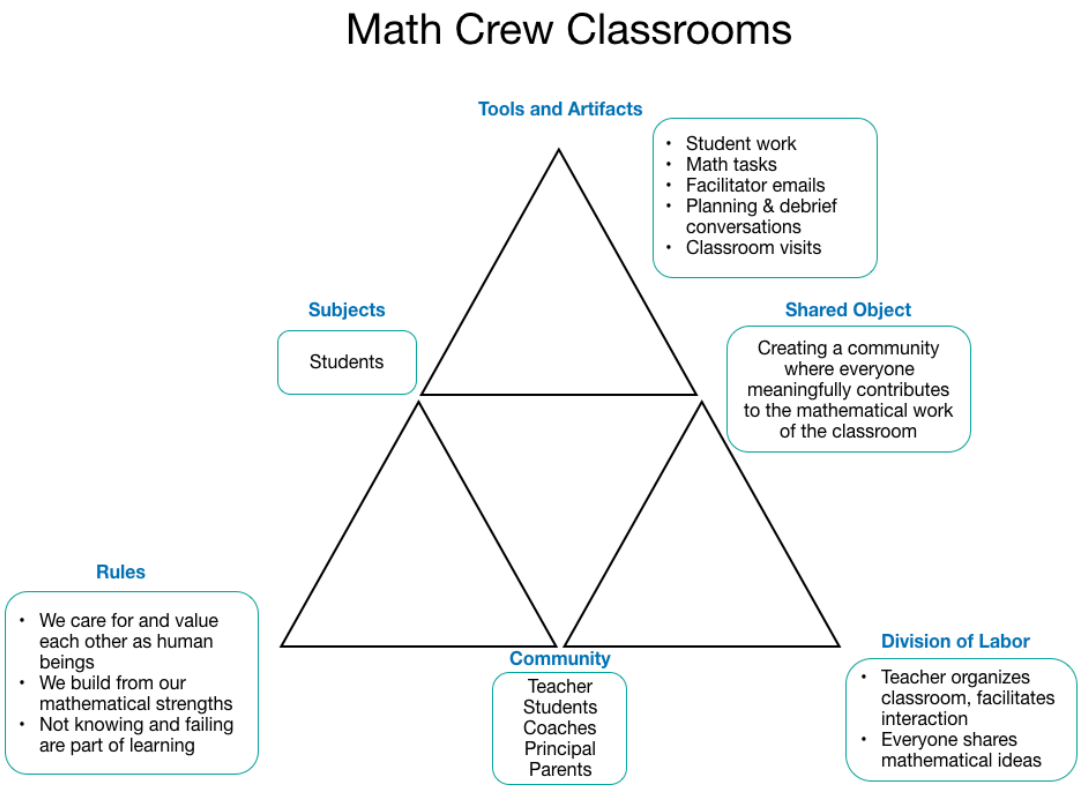


Figure 4. Math Crew Intended Classroom Activity System

These representations show a different view of the parallels across the teacher activity system and intended classroom activity system, and the ways design principles were attended to across different aspects of activity.

Data Collection

As Math Crew was organized around the two central structures described above of monthly community meetings and classroom visits from the facilitator, the primary data sources were collected during these structures, as described below.

Math Crew Monthly Community Meetings. Each month participants met for approximately two hours at my home. These meetings were video-recorded with the camera positioned so as to attempt to capture front views of the participants and the inscriptions by me as facilitator on shared posters as much as possible. The video did not capture participants' inscriptions. Table 4 shows an overview of the meetings, including participants, agenda items, and notes about the data.

Table 4. Video Recordings of Math Crew Monthly Meetings:

Date	Participants	Key Agenda Items	Notes:
9/2/16	All except Maritza	Creating Shared Commitments and Indicators of Equitable Math Communities	
10/7/16	All except Lauren	Positive Story from Tina Student work from Selina Doing Math	
11/4/16	All	Positive Story from Maritza Student work from Lauren Doing Math	
12/11/16	Maritza, Tina, Selina	Student work from Maritza Doing Math	Shorter meeting, rescheduled because of conflicts
1/6/17	All	Positive Story from Marie Discussing focal students Doing Math	Problem with Video- only first half recorded
2/3/17	All	Positive Story from Lauren Dilemma from Tina Doing Math	Shorter meeting for focus group
3/17/17	Maritza, Kara, Tina, Selina	Positive Story from Kara Dilemma from Selina Doing Math	
4/14/16	All except Tina	Positive Story from Selina Dilemma from Kara Doing Math	
5/12/17	All except Marie	Reflecting on the year, and on commitments and indicators Moving forward with Math Crew	

Classroom Visits. As facilitator, I visited classrooms several times over the course of the year, collecting field notes during each visit. For the second visit, I met with each participant beforehand to talk about the upcoming lesson. Two participants asked not to continue participating in these planning conversations, Marie after the first conversation and Kara after the second, each citing time pressure. The other participants chose to continue these planning conversations. All planning conversations were audio-recorded. During the classroom visits I would interact with students in ways that had been discussed and agreed upon with the teacher before the visit, often focusing on students the teacher was most curious to know more about and taking notes on the mathematical strengths of these students. After classroom observations, I would use the jottings I had taken during the lesson to write ethnographic field notes. I tried to write these up within 24 hours of the visit so that my memory would be fresh, though this was not always possible given other time constraints. Table 5 shows the number of visits and planning conversations conducted with each teacher.

Table 5. Classroom visits

Participant	Planning Conversations (audio recordings)	Lesson Observations (field notes)
Kara	2	6
Lauren	3	4
Marie	1	4
Maritza	4	6
Selina	3	4
Tina	4	6

After my visit, I would send the teacher a follow up email about what I noticed. For the first visit, the follow up email focused on observed student strengths. From the second visit on, the emails followed the same structure of naming some observed student strengths, naming some teaching actions that had made those strengths possible, and suggesting ideas for moving forward based on the observed student and teacher strengths.

Example of email to Kara after second classroom visit, sent 10/23/16:

> <u>Student strengths:</u>
> *I heard Nanor ask her partner during the math talk "How many shelves does he have?" and then connect her question to her partner's solution, saying "oh he has 4 shelves?" after her partner gave the solution of 10, 10, 10, and 10. This question got right to the heart of the problem and was evidence that she was connecting the situation to the big mathematical ideas.
> *Hector was really persistent in trying to arrange the tiles in a rectangle, even when his group kept taking some of the tiles to do with other things (building, sorting by color etc.). He eventually was able to get all 24 tiles and he arranged them in a 2 x 12 array. Dariel was then starting to mess with the tiles and Jorge said "Hey, don't destroy the thing that Hector built". The 2 x 12 array eventually

made it onto the group paper. It seemed clear that representing multiplication using arrays was a strength for Hector.
*I saw Oscar discussing his ideas with his group and working to connect his drawing to a multiplication sentence. One of his group members questioned his multiplication sentence and he revised it based on her input.
*I saw Rico and Lissette working together to represent their thinking. Lissette was drawing an array and together they were figuring out what numbers to write on top of the array (4, 8, 12...24). Rico then started drawing another array that appeared to be the start of a 3 x 8 (he drew each side and then was starting to fill it in) and at that moment students were called back to the carpet. I asked him what he was writing and he said he wanted to make sure that an idea that Lissette had shared made it on to their paper. I would say that both Rico and Lissette showed the strength of connecting an array to multiplication using equations and labeling and that Rico also showed the strength of translating someone else's verbal idea into a representation.

Teacher moves that made space for these strengths:
*Providing one set of tiles per group made space for Hector's idea to be recognized and taken up by his group and I think this really mattered both for his mathematical confidence and for the learning of his other group members.
*Your choice of math talk problem was awesome and so clearly in line with your goal of providing kids with opportunities to solve problems with multiple solutions. The open wording of the problem made space for Nanor to figure out what important questions to ask.
*Your emphasis on celebrating mistakes over the first weeks of school and in this particular task made space for Oscar's partner to point out an error and for Oscar to listen and revise his thinking.
*Your class norms of discussing, asking questions, and explaining thinking were evident across many groups and Rico took that up by really carefully listening to Lissette and then working to represent her thinking.

Some thoughts/ideas:
*That math talk problem was awesome and I think that type of a problem would be great for a multiplication/division task. It was interesting for a math talk and there wasn't enough time to get into some of the meat (e.g. Nano's question about how many shelves). One of the nice things about the problem is that 2 x 20 and 20 x 2 would mean really different things (2 shelves with 20 books each or 20 shelves with 2 books each). You could give that kind of a problem, ask students to come up with as many solutions as they can, and then ask students to think about which ones might make be most reasonable for the context.
*I think students really want to take up their roles (of holding group to a particular norm) because students were really into claiming their job at the start of the task. I think they just need practice in how to actually do that. So my advice would be to keep these groups AND these roles for a little while (maybe 2 weeks?) so that students could work on getting better at it. Then you could look for and publicly recognize students who really do their role and hopefully you'd start to see more

> students really trying them out. I think this could work for the norms or the roles on role cards so just use whichever feels easier/more useful for you.
> *I saw that you were offering lots of opportunities for students to appreciate the contributions of other students (both in math talk and closing of the task) and so far students are taking these up in pretty general ways- e.g. "nice job", "I appreciate _____ for helping me on my work". I wonder if it might be worth building a list of more specific math strengths with your class in kid friendly language (e.g. drawing a picture to show your thinking) and then students would have a list to refer to when they are doing appreciations and compliments. This could be a way to build a common language that might support all of you to know what each member of the community is good at.
> *A very small thing- I think it would have helped students get started more quickly and maybe made you feel a little less crazy if each group had a copy of the task in front of them. You can do this on strips so you don't waste a lot of paper.

There are several other data sources that provide supporting evidence for findings, described below.

Final Reflection Papers. All six participants completed a final reflection paper for the math pedagogy course they took with me as part of ETP. In this paper, prospective teachers wrote about what they had learned in the course about teaching math and how what they had learned informed their thinking about teaching math in their own classroom. These papers provide information about participants' commitments to building more equitable math communities, the ways they talked about teaching, and their questions before Math Crew began.

Focus Group Interview. In February, a colleague not affiliated with Math Crew lead a 45-minute conversation with the teachers (I was not present) about why they had joined Math Crew, if and how it was supporting them in their classroom teaching, and the tensions and contradictions they were encountering at their school sites. This conversation was video-recorded. The interview protocol is included in Appendix A.

Panel Discussion. In April, three participants, Kara, Lauren, and Maritza, participated in a panel discussion with the new cohort of prospective teachers in ETP as this cohort had asked to hear more about the Math Crew project. This was not designed as part of the Math Crew study but provided additional evidence of the ways participants were thinking about their teaching and about the tensions and contradictions they faced in their work. The conversation was audio-recorded.

Closing Interviews. I conducted one-on-one interviews with each participant at the conclusion of data collection for the study. These interviews lasted for 40-60 minutes and were audio-recorded. I asked about participants' math teaching over the year, their participation in Math Crew, and their school site supports and challenges. The interview protocol is included in Appendix A.

Table 6. Other Data Sources.

Date	Data Source	Description
May 2016	Final Course Reflection Papers	Participants wrote about what they had learned about teaching math and how that informed their thinking about their future teaching
2/3/2017	Focus Group Interview (video)	Participants were asked about their experiences in Math Crew and the connection to their classroom teaching
4/20/17	Panel Discussion (audio)	3 participants came to speak to new cohort about their classroom teaching and how they navigated tensions in their work
June 2017	Closing interviews (audio)	Each participant was interviewed about their math teaching, their participation in Math Crew, and their school sites

Analytic Methods

In this section I outline the analytic methods I used for the findings I report in Chapters 4 and 5. These methods were intended to examine learning over time and learning in interaction in the Math Crew activity systems and to relate teacher learning with design choices. For these analyses, video recordings of Math Crew community meetings served as the primary data source as the conversations in these meetings provided evidence for how teachers were engaging with different teaching tools and artifacts such as student work and stories from the classroom. Field notes and emails from classroom visits and audio recordings of the focus group interview and closing interviews served as supporting data sources. I first describe my analytic methods for examining learning over time. I then describe methods for analyzing learning in interaction and for connecting learning to design.

Analyzing learning over time

In line with how my conceptualization of teacher learning as changes in participation in teaching activities, my analyses of learning over time focused on shifts in participation across the teaching activities available in the data I collected. The activities I considered for these analyses were conversations about teaching (as evidenced in video-recordings of community meetings) and classroom teaching (as evidenced in ethnographic field notes and emails from classroom visits). I first describe my process for analyzing changes in participation in conversations about teaching, then describe how I analyzed changes in classroom teaching, and elaborate how I made connections across these two lines of analysis.

To reduce the video data, I created activity logs for the nine Math Crew meetings, breaking them into 8-10 minutes episodes and writing a summary of the activity with observer comments. During this process, the routines of starting each meeting with one participant sharing a teaching story about their classroom math community (suggested by a participant at our first meeting) and sharing teaching dilemmas emerged as activities to investigate for changes in participation over time. These routines happened at six of the nine meetings and followed the same basic protocol. I created more detailed activity logs for these classroom stories, chunking them in 3 to 5 minute episodes and writing detailed notes about the content of the episode and

observer comments about emerging patterns. I worked with a research assistant to transcribe these conversations and to code them using an open coding process to capture teacher participation. We began with a large set of codes, aiming to capture as much as possible about the different ways teachers were participating in community conversations and to keep our codes as low inference as possible such as "asking a clarifying question" or "suggesting a possible teaching idea". We then began to consolidate codes, to eliminate codes that were used infrequently, and to identify patterns in participation over time. Through this process we decided to focus on three categories of codes that best captured the changes we were seeing in the video-recordings: how participants connected to larger teaching themes, how teachers connected to the classroom learning ecology, and how participants talked about students. The table below shows our condensed coding scheme.

Table 7. Coding Scheme to Capture Change Over Time

Code	Description	Example
Connecting to ambitious and equitable math teaching	Relating a teaching action to their shared commitment	"At the end of the day the kids are out of my room, I can take a breath and then I can actually look at their work and look at what they are doing and notice their strengths"
Connecting learning ecology with math participation	Relating how students are participating to an aspect of the classroom learning ecology	"It reminds me of Kara's story about Ahmed, like having different content kind of opening up different kinds of opportunities for kids."
Relating to student experiences	Envisioning the classroom from the students' perspective	"I am like, your poor brain, these problems are really hard and they are intentionally tricky"
Connecting to knowledge about students	Using known information about students to connect to and make sense of what is happening in the classroom	"So I think one thing that might of helped Antonio was just having that structure and that space where it is clearly marked, here is where I am putting my work, because one thing he struggled with on his whiteboard is that his work was all over the place"
Sharing students' mathematical actions	Describing mathematical participation of students	"He was able to, you know, interpret his own data and then come up with a question which is really hard and then answer his own question."

This analysis revealed two phases of activity marked by substantial differences in participation. Once the two phases had been identified, I returned to video and transcript to look for overall differences in the character of the conversations. Through this process I identified an overarching difference between Phase 1 and Phase 2 that helped to explain the marked differences in types of participation. In Phase 1, participants tended to quickly offer solutions to issues or questions teachers raised. In Phase 2, participants tended to investigate and problematize issues by considering students' experiences in the classroom and connecting those experiences to complex problems of practice. To further analyze

these differences, I selected one conversation from each phase where the same participant had raised an issue. I then examined the conversations with a focus on how issues were initially framed, how issues came to be understood in conversation, and the teaching responses offered, which confirmed the differences across the two phases in terms of fixing local problems versus engaging in relational investigations of teaching and learning.

I then turned to data sources related to classroom teaching to analyze shifts in teaching and to examine whether or not those shifts related to the two phases identified in community conversations. I first looked across the activity logs of community meetings to identify the problems of practice each teacher most frequently discussed. I then examined field notes and emails sent after visits, aiming to capture the types of teaching practices teachers used (e.g. naming mathematical strengths for tasks) and the ways students engaged with mathematics in the classroom (e.g. students discuss different strategies to solve a problem). I then examined connections between the problem of practice each participant spoke about most often, the teaching practices teachers used over time, and shifts in how students engaged with mathematics over time. This analysis revealed the ways the shift in community conversations toward relational investigation versus fixing local problems was mirrored in classroom teaching, as participants increasingly made changes to their teaching practice in response to deeper investigation of students' mathematical experiences.

To further examine shifts in classroom teaching, I looked closely at the participation of one teacher, Maritza, across classroom visits. I selected this teacher for further analysis because I had robust data sources about her classroom teaching given that I had visited her classroom six times over the course of year, met with her before four of those visits, and taken detailed field notes from these classroom visits. To analyze shifts in her teaching, I examined field notes, audio-recordings of one-on-one conversations before visits, the emails I sent after classroom visits, and the stories Maritza told about her teaching in community meetings to consider the details of how her teaching changed over time and to relate these shifts to the problem(s) of practice she discussed in community meetings and one-on-one conversations before visits.

After conducting separate analyses of changes in participation in conversations about teaching and of changes in participation in classroom teaching, I selected one case to analyze the relationships between these two lines of analysis. For this analysis I selected the case of Tina because she had made the most robust use of resources in Math Crew across both community meetings and classroom visits. I examined all available data sources (emails with Tina, audio of planning conversations, field notes of visits, activity logs and transcript of community meetings), focusing on when and how Tina engaged with the central problem of practice she worked on in Math Crew of expanding conceptions of mathematics and mathematical competence. I identified the resources Tina utilized from Math Crew and analyzed how she made use of these over time to support her students to develop more expansive views of what counts as mathematics.

My analysis of learning over time across community meetings and classroom teaching is presented in Chapter 4 of the dissertation.

Analyzing learning in interaction

To analyze how participants learned in Math Crew, I conducted a microanalysis of one conversation about a teaching dilemma Selina brought to the March community meeting.

During my analysis of learning over time, this conversation was identified as particularly intriguing because it included an extended period of investigation and a substantial shift occurred in the conversation from an initial framing by Selina as a dilemma about what a student was not doing or could not do to the collective construction of a dilemma about the complex challenges of learning place value in first grade and of mathematical representation. The 30-minute conversation was transcribed and coded for the discursive practices participants used to contest Selina's initial framing of the student.

One minute within this activity was selected for microanalysis due to the high level of overlapping action and talk across all participants and because several participants referred to this moment as significant for their learning in subsequent interviews. I analyzed this moment of interaction by focusing on how gesture and talk functioned in the interaction to support teachers to connect with the experience of being a child in an elementary school classroom. I use Gee's notion of "situated meaning" in analyzing contextualization cues such as pitch, intonation, physical movement, and eye gaze, in addition to content of talk, to determine what participants were communicating and how their contributions were interpreted by other participants (Gee & Green, 1998). This analysis revealed a new collective practice that emerged in Math Crew of collectively imagining the experience of being a child in a math classroom. My analysis of learning in interaction is presented in Chapter 5 of the dissertation.

Connecting learning and design

To connect learning over time and in interaction to the design of Math Crew, I first analyzed the focus group interview and closing interviews for what aspects of design participants spoke about as most influential for them. In the focus group interview, participants were not asked this question directly, but in their answers to more general questions about their participation in Math Crew participants commented on aspects of design that were most meaningful to them. The closing interview protocol explicitly addressed this topic.

In addition to analyzing what teachers said about design, I also analyzed the norms of interaction as another aspect of the activity system. Creating a community where each member felt cared for and valued took collective interactional work. To analyze the norms that were established and how these were accomplished in interaction, I looked across activity logs of community meetings for moments when norms were made visible because they were being contested or created. Two moments from the first few meetings were identified as moments when a new norm was collectively constructed. These moments were then transcribed and analyzed for the content of the norm being created and for the interactional work involved in the construction of the norm. The analysis of the connections between teacher learning and design is included in the final section of Chapter 5.

Chapter 4: Learning to Engage in Relational Investigations of Teaching and Learning that Center Students' Mathematical Experiences

This chapter presents an analysis of teacher learning over time in the designed environment of Math Crew. As elaborated in Chapter 2 of the dissertation, I conceptualize teacher learning as changes in participation in teaching activities (Rogoff, 1994). These activities include classroom teaching with students as well as the planning, reasoning, and reflection that shape what happens in classrooms. I take a cultural historical approach to learning, considering how various interacting aspects of an activity system mediate learning toward a shared object. I view the designed Math Crew activity system and classroom activity systems as complex learning ecologies in which people draw on tools and artifacts, take up particular roles and positions, engage in cultural practices, and observe various rules and norms. All of these aspects of the ecology are dynamic and constantly being negotiated by participants as challenges arise in their activity (Cole & Engeström, 1993). These theoretical approaches inform the approach I take to analyzing learning. I examine shifts in collective activity within the Math Crew learning ecology and within classroom learning ecologies as well as examining individual teachers' experiences in those learning ecologies.

In my analysis of learning over time in Math Crew, I find that participants moved from approaching teaching and learning by trying to fix local problems to engaging in relational investigations of teaching and learning that centered students' mathematical experience as it connected to different aspects of the classroom learning ecology. As participants shifted to investigating teaching and learning from this relational perspective, they took up complex problems of practice in their classroom and worked on them over time in ways that were consequential for their teaching. Their learning coevolved and was mediated across the Math Crew activity system and their classroom activity systems, with the travel across systems providing new resources for learning toward ambitious and equitable mathematics teaching. This learning was not without tension, as tensions are a natural part of any learning ecology. The role of tensions in Math Crew will be discussed in Chapter 5 of the dissertation. The learning that became possible for Math Crew participants was closely connected to the mediation afforded by specific design choices. The connections between learning and design will also be taken up in Chapter 5.

My analysis of teacher learning over time is divided into three parts. In part one I examine changes in teachers' participation in community conversations about teaching over the course of the school year. I show how the activity of making sense of classroom teaching in Math Crew conversations shifted from teachers reasoning about teaching by trying to fix local problems, to teachers engaging in relational investigations of teaching and learning that centered students' mathematical experience. In part two I show how this shift toward relational investigation connected to new forms of participation in classroom teaching. I find that teachers began to think about complex problems of practice from the perspective of their students, and to test out and adjust different teaching responses to shift their classroom learning ecologies. In part three, I use one elaborated case to show how the process of relational investigation coevolved and was mediated across community conversations and classroom visits, with the travel across activity systems allowing for deeper investigations into how to adjust the classroom learning ecology to better support students' mathematical learning.

Part 1: From Teaching as Fixing to Teaching as Relational Investigation
Over the course of the school year, participants brought different teaching stories to discuss in Math Crew as they tried to enact their commitment to ambitious and equitable math teaching. Analysis of this activity of making sense of teaching stories over the course of the school year revealed two phases of observed activity: Phase 1 in which teaching was minimally investigated and where relatively simple solutions were offered to complex teaching issues with little connection to a broader vision for teaching, and Phase 2 in which Math Crew teachers began to investigate students' mathematical experiences as part of a complex classroom learning ecology. As teachers engaged in these relational investigations, they increasingly made connections among what they chose to do in the classroom, what they saw students doing in response to these choices, and their shared commitment to creating ambitious and equitable classroom math communities. In this section I first provide an overview of Phase 1 and Phase 2 and then provide detailed examples of conversations from each phase to illustrate the differences between the two.

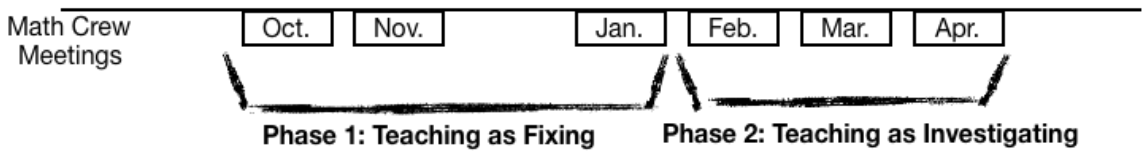


Figure 5. Change over time in Math Crew

During Phase 1, when teachers engaged in the routine of sharing a teaching story, both the telling of the story and the conversation that followed focused on relatively simple ideas or solutions. Conversations did not explore the complex contexts that might be giving rise to what teachers were seeing or how what they were seeing connected to their commitment to ambitious and equitable teaching. Participants tended to focus mainly on the perspective of the teacher and to minimally investigate the reasons students may be acting in particular ways or how their actions connected to different aspects of the classroom learning ecology. During Phase 2, stories or issues were still sometimes initially framed from the teacher perspective, but the discussions that followed began to include investigating students' mathematical experiences and making connections between student actions and different aspects of the classroom learning ecology. Teachers began digging into possible reasons for student actions, leading to extended discussions of potential teaching responses and how those responses might shift the learning ecology to foster more equitable interactions. These discussions touched on many larger themes of teaching related to the Math Crew shared commitment to ambitious and equitable math teaching. This led the group to consider complex problems of practice such as how to support students to see value in each other's mathematical contributions and how to support students to recognize many different ways to be good at mathematics. Table 1 shows a summary of the topic of the story, the length of the telling of the story and discussion, and the central topics that were discussed after each story.

Table 8. Shift in How Stories are Told and Discussed Over Time

	Teacher Date	Topic of Story	Time (min)	Discussion of Story
Phase 1	Tina 10/7/16	How students respond to each other when an error is shared during a Math Talk	8	• How to get kids to be "kind" to each other when responding to each others' thinking • Creating and posting math norms
	Maritza 11/4/16	One student's changing participation and status with mathematics over time	16	• Difficulty of noticing student strengths • How helpful it is to have facilitator notice strengths during classroom visit • How to deal with other adults in the classroom who may not share vision (e.g. RSP teacher) • How to respond when kids ask "why are we learning this?"
	Marie 1/7/17	Students reflections about enjoying math (writing and video)	9	• Different participation structures for math lessons (e.g. stations/centers) • How to manage when students finish math work at different times
Phase 2	Lauren 2/3/17	Students naming each other's strengths, changing status of one student	18	• Communicating math strengths to students • Supporting students to "see value" in each other's contributions • Ways of grouping students, impacts of grouping on collaboration • Affordance/constraints of different math content
	Kara 3/17/17	One student's changing participation and status with mathematics over time	11	• Affordance/constraints of different math content • Supporting students to see value in each other's contributions • The role of language in mathematical learning

	Selina 4/14/17	One student's changing participation and status with mathematics over time	32	• Affordances/constraints of different math content • What is revealed and not revealed in different forms of assessment • Dealing with language demands of written assessments • Relationship of elementary school math to math as we use it in the world

The table above captures a broad snapshot of how the activity of sharing and discussing teaching stories shifted over time. Conversations tended to last longer, to span more topics, to be more connected to each other across different meetings, to increasingly center individual students' mathematical experiences, and to become more focused on problems of practice related to the shared commitment of building a math community where every student meaningfully contributes to the mathematical work of the classroom. Whereas discussion topics in early meetings tended to focus on the local situation at hand and on the teacher, such as getting students to be "kind to each other" about mathematical errors or responding to the question "why do we have to learn this?" topics in later conversations tended to focus on students' mathematical learning from a relational perspective that attended to multiple interacting aspects of the classroom learning ecology. As teachers shifted to these relational investigations of teaching and learning they shared more in depth stories about individual students, and they discussed topics such as how to support students to see each other as mathematical resources and how different mathematical content might open up opportunities for students to participate in new ways.

To provide a more detailed look at the changes in these conversations over time, I examined the ways teachers participated in these conversations, analyzing how teachers talked about students and about mathematics and the connections they made to their shared vision. Table 9 shows the frequency and nature of these discursive practices during the story telling routine.

Table 9. Discursive Practices over Time

	Phase 1			**Phase 2**		
	Teaching Stories			Teaching Stories		
	Oct.	Nov.	Jan.	Feb.	Mar.	Apr.
Connecting to knowledge of students	0	3	0	5	7	4
Relating to students' mathematical experiences	1	1	0	3	1	5
Sharing students' specific mathematical actions	1	3	1	6	5	6
Connecting learning ecology with student	0	2	0	1	5	10

math participation						
Connecting to ambitious and equitable math teaching	0	0	1	7	9	11

As is evident in the table above, during the first three Math Crew meetings, discussions of teaching were not closely connected to what teachers knew about their students, to their math participation, or to students' mathematical experiences. These discussions were also not well connected to their shared commitment to ambitious and equitable math teaching and to the classroom learning ecology. The conversations about teaching during phase 2 included many more instances of connecting to the specifics of what students were doing in the classroom as well as connecting to themes and questions related to the Math Crew shared commitment of building a math community where every student meaningfully contributes to the mathematical work of the classroom. These discussions led to different articulations of teaching issues. Whereas in early meetings issues tended to remain local problems related to a particular classroom or lesson or to particular students, in later meetings even if issues were initially framed in local terms, participants made connections to larger problems of practice related to the shared vision of Math Crew. They also began to consider the issues from the perspective of how they might shift aspects of the classroom learning ecology.

Phase 1: Teaching as fixing local problems.

An example of this early form of making sense of teaching where complexity was left relatively unexplored, occurred in the October Math Crew meeting when Tina shared a story from her 5th grade math classroom. She described a moment when a student offered an incorrect answer to a division problem and other students responded by critiquing the student. In describing the moment, Tina said, "another student turned around and said, 'WHAT?!?'. And so right there and then I was like okay we need to refocus, this is not the way we talk to each other in math or in general or any other time of the day." She went on to say, in reference to trying to reinforce the math norm that was posted in her classroom of 'the answer is important but it's not the math', that "I had to remind myself just cuz I tell my students once, they are not going to immediately change their mindset and be able to be the kindest and nicest people in the world." In Tina's telling of this story, she describes the issue as students not being kind to each other, with no exploration of why students might be responding critically to incorrect answers. The conversation after Tina's telling of the story lasted for three minutes and is shown in the transcript below.

Mallika: Does anyone have any questions or connections or things that made you think about with your own classroom?

Kara: Umm I think just like the responses to the other thinking. Like when there is an answer that seems to other kids kind of out of left field like "what!?" you know like "65!?" You know, those really extreme reactions, and then I get mean and grouchy and I am like 'hey don't yell like that [wags her finger]'. It kind of like takes on this icky feeling of kids really being critical of each other's thinking and I don't know, not like, yeah, I just need a bit more

discussion based. “Oh this is really interesting” about that answer “what was your thinking along the way?” Cuz there is always a reason, there is always a thought connected to the other and they thought it was 65. Umm yeah and then kind of along the same thing, I have had some students say “this is easy” and “this is sooo easy”. And I really get on them for that, but I feel like there hasn't been a full change of attitude and so I don't know how to talk. I don't know. I feel like I have just addressed it to the whole class, but I haven't really reached them and I hear that all the time in math.

Tina: Same. I think you just keep repeating yourself.

Marie: I feel like I have to keep repeating myself in response to like some of those negative reactions from students but I feel like I need to create umm or like write out our norms, like I haven't done that. So that if they’re up I remember and then I can point it out to them, and like sometimes just having something physical with a picture that, like, I can remember to come back to. I feel like something that's been on my mind for the last two months, to create that and laminate it. But it hasn't actually happened yet, and just hearing your story made me feel like I need to put that task at the top of my list, like get it done and get it out. Like make norms actually norms.

Selina: I have especially one kid that’s just always talking and is always like “what!?” and, or laughing and talking and I am like, you know what this person sometimes like “if we laugh at them do you think they are going to want to share your answers again if someone laughed at you would you want to share an answer and then are we learning if we are not sharing answers or thinking?” And then it's just a constant reminder that when they are saying “what!?”, instead they can say “can you tell me more?”

The teaching responses generated by participants during this discussion were to “keep repeating yourself”, to “write out our norms” so that everyone has an explicit visual reminder of the norms, and to ask students to say “can you tell me more?” instead of shouting “what?!?” These ideas are sensible, but they are limited and the limitations are directly related to how teachers made sense of Tina’s story. The conversation stayed centered on the perspective of the teachers, with the issue being understood as how teachers can get students to be kinder to each other. If the issue had been investigated from a relational perspective that centered students’ mathematical experiences, teachers may have considered possible reasons *why* students might be responding negatively to incorrect answers such as students not seeing what they can learn from incorrect answers or as not seeing value in each other’s ideas (as was discussed in later Math Crew meetings). This could have led to very different conversations about teaching and learning that included considerations of issues of status or of narrow cultural notions of what math is, which may have led to very different potential teaching choices that were more responsive to the complexity of the issue and of the classroom learning ecology.

Phase 2: Teaching as relational investigation.
To illustrate the shift from participants approaching teaching as fixing local problems to beginning to take on relational investigations of teaching and learning, I use the example of a teaching dilemma Tina brought to the February Math Crew Meeting. This discussion provides a useful contrast to Tina's Math Talk story as it is the same participant bringing the story and yet both the story and the conversation that follows are quite different just a few months later. The group made sense of the classroom dilemma Tina shared in February by problematizing various aspects of the dilemma while led to new understandings of the issue as a complex problem of practice embedded in a classroom learning ecology. Teachers participated in this conversation in ways that were typical of Math Crew community conversations during phase 2 of the school year in that teachers investigated specific student work and participation and then connected student participation to their shared commitments and to the classroom learning ecology.

Tina explained to the group that one of her students, Albert, had asked her if they did math at the end of the day because it wasn't important. She reported that his question had led her to have her students respond to the writing prompt, "Do you think math is important? When do we use math outside of math class?"[4] In the student responses to this prompt, Albert was the only student who wrote that he didn't think math was important. She read his response to the group and passed his paper around (Albert's response is shown below).

> "I don't think math is important. Because you don't use it as much. Another reason is because when you will have a calculator. You will kind of never use it. Because you also have machines. Like the cashier thing. You also have other things to help you calculate things. It will only be useful if you don't have enough. Another time you would actually is useful is because you don't like using it. Another reason it will be useful is that you want to be smart. Another reason is useless because most people don't like math."
>
> Albert, Written Reflection, February 2017

Tina went on to say, "so I have the question now of how I can continue to show the class that I do value math and that it is very useful…a lot of it has to do with growth mindset too with this particular student, if he's willing to open himself up to liking math or not having this idea that math is useless and he hates it." In Tina's initial description of the issue, she frames it as a relatively simple issue of her teaching ("how can I continue to show the class that I do value math") and of Albert being "willing to open himself up." In the fifteen minute conversation that followed, participants investigated what Albert had written and his experience in the classroom learning ecology in ways that problematized Tina's initial framing by bringing in sensible reasons why Albert might not yet name math as important.

Lauren: What stood out to me was that the one reason he gave for being good at math was because he wanted to be smart which means he associates being good at

[4] I will return to this story in section two of the chapter, providing more information about the circumstances that led Tina to offer this writing prompt.

math with being smart. And since he doesn't associate himself with math then he doesn't think he's smart

Maritza: Yeah, I kinda thought that he only associates math with calculations. He seems to think like calculating numbers is boring so therefore, math is boring.

Selina: The thing that stood out to me was like, well, 'who do you think programs those calculators and those machines to do math?' You have to know how to use math to make these things. I think he just locked on that math equals calculations and just numbers. And thinking about engineering and stuff like that is pretty abstract stuff that he may not be exposed to.

Mallika: I feel like the way elementary standards are, it's kind of a valid point to make that math feels like a lot of calculation in elementary school. So it feels like, umm, you know, I think he got to that, you know, with the logic of his own experiences. It's not like he is way out in left field thinking about math being calculation.

Lauren: And I've heard the calculator thing from a few of my students. It's like why do we need to know the multiplication algorithm. And it's hard for me to come up with a response because, yeah, I don't do the multiplication algorithm for multi-digit multiplication. I use a calculator, so it's true. But you also need to know how to do math to use a calculator. It's not just like typing in random numbers, you need to interpret situations and know what operations to use. But I wonder, like, a lot of the math he seems to be doing is mental math, and I wonder if when he does mental math like number talks or something like that, something to point out to him. Does he participate in those?

Tina: Not very often. We do math talks about two to three times a week but he is not usually one of the students to participate. But if I do call on him, this past two weeks we had been working on multiplying and dividing whole numbers by decimals. And decimals with decimals. So starting off with one of our math talks was just like 32 divided by 2. Is the quotient going to be smaller or bigger than 32? And then 32 divided by half is that going to be bigger or smaller and he was able to participate and use his prior knowledge to build on something I was just introducing to them. So it's not like he can't do the math. Yeah so I mean he, umm, really likes, his first method always is the algorithm, which is the same with a lot of the students, especially the ones who do tutoring outside of school. So it's a lot of questions with algorithms and I've been emphasizing with the class, I haven't even talked to them about algorithms because I told them that it was super important for them to just understand what it is that they are doing. We have been working in the context of money and other word problems. And still when he does his work the first thing is the algorithm. So I don't know, it must be really boring for him.

In this part of the conversation, participants dug into what Albert had written, asked questions about his participation, considered the classroom from the perspective of students, and suggested sensible reasons for Albert's views on mathematics. They considered how different aspects of school and classroom ecologies might have supported Albert to come to see math as useless. This investigation then led to a conversation about math and smartness in which Marie continued with the theme of thinking about how Albert might have come to his views about math.

Marie: Well what's so sad is that most of the time they are not the ones who told themselves they're dumb. It just reminds me of, there is this group that comes into my classroom twice a week. It's like a math tutoring group and there is almost always a sub. And the subs are really under qualified to be doing the work that they are doing. And I think it was last week we had a sub in there and I'm usually trying to prep my classroom, but I overhear their conversations and they were asking those kinds of questions like "why do I need to do this? You know I could just use a calculator" and the sub is just like, "Well think about if you were stranded on a desert island and you don't have a calculator. What are you going to do?" And they are like (*Marie acts out looking around in confusion*, *other participants laugh loudly*)

Kara: I wouldn't be solving 8 x 25!

Marie: And it just like reminds me of all of the times that these kids have had interactions around math with adults. Who, when you are a kid, you naturally look up to these people and you take what they are saying as truth. And just like recognizing that, you know, that it is a bigger issue that we have of in our culture about math, umm, and the value of it, and if it is useful or if it isn't useful and what math even means. Umm, yeah, it just, I don't know. It's hard. It's just like a symptom of such a larger problem. You know and it's not like these kids are just coming up with these ideas about math. They are things that they have been told or things they have observed or felt.

With her contribution, Marie problematized what Tina offered as an issue of whether or not she was doing a good job showing that she valued math or Albert being "willing" to like math. Marie suggested that Albert's writing could be understood as sensible given pervasive and narrow cultural narratives about what mathematics is and what it means to be good at it. The explicit attention to Albert's perspective as one that is sensible given the sociocultural context, not an individual problem of Albert's, shifted participants' attention to a more generative discussion about what they might do. After Marie's comments, participants further explored the sense in Albert's comments and considered how teachers might support their students to see elementary math as a more expansive space that is not just about calculation.

Lauren: I think math is what happens in a math class. Actually what you said (*turning to Selina*) about the morning math thing made me think of like something, I don't know, something to keep track throughout the day. Like it could be someone's class job "when are we doing math right now". I don't know just like to keep a list of like practical things because the things we do use as adults are like the things that we do in number talks. In my head I do split things by place value if I am computing mentally, like that is what I do as an adult. And there are reasons I do it as an adult and I do have a calculator but like I also compute mentally in my head. I don't sit and do the long division algorithm. But I estimate. Estimating is something, so I don't know just like thinking about the things, like maybe keeping a tally something that I might do after hearing your story like for those kids who don't see a purpose in it and rightfully so in a lot of ways. Like who is going to sit as an adult and do the long division algorithm over and over again?

Marie: On a desert island

Lauren: On a desert island! (*laughter*) But who does divide, how much time do I have left till recess and like how many different things do I need to do in that time? Or I don't know like keeping a list, the kids all like jobs, especially in fifth grade like someone keeps track of all the times we do math that day. That might be interesting. And then you are not in charge of it, the teacher is not in charge of it, someone else is in charge of it and they keep track of it and report out I don't know at the end of the day or at the end of the week or something.

Kara: And just doing more think alouds yourself. Like there are so many times we use elementary school level math throughout the day. Like 10:45 it's 10:27 how much time left do we have of Reader's workshop and just like kind of putting up to them you know thinking out loud ummm

Mallika: And maybe asking [Albert] since he, how do you know so fast? Like what's your strategy?

Kara: And like actively working that in to other parts of the day. Cuz I feel like I totally get that like existential angst of like "why are we doing this?" (*laughter*). But starting, because like yeah I actually do use this stuff all the time. Like the four basic operations come in handy a lot and I feel like when we were doing like introducing multiplication it was kind of like, it's so exciting we're learning multiplication and you will use multiplication forever. (*laughter*) It's really good to know. How to multiply.

Lauren: It's a super important adult skill. But I think saying that and making it believable by actually tallying when are we using math right now might be

a different thing then saying it.

In this part of the conversation participants took seriously Albert's point that math is useless and considered why and how he might be getting that message and what they might do about it. Lauren pointed out the ways that students' views of math are heavily shaped by what happens in math class and she explicitly named the fact that kids might not "see a purpose in [school math]" as "rightfully so in a lot of ways." Kara continued this theme when she commented, "I feel like I totally get that like existential angst of like 'why are we doing this?'" There were also multiple moments in the conversation where teachers thought about their own experience doing math to connect to students' experiences, with Lauren acknowledging that she doesn't sit down and do long division, and both Lauren and Kara reflecting on the math they use in their own lives. Here Math Crew teachers investigated Tina's dilemma from a relational perspective that honored Albert's perspective as sensible and used it as a resource to consider how they might shift the classroom learning ecology. The teaching responses they offered of keeping a list of the math they use during the day and thinking aloud when they themselves use math during the school day responded to the complex problem of practice of the difficulty of seeing the relevance of elementary school math when the standards and curriculum often seem very disconnected from students' lives. There is still more that could have been explored, such as the diverse ways students might use math outside of school and how teachers might invite these into their classroom. However, the ideas suggested here represent a shift in that they were responsive to the issues raised by Albert. This conversation was typical of the conversations about teaching and learning in Phase 2 of Math Crew in that investigating students' perspective was central to the conversation and the teaching responses suggested were responsive to this student-centered view of the classroom.

Summary of shifts in community conversations.

In Phase 1 of the activity of making sense of teaching in Math Crew, classroom stories were shared and discussed in ways that offered some new teaching ideas. These conversations provided teachers with a space to make sense of teaching together and offered new resources for classroom teaching such as posting norms and giving students new ways to respond to each others' thinking. In Phase 2, as teachers dug deeper into teaching stories from a relational perspective that centered students' mathematical experiences, they participated in ways that created many more opportunities for equity-oriented learning. Lauren and Maritza analyzed the specifics of what Albert was saying and then connected his writing to broader issues of teaching and learning. Marie connected Albert's perceptions about himself and about mathematics to dominant cultural narratives about mathematics. Lauren and Kara suggested teaching responses that might provide students more opportunities to see how the math they are learning connects to their everyday lives. These ways of participating were generative for the conversation in that they led to new ways of understanding the issue, They were also generative for ongoing teacher learning in that analyzing and problematizing what we think we see in the classroom is integral to creating a classroom math community that functions very differently from what is currently typical in schools.

Part 2: Classroom Teaching: Working on Complex Problems of Practice

The shift in participation in community conversations toward relational investigations of teaching and learning that centered students' mathematical experiences was accompanied by a parallel shift in teachers' classroom teaching. Over the course of the school year, five of the six Math Crew participants took up complex problems of practice that they worked on over time in their classrooms. Here, I analyze the participation of these five participants, connecting their relational investigations of teaching and learning to their classroom teaching. In Appendix C of the dissertation, I offer a brief preliminary analysis of the experiences of Marie, which differed in interesting ways from that of the other five participants. In future research and writing I intend to take up her case more fully to explore why she did not experience the same shifts as the other five participants.

An analysis of the shifts in classroom teaching did not reveal two phases as clearly as in the community conversations, but instead a deepening over time of the ways participants investigated and worked on problems of practice in their classroom from a relational perspective. Kara, Lauren, Martiza, Selina, and Tina all came to take up different problems of practice in their classroom. Over the course of the school year, they worked on these problems of practice by trying out new teaching ideas, reflecting on these ideas, and making adjustments to their teaching in response to what they noticed about students' mathematical learning. Though these participants focused on multiple problems of practice in their teaching, not all of those problems were discussed in depth in Math Crew community conversations or in classroom visits. In my analysis of learning over time in classroom teaching, I identified the one problem of practice each teacher referenced most in the available data sources to consider how they investigated this problem over time. Table 3 shows an overview of the problems of practice these five participants discussed most frequently in Math Crew and the teaching responses they tried out in their classroom related to these problems of practice.

Table 10. Problems of Practice in Math Crew

Participant	Problem of Practice	Classroom Teaching Responses
Kara	Supporting equitable participation during group work	• Adjusting mathematical tasks to make them more open to different math strengths • Placing students in randomly chosen trios for one week at a time • Having trios share one workbook and one pencil • Co-creating and reflecting on group work norms with students
Lauren	Supporting positive mathematical identity development	• Having students write strengths on post-it notes on peers' math posters • Naming mathematical strengths for tasks • Assigning competence to students for their mathematical contributions • Having students name each others' strengths in debrief conversations and on post-it notes • Induction inquiry project on strengths • Reviewing student work to look for strengths and sharing these strengths during conferences

Maritza	Creating more space for students' mathematical ideas	• Brainstorming a list of mathematical strengths with students • Assigning competence to students for their mathematical contributions • Adjusting mathematical tasks to make them more open to different math strengths • Introducing a routine of starting class with a Number Talk to discuss multiple strategies • Induction inquiry project on Number Talks
Selina	Increasing mathematical participation of focal students	• Adjusting mathematical tasks to make them more open to different math strengths • Using different participation structures for math tasks • Assigning competence to focal students for their mathematical contributions
Tina	Expanding students' conceptions of mathematics and mathematical competence	• Naming mathematical strengths for tasks • Having students name each others' strengths using post-it notes and in debrief conversations • Having students respond to written prompts about their perceptions of mathematics • Assigning competence to focal students for their mathematical contributions

As is evident in the above, all of the problems of practice that teachers chose to work on are closely aligned with their shared vision of creating a math community where everyone meaningfully contributes to the mathematical work of the classroom. Each of these five teachers tried out new teaching ideas in their classrooms and some of these teaching choices became typical, meaning that they were repeated over time (as evidenced in classroom visits and in what participants reported about their classroom teaching in community conversations). In addition, as teachers experimented with their teaching, some new ways of interacting with mathematics and with each other became typical for students. Table 11 shows new practices that became typical in each of these classrooms as was evident in the available data sources.

Table 11. New Typical Classroom Practices

Participant	New Typical Practices
Kara	• Students work in randomly assigned math trios for one week at a time • Students share one workbook and one pencil for math tasks • Many different students share their mathematical ideas and respond to each others ideas in small groups and whole class discussions • Increased mathematical participation from focal students over time
Lauren	• Students work regularly with a partner on rich mathematical tasks • Many different students share their mathematical ideas and respond to each others ideas in small groups and whole class discussions • Teacher and students name many ways to be good at math

	• Students use many different representations and strategies to solve problems • Increased mathematical participation from focal students over time
Maritza	• Many different students share their ideas and respond to each others ideas in small groups and whole class discussions • Class discussions focus on student ideas • Students use many different representations and strategies to solve problems • Teacher notices and names students' diverse mathematical strengths • Students ask their own mathematical questions • Increased mathematical participation from focal students over time
Selina	• Teacher creates rigorous math tasks • Teacher adjusts participation structures based on observed participation problems • Students uses many different representations and strategies to solve problems • Increased mathematical participation from focal students over time
Tina	• Students uses many different representations and strategies to solve problems • Students notice and name each others' math strengths • Many different students share their ideas and respond to each others ideas in small groups and whole class discussions • Increased mathematical participation from focal students over time

Kara, Lauren, Maritza, Selina, and Tina all made changes in their classroom teaching that appeared to support new forms of participation for their students from increased participation of their focal students to students noticing and naming each others' strengths. To give a sense of how these new practices represent a shift over time and connect to relational investigations that centered students' mathematical experiences, I offer an illustrative example from Maritza's fourth grade classroom.

Maritza: Creating more space for students' mathematical ideas

Over the course of the school year Maritza made some substantial changes to her daily classroom teaching practice from a focus on modeling and practicing mathematical procedures to eliciting and building on students' diverse mathematical ideas. To provide some sense of what this shift looked like in her classroom, I analyze how Maritza chose to start her math instructional time, as this part of her teaching showed the most marked contrast across the year with respect to her commitment to shifting her instruction to make space for her students' mathematical ideas.

The curriculum used by Maritza's school district was heavily teacher-centered, with lessons structured around teacher-led "concept development" which often consisted of modeling a procedure followed by partner or independent work practicing that same procedure. In the first lesson I observed in September, Maritza taught a lesson that followed this basic structure, focusing on the content of solving multi-step word problems using addition and subtraction. Maritza began her instructional period by having the students sit on the carpet and solve the following word problem:

> Owen wants 1,000,000 visitors to his website. In month 1 he has 228,221 visitors. In month 2 he has 301,856 visitors. In month 3 he has 299,542 visitors. How many does he need in month 4 to reach his goal?

Students worked on the problem in partners, writing on small white boards. All students solved the problem using standard US addition and subtraction algorithms. For several pairs I observed, the two students arrived at different answers and weren't sure how to resolve the differences. After 10 minutes, Maritza called on a volunteer to solve the problem at the board. Sophia came up to the board and solved the problem by first adding month 1 and 2, then adding month 3, and then subtracting the total from 1,000,000 using US standard algorithms for addition and subtraction. She did not explain what she was doing or why she was doing it. Maritza reviewed and evaluated each step of her procedure out loud as Sophia wrote on the board. When she arrived at a solution, Maritza then prompted her to use addition to check her answer. One of the other students who had arrived at a different answer commented, "I feel like I did a lot of math and I have the wrong answer." Students then went back to their seats to work with their table partner on the same types of problems in their math workbook. Students used the same procedures to solve the problems in their workbook. When I spoke briefly with Maritza afterwards, she was not particularly pleased with the lesson or with how math was going in general, but she was not sure what else to do. She was trying to follow the curriculum she had been given as best she could but she was noticing that some students were not participating very much and she mentioned a student she was concerned about who was not feeling much "confidence in his own math ability." She did not like the way the curriculum was so teacher-centered, but she felt unsure of what to do about it, especially given that the district-mandated assessments she was required to administer were closely aligned with the curriculum.

Over the next several months, Maritza continued to think and wonder about why some of her students were not participating as much as hoped. She began to consider how she might make adjustments to the curriculum and to her pedagogy to invite students to share more of their ideas. Over the course of the year, Maritza tried out new teaching strategies to try to provide more ways for her students to engage with mathematics and to invite more participation from students who were not yet participating often. For my next visit in November, she asked for help in creating a task to help students think about area and perimeter. We co-designed a task in which students came up with different ways to create rectangles using 24 square tiles and made observations about what they noticed about the area and perimeter of these different shapes. In the subsequent classroom visit, we collaborated to modify a lesson on division from her curriculum from one that focused on modeling and practicing particular strategies for division to a lesson in which students worked with a partner to come up with different strategies to solve division problems and then shared those strategies. In February, Maritza began starting her math instructional time with the classroom routine of using a Number Talk (Parrish, 2010). This was a routine that she had been introduced to during her math pedagogy course in teacher preparation and it was a routine that was discussed during Math Crew as several teachers were using it regularly. Maritza decided to start using Number Talks as a way to provide some structure and consistency for students to share their mathematical ideas. In

Maritza's classroom, Number Talks followed the basic structure of the teacher writing a problem on the board, students thinking quietly to themselves, students sharing possible answers, and then students explaining different strategies to get to a solution. Sometimes the content was directly related to the main content of the lesson and sometimes it related to mathematics topics students had already explored. After trying out Number Talks and seeing students share lots of different strategies and ideas, Maritza decided to keep using the routine. In fact, she chose to focus on Number Talks for the Beginning Teacher Support and Assessment (BTSA) inquiry project she had to complete as part of her credential induction program.

To provide a sense of the shift in Maritza's typical classroom practice, I offer one example of a Number Talk in her classroom that occurred in March. Maritza launched her math instructional time by doing a Number Talk in which students solved and discussed a related sequence of division problems. For each problem, Maritza wrote the problem on the board, gave students silent think time, asked students to share answers, and then called on students to share their strategies. For the first problem, 100 ÷ 4, the discussion began with a student sharing how she used a partial quotients algorithm to get the answer, mentally calculating 10 x 4, 10 x 4, and 5 x 4 for a total of 25 groups of 4. Another student agreed with the answer of 25 and shared that she divided by 2 twice, first solving 100 ÷ 2 and then 50 ÷ 2 to get to 25. Another student shared that he thought of it as 100 cents and he knew 4 quarters would get to a dollar. The next student who volunteered shared that she first tried adding four 20s to get to 100 but that was too small. She knew it was 20 less than 100 and five fours is equal to 20 so she knew she needed to add 5 to each of the 20s for an answer of 25. As students shared their answers, Maritza recorded their strategies on the board, occasionally asking clarifying questions.

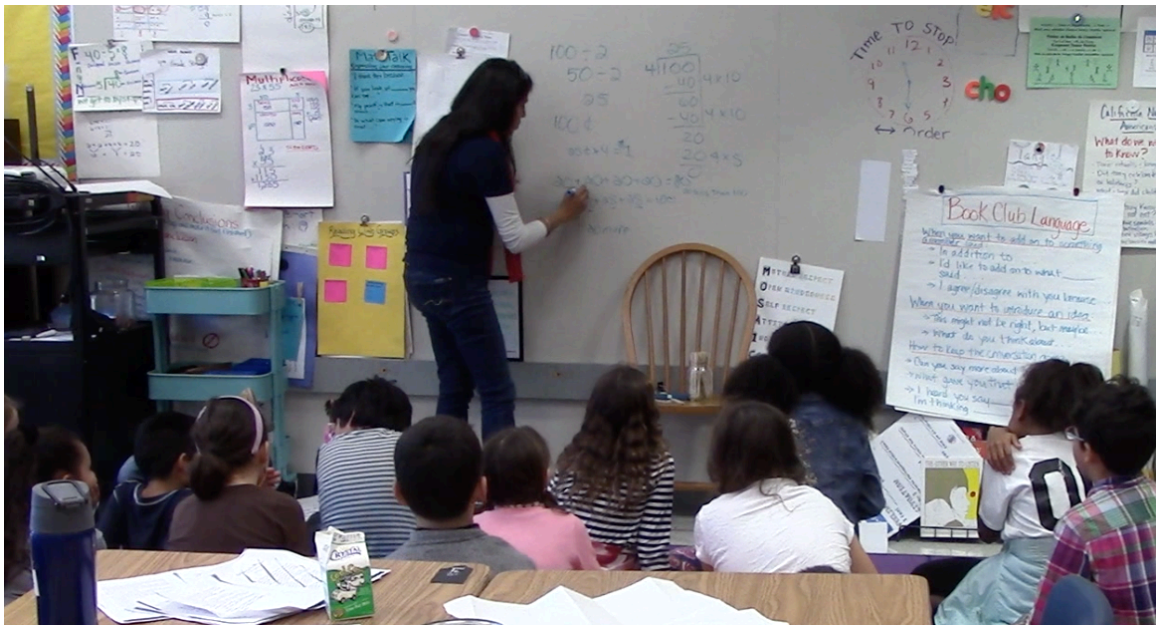


Figure 6. Maritza recording student strategies

After discussing strategies for 100 ÷ 4, Maritza followed up with a discussion of strategies for solving 200 ÷ 4, and then 216 ÷ 4. For each of these next two problems students also shared multiple strategies. Throughout the Number Talk, many different

students participated and many different strategies were shared. There were 15 students in Maritza's classroom for this lesson and twelve of the fifteen students shared a strategy or mathematical question at some point during the Number Talk.

This Number Talk was typical of the three other Number Talks I observed in Maritza's classroom and of how she spoke about Number Talks in Math Crew community meetings. In terms of her problem of practice of "creating more space for students' mathematical ideas", the ways she began her lesson in September and in March provide a stark contrast. In September, students all appeared to solve the problems using the same procedures. One student, Sophia, had a chance to share her work by writing her procedures on the board while Maritza checked them. During the Number Talk in March, many different students shared their ideas and the ideas that were shared were mathematically diverse. Students shared their own reasoning in detail and engaged with each other's ideas. Maritza recorded their ideas, asked questions, and facilitated conversation among students.

Student participation and the mathematical focus of the activity were markedly different across these two examples. In the lesson launch in September, participation was limited to practicing and showing a previously learned procedure. The mathematical conversation focused on accurately performing that procedure. In the Number Talk in March, students were invited to share the different ways they were thinking about the problem. The mathematical conversation focused on explaining their ideas and connecting them to other ideas. This general shift from modeling and practicing procedures to discussing and making connections across strategies was evident across my visits to Maritza's classroom and the stories she told about her classroom during Math Crew.

This change in her classroom teaching was not without tension for Maritza. The district-mandated assessments she was required to give her students were written in the same style as the curriculum, which meant that sometimes the assessment directions dictated which strategy students should use to solve a given problem. Maritza struggled with whether she was adequately preparing students for these assessments given that she was often encouraging them to use the strategies that made the most sense to them rather than having them practice the specific procedures suggested in the curriculum. However, Maritza also received some positive feedback for the direction she was taking. During the March Math Crew meeting, she related this story about being observed by her BTSA coach for her inquiry project:

> "We've been doing fractions and it's been going really well and it seems like they're really understanding it. And I was observed by my BTSA coach this week in math and I was really nervous. For my BTSA inquiry thing I said I was going to do fraction Number Talks to help deepen kids' understanding of fractions. So I did a fraction Number Talk and I put a fraction on the board and kids had to say if the fraction was closer to 0, closer to ½ or closer to 1 and explain. And the kids did it and explained and it went really well. And afterwards [my BTSA coach] said she was blown away by how well my kids understood fractions. Which I thought was nice. And then she said that she learned things that she thought she already knew, which was fun."
>
> Maritza, Math Crew Community Meeting, 3/17/17

Summary of shifts in classroom teaching

Over the course of the school year, Maritza made substantial changes to her classroom teaching in ways that connected closely to the Math Crew shared commitment of creating a classroom community where each student meaningfully contributes to the mathematical work of the classroom. Early on in the school year, opportunities for student participation were heavily constrained. Students were often limited to showing and practicing procedures, as was evident in the introduction to her lesson on solving multi-step word problems involving addition and subtraction. Over time, as Maritza began to try out different ways of using the curriculum and to introduce new teaching routines, students had many more opportunities to participate including offering explanations of multiple strategies and representations, asking mathematical questions, and making sense of each others' strategies, as was evident in the Number Talk about division described above.

This shift in Maritza's classroom teaching is one example of how Math Crew teachers worked on problems of practice over time and deepened their investigations to make enduring changes to their classroom learning ecologies. Maritza began her investigation of how to make space for diverse ideas by trying out different ways of modifying her curriculum. These early attempts tended to be prompted by classroom visits by me rather than as part of her daily practice. As she tried out different approaches she found that Number Talks worked well for her and for her students. She took this up as a regular part of her practice and even as a focus of her BTSA inquiry project. This path of trying out multiple new ideas during classroom visits and then eventually making more enduring changes to classroom teaching was typical across the five participants who made substantial shifts in their practice toward the shared commitment of Math Crew. The shifts teachers made in their classroom teaching were closely related to the conversations teachers had in Math Crew monthly meetings. The move toward relational investigation that centered students' experiences in monthly meetings provided many resources that mediated teachers' thinking in new ways and these resources were then taken up as teachers worked on problems of practice in their classrooms. In the next section I will share another example of shifts in classroom teaching, focusing on how travel across Math Crew and classroom activity systems provided new forms of mediation and supported ongoing relational investigations of teaching and learning.

Part 3: Learning Across Activity Systems

In the previous sections, I examined learning in Math Crew community conversations and then in classroom teaching. Though I conducted these analyses of learning separately, in practice learning across these spaces co-evolved. Stories, new ideas, and reflections traveled across activity systems and mediated teacher learning as teachers worked on different problems of practice. I use Tina's case to illustrate the ways Math Crew teachers took up threads of investigation across different spaces, utilizing a rich array of resources made available through their participation in Math Crew. Tina's case was typical of how these five teachers took up investigation in that all five teachers engaged with problems of practice across Math Crew conversations and classroom visits and made use of resources across these spaces to experiment with new ideas. Tina's case is also atypical in that she made particularly robust use of resources across these spaces as she investigated teaching and learning in her classroom.

Table 12 shows a timeline of Tina's investigation over time of the problem of practice she focused most on over time in Math Crew of expanding students' conceptions of mathematics and mathematical competence.

Table 12. Tina's Investigation of a Problem of Practice

Time frame	Data Source	Summary
Sept-Nov	Field notes (9/2018)	**Naming mathematical strengths** • Tina notes general strengths on poster while students work on math partner task (not attached to students)
Nov-Dec	Math Crew video (11/18)	**Involving students in naming mathematical strengths** • Discussion in Math Crew meeting of how to support students to notice and name each others' strengths
	Audio recording	• Tina and Mallika meet to plan lesson before visit, discuss how to debrief lesson with strengths
	Field notes	• Tina shows poster at beginning of class about different ways to be smart, students share how their partner was being smart in math
1/2018	Email with facilitator	**Investigating focal student experience** • Tina emails Mallika to ask for help in thinking about one of her focal students (Albert), Mallika responds
2/2018	Email with facilitator	• Tina emails back with more questions about Albert and with an example of something he wrote about math
2/2018	Math Crew video	• Tina brings student writing and dilemma about Albert to ask Math Crew for help • Lauren shares story about supporting students to notice strengths
2/2018	Field notes	**Co-constructing expansive language of math competence** • Tina has students write math strengths of their partner on post-it notes and share out at end of class
3/2018	Math Crew video	• Tina reflects on focal student participation and post-it routine
4/2018	Field notes	• Tina uses specific list of strengths to launch math task • Tina has students add to the strengths list at the end of class

Figure 7 shows how Tina's investigation into her problem of practice developed over time across Math Crew monthly meetings, visits and conversations from me as facilitator, and Tina's daily classroom teaching. I will return to this figure at the end of this section to summarize the ways Tina's learning co-evolved across activity systems.

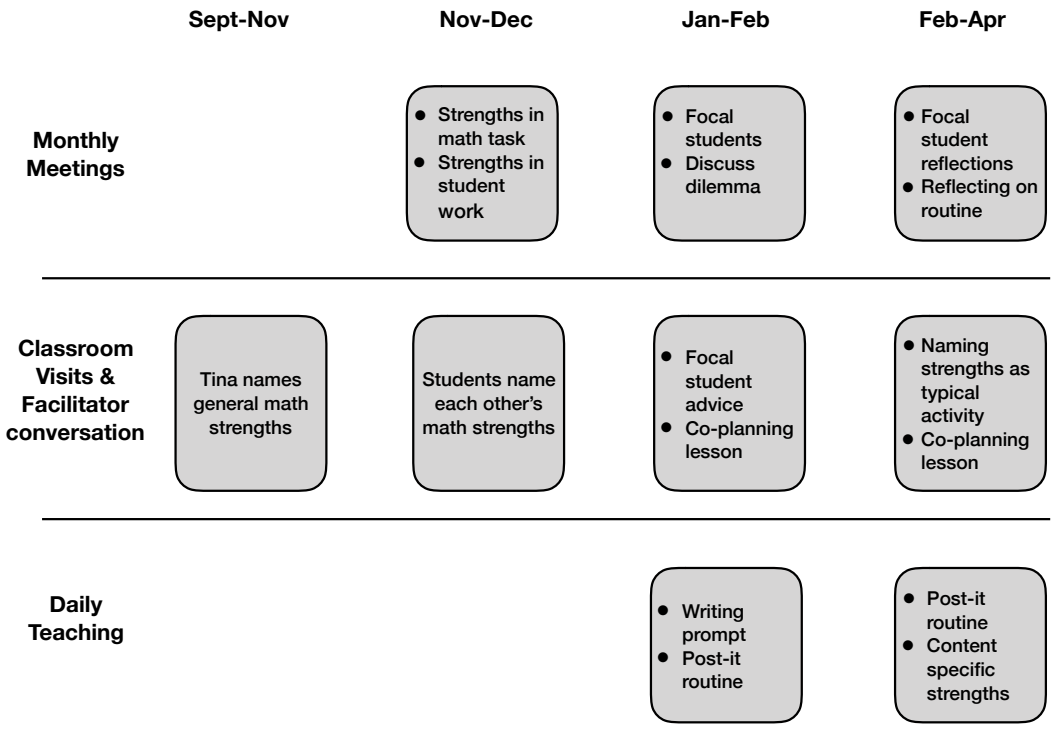


Figure 7. Learning across Activity Systems

This figure is meant to suggest the ways that Tina's learning was mediated and amplified across time and different activities and spaces. Figure 8 shows a schematic representation of this figure, highlighting the amplification across different spaces over time.

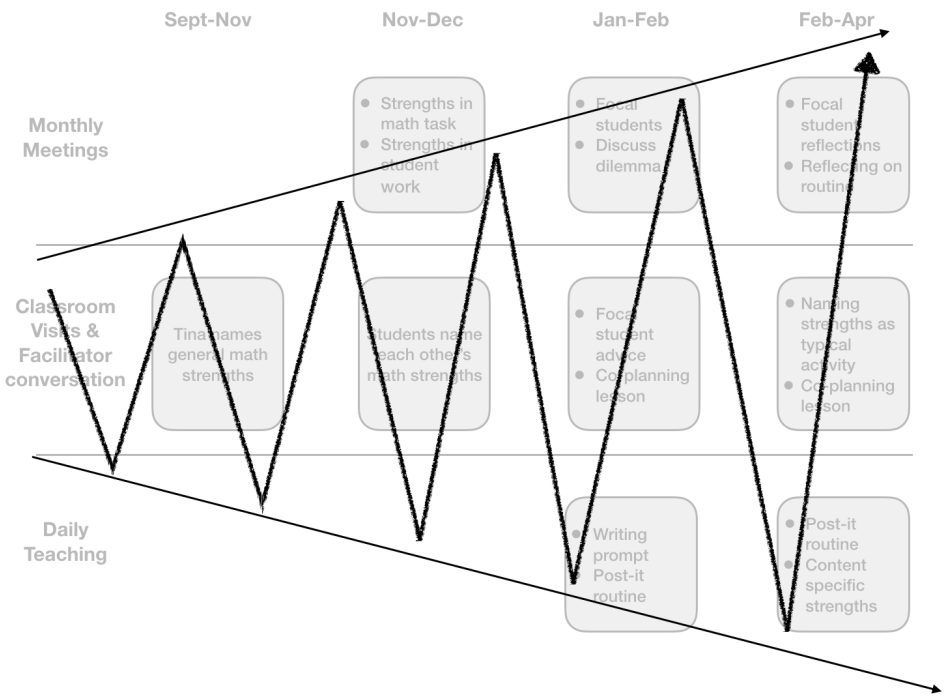


Figure 8. Schematic of Tina's Learning Across Activity Systems

From the beginning of the school year, Tina was committed to expanding what it means to be good at math in her 5th grade classroom. The ways that she talked about mathematical competence and worked on expanding notions of what it means to be good at mathematics with her students shifted and deepened over the course of the school year. At first, Tina focused solely on her role in expanding conceptions of what mathematics is and of mathematical competence. Over time, she began to involve students and to investigate how student participation might be related to conceptions of mathematics and mathematical competence. This investigation supported Tina to increasingly attend to how she might create a learning ecology that supported students to notice and value each other's mathematical strengths. This shift in Tina's participation coevolved across both the Math Crew activity system and her classroom activity system. To give a sense of the shifts across these different activity systems and the ways Tina's learning was enriched by the travel across systems, I provide a narrative overview with embedded data and vignettes of several key moments.

September-November: Offering an expansive view of mathematical competence. During my first visit to her 5th grade classroom in September, Tina used a poster she had created titled "Multiple Abilities and Strengths for Groupwork" with a list of eight items, including "using multiple strategies and representations" and "thinking outside the box". In this lesson, Tina read the poster aloud, listened for and recorded student strengths on the board while students worked in partners, and read out the list at the end of class. The strengths she read were not connected to any particular students or mathematical actions and instead were more general such as "multiple representations."

In the November Math Crew community meeting, much of the conversation focused on noticing and naming diverse mathematical strengths. As facilitator, I had

chosen this as a focus after noticing that participants seemed to want to work on expanding conceptions of mathematics and mathematical competence in their classroom community but no one was yet involving students in that process. After working together on a mathematical task involving solving a missing addend problem with decimals using multiple strategies, I facilitated a discussion where we practiced naming the different mathematical strengths participants had noticed while working with each other. We then looked at some student work Lauren brought from her classroom dealing with similar content (decimal addition) and named the strengths we saw in the student work. Following this conversation, we brainstormed ways to develop a shared language for diverse mathematical strengths with their students. Marie suggested having a strengths list in the classroom with pictures for her first graders. Lauren suggested having a debrief discussion at the end of an activity where students could share strengths of their partner, similar to what we had done after the mathematical task they had worked on in the meeting. Tina commented, "Many times when my students do group work, I have a group strengths chart up on the board, and so I go around and notice what they are doing well. And then afterward, its anonymous, but they are really pleased to be able to identify 'oh that was our group' or 'that was me!' whether or not it was from their group, that feeling of 'I'm up there somewhere.' I think it would be really cool to transfer that responsibility onto them. At the end, publicly complement someone, don't just say 'good job', but share with the class something that your group did well."

November-January: Involving students in defining mathematical competence.
Tina decided that involving students in noticing and naming mathematical strengths was something she wanted to focus on for her next classroom visit. She and I met a couple of days before the visit and discussed her lesson, thinking together about how she might try out transferring some responsibility to her students for naming diverse mathematical strengths. She started her lesson by bringing out her multiple abilities poster again and reading it to students. She then gave them a task in which students worked with a partner to come up with multiple strategies to solve a word problem involving combining mixed numbers. She asked students to remember two things when they were working: "show your work in as many ways as possible", and "notice how your partner is being smart at math." For the last few minutes of class, Tina called students back to the carpet. She said "I saw so many ways you were being smart" and then asked students to share ways they saw their partner being smart at math. Several students volunteered to share, offering, "when we were stuck, [my partner] knew what to do" and "my partner was being smart by finding new ways" and "using the hundred grids and looking at our math notebooks."

During the January Math Crew meeting we returned briefly to the theme of expanding conceptions of mathematical competence. I asked the group if they had tried anything related to the ideas we had brainstormed in the November meeting. Kara shared that she sometimes had her students share compliments at the end of math but they were not always math specific. Tina shared that she had been using her own strengths list and strengths lists that were sometimes offered in her district curriculum and had students share what they noticed about their partner, but that she had noticed that some students with higher status were getting recognized more often.

January-February: Investigating focal student experiences.
In our January community meeting, I asked participants to choose three or four "focal students" for Math Crew. I told them they could choose any students who they were curious about and wanted to think about how to support better. Tina chose to focus on Albert, Michael, Barry, and Julie because she did not think these students saw themselves as good at math. During that meeting, participants talked with a partner about their focal students, sharing what they knew about their strengths and the questions they had about supporting these students. I also let them know that these were the students we would focus on during my classroom visits. Three weeks after that meeting, Tina sent me the following email:

> Just wanted to let you know that it's been so helpful to choose just a couple focal students for my strengths inventory -- I feel that they are also feeling more positive about math.
>
> Quick story: Every morning, I review the daily agenda with the class, and about a week ago, Albert (a focal student) asked, "Why do we always end the day with math? It is cus it's not important?" I responded by saying that the students are usually in the mood to work together and chat in the afternoon, and since math is usually done in pairs or groups, the afternoon is the perfect time for math. (But in reality, even more so than what I told the class, there is the school-wide expectation to do reading and writing in the morning, when students are more awake and focused...)
>
> I was pretty concerned that students had / have the idea that math is not as important as other subjects. However, I once had them do a writing assignment in which they explained which subject/skill that they are learning in school would be most useful as an adult, and the majority of them said math is most important.
>
> I wonder what I can do to address this idea about how much I value math?
>
> Tina, Email communication, 1/27/17

I responded to Tina with some vague thoughts and ideas, including: "I think you could also involve students in this issue by sharing with them the effect Albert's question had on you and thinking with them about ways that are not about when you teach math to better reflect how much you really do value math and/or maybe have them do some writing about how they use math in their lives." Tina wrote back three days later with this response:

> I had the students write a response to the prompt, "Do you think math is important? When do you use math outside of math time?" Interestingly, every student but Albert said they think math is important. Many of them said it's important in everyday life because they purchase things and need to tell time, and

> a bunch of them said it would be helpful "when they are an adult" (e.g. if their job was to be a cashier).
>
> Albert's response was this:
>
> "I don't think math is important. Because you don't use it as much. Another reason is because when you will have a calculator. You will kind of never will use it. Because you also have machines. Like the cashier thing. You also have other things to help you calculate things. It will only be useful if you don't have enough. Another time you would actually is useful is because you don't like using it. Another reason it will be useful is that you want to be smart. Another reason is useless because most people don't like math."
>
> I do need to continue to emphasize the importance of math to the whole class, but on top of that, I would like to help Albert shift his attitude about math. (Julie's response was also kind of on the fence, and overall Barry could use some help with his growth mindset. Michael has come a long way in terms of believing in himself and not giving up as quickly, but he does struggle with some fundamentals, so that often affects his attitude...)
>
> Tina, Email communication, 2/1/17

I was intrigued by Albert's writing and decided to respond by inviting Tina to share this dilemma with the group since we had a Math Crew meeting scheduled for later that week:

> Thank you for sharing, this is fascinating! I think you are totally right that this is about something else for Albert and infusing math in other ways will not address what he raises. His response is amazing- super honest and he makes some good points (and adorable, great closing line!).
>
> If you're willing to share this story on Friday and Albert's response, I think it would be interesting for us to think together as a group about what to do as a teacher. I'm sure everyone has at least one student like Albert in their class.
>
> Mallika, Email communication, 2/1/17

This email interaction led to the discussion included earlier in the chapter investigating Albert's writing and connecting it to cultural narratives about math and smartness and the limitations of the elementary school math curriculum. In addition to the parts of the conversation shared earlier, there was also a stretch of conversation that focused more centrally on Albert's relationship with mathematics, shown below.

Mallika: I mean I wonder about, thinking about what Lauren said about the smart piece and, that resonated with me too, like oh wow, math and smartness being kind of synonymous or something, which I think is kind of a big

societal thing, right? But, it made me think about your story with Arturo (*gesturing to Maritza*), and I wonder if part of it is not only about… self-perception and how others see you is so intertwined. And figuring out ways, that could be something we try out when I visit your class again, but figuring out some really public way that Albert gets to show his strengths or feel really smart publicly. I wonder, is it about math or is it about the fact that he doesn't think he's smart? It's hard to disentangle that sometimes for people.

Lauren: I tried something like that with this math intelligences thing. The same student asks me why do we have to do this and he is obviously struggling a bit and I don't think he sees himself as like a strong math learner. Finn (*gesturing to Mallika*), who you and I both noticed his partner wasn't listening to him, but he's not good at actually expressing his ideas, he just expects people to listen and if they don't he gets frustrated and uses it as an excuse to not participate, like I've noticed that across group work contexts. But he had great ideas and like no one was listening to him. So for my example of how I would state an appreciation for my partner I used him as an example on purpose because he of everyone seemed a little downtrodden by that activity. I guess my example was, 'if Finn was my partner I would say, "I noticed Finn was smart because…and here's something I noticed, he did this and this and this."' I mean it's probably like the one thing at one level is probably not enough because he still battles with it. But I try to remind myself that he'll probably remember like that one thing I said at one point. I don't know. Using him as an example sometimes when I've noticed him doing something smart in math and like sharing it with the class.

Tina: Mmhmm. It takes a lot of it.

Lauren: Yeah. It takes a lot. It hasn't like miraculously made some sort of, my student sounds similar to yours in that way.

Tina: But just like hearing a teacher say that you're smart. Because I'm been using "oh you're so smart at this" or "you're so smart at that" especially in math. A lot of them are just like, "no, I'm not, I'm not smart. I'm so dumb. That guy is smart because he's so good at the algorithm." Whereas the person who was saying they're dumb was actually the one who was understanding the context and the reason we, like what it means to divide by decimals, and the other kids are just like, use the algorithm. But they just have this idea by 5th grade, if they've been telling themselves they're dumb at math, they're just like you're making that stuff up.

Marie: Well what's so sad is that most of the time they are not the ones who told themselves they're dumb.

In this conversation, I deliberately attempted to shift the discussion from Albert's negative relationship with mathematics as a problem with Albert to an issue of the learning ecology. In Lauren and Tina's subsequent comments it is evident that they tried to take up thinking about the learning ecology and also that shifting away from a focus on individuals was not easy for them. Lauren acknowledged that Finn wasn't being listened to and then pointed out individual reasons why this might be Finn's fault ("but he's not good at actually expressing his ideas, he just expects people to listen and if they don't he gets frustrated and uses it as an excuse to not participate"). Tina talked about the ways that what gets seen as smart in the classroom is not always what she values as mathematical strengths and shared how she tried to counteract that, and then concluded with a statement that "they've been telling themselves they're dumb at math", again putting it back on the individual. Marie directly countered this focus on the individual by pointing out that maybe they aren't actually the ones telling themselves this. Throughout this stretch of conversation, resources made available by the travel across activity systems mediated the conversation. Classroom stories shared previously in Math Crew and experiences from my classroom visits were referenced in the discussion to support ideas with concrete examples and connections (e.g. Maritza's story about Arturo). This conversation about Albert gave Tina extended time to consider the classroom from Albert's perspective, thinking with the group about why Albert might be experiencing mathematics and his own mathematical competence in somewhat negative ways.

Before this discussion of Albert's mathematical experiences, Lauren had shared a story from her classroom about how she supported her students to notice and name each other's strengths during one task. This story was from a lesson Lauren and I had discussed together for a classroom visit. Some ideas from this story then showed up in the strategies Tina tried in her classroom. Lauren related a lesson she had taught where she launched the math task by showing students a list of mathematical strengths they would need for the task (e.g. using academic language to show your thinking, looking for patterns in geometric shapes). At the end of the task she had students share out strengths they had noticed from their partner, using the language from the list as well as adding new strengths to the list. In telling this story, Lauren also shared how she had students use post-it notes to write strengths on each other's posters in another lesson. In our final Math Crew meeting of the year in May, Tina thanked Lauren for sharing these ideas because they had sparked some new ideas for her.

February-April: Enduring shifts to the classroom learning ecology.

In February, after the Math Crew meeting in which the group discussed Albert and Lauren shared about how she was attending to strengths in her classroom, Tina decided to introduce a new routine related to math strengths in her classroom. She introduced the routine on her own, not as part of a classroom visit from me. When students worked on a math task with a partner, she would pass out post-it notes and ask them to notice their partner's strengths while they worked. She then gave students time at the end of class to write these down and attach them to their math papers. At the Math Crew Meeting on March 17th, Tina shared some reflections about her focal students and she also referenced the post-it routine, describing how students were taking it up on their own:

Tina: 3 of my 4 focal students who just never really participated, um, kind of struggled to show themselves as mathematicians, they're always raising their hands in math class now. Um, Albert, Barry, and Michael, they're always raising their hands. Sometimes they'll raise their hands and then be like 'never mind, I don't know.' But they're still willing to put themselves out there and share. And even if whatever is on the board is incorrect, other students have gotten the hang of 'we're not gonna disagree with the person, we're gonna disagree with what's on the board.' So I think in the beginning of the year it still felt really personal for a lot of the students. But they're getting more used to it. And it's just so nice to see the students who I had no idea, uh, you can't do the math and you don't feel good about it, but really see those students coming out of their shells. It's really nice to see that they feel like they can. When they are participating it shows me that they know that its something they can do as well, even if, when I say you're so smart, they say I don't know, 'you mean "smart."' But at least it's a step-by-step process. It's been really positive to see that happening. Oh, I took your idea (*turning to Kara*) of keeping math partnerships. So I've actually had the same partnerships for two units now. They're like when are we going to switch?

Kara: Mine are a week! (*laughter*)

Tina: I just kept them (*laughing*). Yeah, so, Most of the time, I've been having them write out their partner's math strength or how they're being smart on a post-it and a couple of times recently I didn't have them do that. But some of the partnerships kept that up.

Kara: Aww, sweet.

Tina: Which was really nice. Yeah, so, I didn't say it to them, that's not what I was expecting, but then when I was looking through their work, 'hey, what's this post-it?', 'My partner was being smart by', you know, dadada. So, it was really cool that they kept that up.

When I visited Tina's classroom in April, I had an opportunity to observe how noticing diverse mathematical strengths had become a typical practice for students in this classroom community. Students were working on a math task about extending a pattern by looking at drawings of a 1 x 1 x 1 cube, a 2 x 2 x 2 cube, and a 3 x 3 x 3 cube and then calculating the volume of those cubes. Tina had launched the lesson similarly to how Lauren had launched the lesson she described in February, by sharing a list Tina and I had come up with before the lesson of some of the mathematical strengths students would need, including "building 3-D figures from 2-D pictures" and "making connections between figures, situations, and formulas". Albert and Barry, two of the students Tina had selected as focal students, were working together on this task. As Barry was building and explaining what he thought the 3 x 3 x 3 cube should look like, Albert grabbed a post-it note and wrote down that Barry was good at "building figures from pictures." After more conversation, they decided that the next figure should have 4 units in each

direction and worked together to build a 4 x 4 x 4 cube from unit cubes. Barry started counting the cubic units in each layer one by one to figure out the volume. Albert pointed out that they could use multiplication, saying "4 times 4 is 16." Barry nodded, writing 16 + 16 + 16 + 16 for the 4 layers of the cube. Albert again connected Barry's thinking to multiplication, commenting, "it's 16 times 4." Barry reached for a post-it and noted Albert's strength of "finding easier ways to count the cubes using multiplication and arrays." Both students grabbed the post-its without any prompting from a teacher and they used their own language to describe what they saw their partner doing. The fact that Albert and Barry noticed the specific mathematical strengths they each contributed to their partnership provides strong evidence that the changes Tina made in her teaching created a classroom community where valuing diverse mathematical strengths became incorporated into students' regular activity. Albert and Barry's interaction is all the more powerful given that these two students had previously expressed that they did not see themselves as good at math.

Summarizing Tina's learning across activity systems

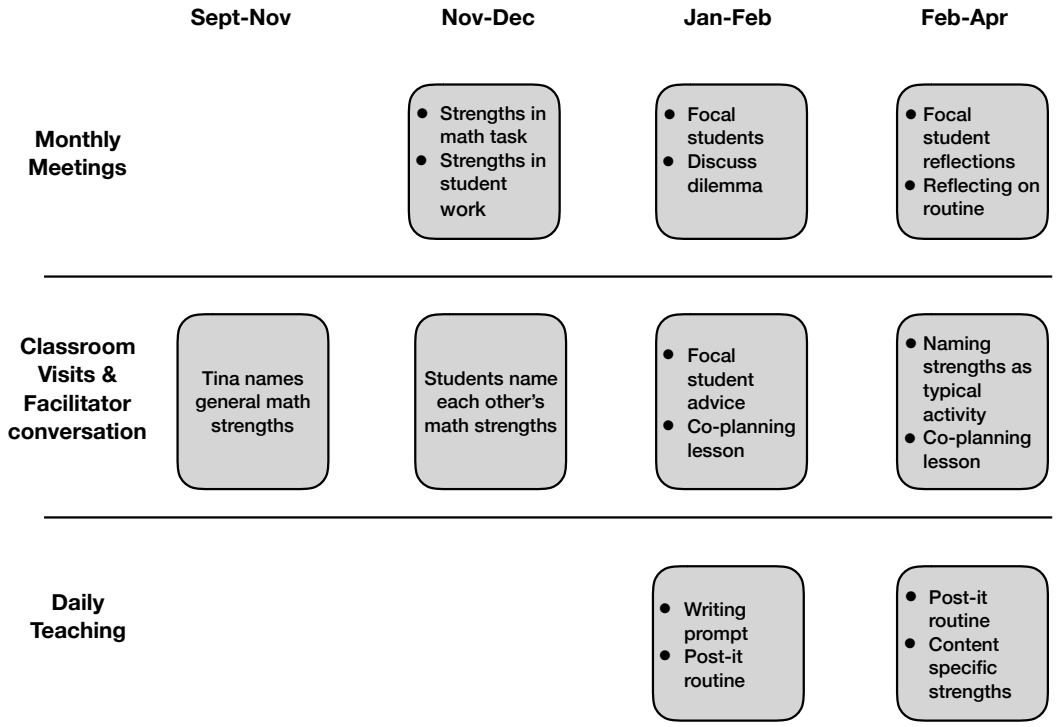


Figure 7. Learning across Activity Systems

Tina was committed to expanding conceptions of mathematics and mathematical competence from the beginning of the school year, and her participation in Math Crew provided her with many different resources that mediated how she worked on this problem of practice over time. As Figure 7 shows, her engagement with this problem of practice across community meetings, classroom visits and her daily teaching increased

over the course of the school year and became more connected across these systems. The discussions and activities in community meetings from working on mathematics together, to noticing and naming strengths in student work, to sharing stories from the classroom provided her with teaching ideas related to the problem of practice she was investigating. Classroom visits and planning conversations with me provided Tina with opportunities to discuss and reflect on the specifics of how she might implement these new teaching ideas in ways that made sense for her classroom learning ecology. Though initially, Tina worked on her problem of practice mainly in community meetings and classroom visits, as the school year progressed, Tina also began to investigate how she might expand conceptions of mathematical competence in her daily teaching. She moved from trying new teaching ideas when I visited her classroom to incorporating consistent routines into her daily teaching practice. The introduction in Math Crew in January of the structure of choosing focal students was an integral component of this shift toward investigation in her daily teaching. As Tina engaged in deeper investigation of her focal students' mathematical experiences she implemented several new practices such as giving students a writing prompt about math and introducing the routine of having students note each others' strengths on post-it notes. This deeper investigation offered Tina new ways of understanding her focal students and supported her to shift from a more individual view to a more relational view of the classroom learning ecology where students' relationship with mathematics was socially constructed. The interaction between Albert and Barry described in this section indicates that these new teaching responses shifted the learning ecology so that noticing and naming diverse mathematical strengths became a shared cultural practice in the classroom community. Participating in Math Crew provided Tina with a wide array of resources across activity systems that she leveraged to mediate her learning toward expanding conceptions of what math is and what it means to be good at it.

This more detailed account of one case of learning shows that Math Crew community conversations, classroom visits, conversations with me (in person and over email), and daily classroom teaching mutually informed each other and provided diverse resources that mediated equity-oriented teacher learning. The travel across activity systems of people (in this case me and Tina), artifacts (e.g. Albert's writing), and ideas (e.g. post-it notes to note strengths) provided many opportunities for teachers to try out new ideas, to reflect on what they saw in the classroom from the perspective of their students, and to discuss and observe how different teaching responses affect a classroom learning ecology. Though Tina made the most robust use of resources across activity systems, Kara, Lauren, Maritza, and Selina all worked on problems of practice over time in ways that aligned with the shared commitment of Math Crew. All five teachers investigated the mathematical experiences of their students, connected these experiences to the classroom learning ecology, and tried out new teaching ideas that were responsive to their investigations. Math Crew was designed to support this type of rich learning across activity systems. I return to this design feature in the concluding chapter of the dissertation to discuss implications for how we might better support equity-oriented learning for beginning teachers.

Conclusion

The purpose of this chapter was to provide a detailed picture of the rich learning toward ambitious and equitable mathematics teaching that can become possible when

beginning teachers are part of a learning community oriented toward a shared vision. In Math Crew, first-year teachers learned how to engage in relational investigations of teaching that centered students' mathematical experiences. They moved beyond focusing on the overwhelming list of day-to-day concerns that tend to dominate for most first-year teachers to dig into complex problems of practice and to consider how their teaching choices might shift the classroom learning ecology to support each student to meaningfully contribute to the mathematical work of their classroom.

This shift toward relational, student-centered investigation happened both in conversations about teaching and in the choices teachers made in their daily classroom teaching. Learning toward ambitious and equitable mathematics teaching coevolved across the Math Crew activity system and teacher's classroom activity systems, with the travel across systems providing robust resources for learning that connected closely to their classroom learning ecologies. As teachers thought more deeply about how individual students were experiencing mathematics in their classrooms, they reflected on and tried out new teaching ideas that were responsive to students' experiences. These changes to their daily teaching led to new forms of activity that increased opportunities for their students to engage with mathematics. The shift from fixing local problems to engaging in relational investigations of teaching and learning supported teachers to continuously work toward their ambitious commitment to creating classroom math communities where everyone meaningfully contributes to the mathematical work of the classroom.

In this chapter I focused on *what* teachers learned. In the following chapter I look at *how* teachers learned in Math Crew, examining learning in interaction and making connections between design choices and learning opportunities.

Chapter 5: Engaging with Tensions to Collectively Construct an Inclusive and Empathetic Professional Vision

Learning to engage in relational investigations of teaching and learning that center students' mathematical experiences calls for a different type of seeing and making sense of the classroom than is typical in systems of schooling. This relational view of the classroom requires seeing each student as a unique mathematical learner situated in a complex learning ecology, and. However, seeing the classroom in this way is difficult to do when working within systems of schooling that tend to be organized to hierarchically sort students based on what they can or cannot do, rather than to recognize, value, and build on their diverse ways of engaging with mathematics (Jilk, 2016; McDermott et al., 2006). This focus on sorting individual students into hierarchical categories tends to create distance between teachers and students, making it difficult for teachers to relate to students as complex human beings with their own fascinating ways of making sense of mathematics.

The shared commitment held by Math Crew teachers of building classroom math communities where everyone meaningfully contributes to the mathematical work of the classroom represents an attempt to create robust learning environments grounded in relationships of care, dignity, and connection. However, Math Crew participants worked in schools where they encountered material artifacts and discourses such as pacing guides, individual assessment reports, and deficit narratives about students from nondominant communities that push teachers to focus on measuring and sorting individuals rather than building a strong community. Enacting their commitments in these spaces required "teaching against the grain" (Cochran-Smith, 1991) and led to many moments of tension. A central issue facing teachers attempting to create transformative classroom learning spaces while working within problematic systems is how to navigate these tensions in ways that maintain their commitments to equity-oriented teaching.

In this chapter I analyze *how* the Math Crew learning community supported participants to surface and engage with the tensions in their work as opportunities to contest hierarchical ways of seeing and to collectively construct an alternative professional vision. I find that developing an inclusive and empathetic professional vision for mathematics teaching and learning takes collective interactional work as teachers learn to pay attention to what students *are* doing and to understand and relate to them as unique mathematical learners immersed in a complex classroom learning ecology. I argue that this way of seeing and making sense of the classroom closes the distance between teachers and students, fostering more generative views of mathematics teaching and learning that disrupt the hierarchical and racialized systems of sorting that are prevalent in systems of schooling. As background for the analyses that follow, I first provide some brief theoretical perspectives on how I conceptualize professional vision for teaching.

Professional Vision for Teaching

In conceptualizing what it means to learn to see in a given profession, I draw on Goodwin's conception of professional vision as "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular group" (Goodwin, 1994). This notion of professional vision attends to the social and cultural nature of how we come to see and make sense of what is going on in a given context. Goodwin writes about the intertwined practices of *coding*, *highlighting,* and *producing*

and articulating material representations by which professionals build and contest what it means to see in their field. Coding is the process of transforming observed phenomena into categories and events that are relevant to a given profession. Many such coding schemes are prevalent in schools and are used to sort students into particular categories. Some of these categories are formalized such as "English Language Learner" or "Learning Disabled" while others are informal such as "struggling" or "advanced." These coding schemes function to make particular objects or actions salient within a perceptual field, which Goodwin refers to as highlighting. For example, if "struggling" and "advanced" are categories that are deemed relevant in a school or classroom activity system, when a teacher looks at student work, certain aspects of the work (such as incorrect answers) are highlighted to aid in the categorization process. These coding schemes, and the assumptions underlying them, are reified in material representations of schooling such as assessment reports that sort students into levels such as "proficient", "approaching proficiency", and "not proficient" based on numerical scores. The intertwined practices of coding, highlighting, and representation thus structure how teachers see and make sense of a complex classroom learning ecology. These practices develop over time in systems of schooling and tend to operate tacitly, as taken-for-granted ways of seeing and understanding what is happening in the classroom.

Given the ways that racism is built into the fabric of life in the United States, professional vision is necessarily a racialized activity (Bonilla-Silva, 2001; Omi & Winant, 2004). Research has increasingly uncovered the ways that interactions in mathematics classroom are intertwined with larger social inequities. For example, racial narratives have been shown to mediate how students are positioned in the classroom (Nasir & Shah, 2011; Nasir, Snyder, Shah, & Ross, 2013) and preoccupation with achievement "gaps," named in terms of race, socioeconomic status, or English language proficiency, often perpetuate deficit perspectives about students from nondominant communities (R. Gutiérrez & Dixon-Román, 2010; Leonard & Martin, 2013; McDermott et al., 2006). Hierarchical sorting systems and the accompanying focus on deficits that often saturate school learning environments intersect with these narratives, resulting in ways of seeing and understanding students that tend to perpetuate the status quo and preserve what Martin (2009) has termed a "racial hierarchy of mathematical ability." The shared commitment in Math Crew of creating classroom communities where everyone meaningfully contributes to the mathematical work of the classroom aims to intentionally disrupt the racialized sorting of students into hierarchical categories. The practices of coding, highlighting, and articulating material representations tend to operate tacitly in schools, rather than being explicitly negotiated. Therefore, constructing a professional vision that disrupts hierarchical, deficit-focused ways of seeing requires ongoing collective work to contest and renegotiate ways of seeing the classroom. Given the social and cultural nature of how we see, I take professional vision to be a collective practice that is dynamic and always in negotiation. The central focus of this chapter is to unpack the nature of the work entailed in collectively constructing and negotiating an inclusive and empathetic professional vision for mathematics teaching and learning that runs counter to ways of seeing that are typical in systems of schooling.

Overview of the Chapter

I argue that developing an inclusive and empathetic professional vision for mathematics teaching and learning involves surfacing the tensions that emerge as teachers attempt to

disrupt dominant ways of seeing and collectively engaging with those tensions to construct new ways of seeing and making sense of the classroom. This argument is organized into three parts. In part 1, I examine the tensions teachers surfaced in Math Crew as they navigated systems of schooling where tacit ways of seeing and making sense of the classroom function to create distance between teachers and students. I find that these moments of tension provided opportunities to make visible the professional vision at work in systems of schooling and to explicitly articulate alternative ways of seeing the classroom grounded in coming to know students as unique mathematical learners. In part 2, I provide an in-depth look at one Math Crew conversation to analyze the nature of the interactional work involved in collectively constructing an inclusive and empathetic professional vision for mathematics teaching and learning. I find that teachers created new ways of coding, highlighting, and articulating material representations as they looked at student work. These new practices functioned to contest ways of seeing that focus on what students are not doing and to collectively construct alternative ways of seeing that center what students *are* doing and why their actions might be sensible. I find that constructing this empathetic professional vision supported participants to not only make sense of the classroom differently, but also to collectively imagine what it might *feel* like to be a child in a mathematics classroom. In part 3, I analyze features of the Math Crew activity system that helped to create a space in which teachers surfaced the tensions in their work and engaged with them in ways that were generative for their teaching. I argue that the design principles of maintaining a shared orientation toward strengths and grounding our work in an expansive view of mathematical activity, and the norms of interaction of inviting vulnerability and holding space for deep investigation, were integral to creating a caring community where participants could engage productively with tensions to support rich equity-oriented learning.

Part 1: Surfacing Tension

Math Crew teachers experienced many tensions as they tried to maintain their commitment to creating ambitious and equitable mathematics communities while working in systems of schooling organized to measure and sort individual students into hierarchical categories. In this section I provide an overview of the types of tensions that were surfaced by participants. I describe what those tensions helped to make visible about tacit ways of seeing and making sense of the classroom that are prevalent in systems of schooling. I then analyze a more detailed example to show how moments of tension provided opportunities for teachers to actively contest hierarchical and deficit-focused framings of students' mathematical learning and to articulate an inclusive and empathetic professional vision that contrasted with these framings.

Overview of tensions

Tensions related to competing ways of seeing and making sense of the classroom were raised at every Math Crew community meeting as well as in one-on-one conversations during classroom visits. The tensions teachers voiced in Math Crew were often prompted by interacting with material artifacts of schooling such as pacing guides and school or district assessments and by hearing discourses of schooling such as the sorting of students into "achievement levels." Two types of tensions emerged in analysis: 1) the tension teachers experienced when their commitments came into conflict with common discourse or practices at their school sites, and 2) the tension teachers experienced when they fell

short of enacting their commitments in the classroom. These types of tensions are not mutually exclusive and sometimes both were voiced together. When participants surfaced these tensions in Math Crew, the discussions helped to make visible some of the tacit coding schemes used in schools that serve to sort students into hierarchical categories and to highlight what students are not doing. The conversations also allowed space for teachers to re-articulate their commitment to recognizing and valuing the mathematical strengths of each of their students, even when they were not always able to put these commitments into practice in the ways they had hoped.

Tensions make visible tacit ways of seeing

Math Crew was formed to support teachers to stay committed to creating ambitious and equitable math classroom communities while working in activity systems where that commitment is not widely shared. In my initial email inviting participants to join Math Crew, I named a central purpose of forming a learning community as supporting each other to navigate the tensions that come from working toward commitments that run counter to what is currently typical in schools, writing in part:

> I think you share some commitments about the type of math community you hope to build in your own classroom and the ways you are thinking about making space for the strengths and contributions of all students. I've found that it can be really hard to hold on to some of these commitments in the face of pacing guides, lackluster curricula, "data-driven instruction" etc. My hope is that we could create a learning community where we support each other to stay inspired about what is possible with kids even when its really hard and even when we can't do it quite the way we wish we could.
>
> Mallika, email communication, 8/21/16

During community meetings and classroom visits, teachers regularly surfaced the tensions they experienced as they tried to build a math community where everyone meaningfully contributes to the mathematical work of the classroom. Table 13 shows examples of the tensions voiced by participants. This table does not represent all the moments of tension that were raised in these meetings; it is instead intended to give a sense of the prevalence, themes, and heterogeneity of these moments across the data set.

Table 13. Tensions and Competing Ways of Seeing

Date	Quote about Moment of Tension	What is made visible?
10/7/16	Kara: “I just feel like I have this huge moral dilemma. The math benchmarks are coming up and I have to cover all these things…it’s just weighing on me. And there have been a couple periods where I haven’t been the math teacher I want to be, and very focused on the answer rather than the math and encouraging participation in a way that’s more punitive than safe”	Assessments & pacing guides can encourage “coverage” rather than supporting students to think deeply
11/4/16	Maritza: “So I have um, she pushes in to help with math, because of district tests from last year and she	Students who have been categorized as

	comes in to help Andres, and Oscar, and Miguel and I hate it. I just hate it. When she comes in, she's really nice but we were doing that area problem and she was sitting with Oscar and Oscar didn't get to think any of it through. All of a sudden she's like showing him how to draw a line and showing him how to draw a rectangle and I was like 'go away, go away, let him think, he can do it.' And I just don't know how to deal with it."	"struggling" are assumed to not know and are not always given opportunities to make sense for themselves
1/6/17	Selina: "We're starting place value and I'm already planning to spend more than the suggested time because that's just a really tough concept. But one of my issues has been, especially with this one because I want to delve deep into it and have the kids delve deep into it. It's a lot to process. So its finding how to have them talk about it instead of just going off of Math Expressions (*shakes head furiously*)…The past few days I did the first lesson talking about place value and I was like 'this is terrible.'"	Curriculum and pacing guides do not always support deep mathematical thinking nor so they allow space for teachers to be responsive to their students
2/3/17	Tina: "The other 5th grade teacher has been teaching in this position for like 20 years so she comes with a lot of background and uh different ideas about how to teach and how to talk about kids and how to talk to kids as well. She and I are very different in that way. She's just got more of a deficit mindset about the students. And I know the principal has been trying to push more of like a growth mindset, something you're doing well and then what to work on. But it's been hard for her to kind of like embrace that. Which, it's contagious. It makes me feel really down sometimes. And it's hard for me to say, 'Hey, don't think that way. Don't say that.' Because you know she's been there a long time and she's really respected throughout the school and the entire district as well. It's hard for me to like tell her that I think she's wrong."	Deficit ways of seeing students are common and taken-for-granted in schools, and can be difficult to counter especially for new teachers
3/17/17	Kara: "I think math is a pretty social time and we do a lot of group stuff. And its kind of chaotic but fun. And kids are mostly on task. And I think when its just seen as problem solving with your friends, they see it as really fun and I see this sad cloud of dismay when we take the math [district assessment] and we put up the test dividers. And all of a sudden math is like an individual, and scary and long thing."	District assessments carry with them a different view of mathematics as individual performance rather than collective sense-making
4/14/17	Lauren: "I am like your poor brain, these [district assessment] problems are really hard and they are	District assessments do not reflect what

	intentionally tricky. They are complicated concepts to begin with. Why do you need to, there's a lot of red herring problems. There was one that like all my kids got wrong just because they had intentionally made it so you forgot to count the friend in the problem or whatever, but the whole thing is about interpreting a fraction out of a situation. It was just terrible. I did not give that test back to my kids because almost, more than half of them failed it so I can't, there is no, its not helping anybody to give this back to you. It's not a reflection of what you understand, but yeah. Those are awful."	students understand and are sometimes designed to find what students do not know rather than to show their strengths

Across these examples, Math Crew teachers named different aspects of the misalignment they saw between their commitment to creating ambitious and equitable mathematics communities and the artifacts, actions, and discourse they encountered at their school sites. As is suggested from the examples in this table, district assessments, pacing guides, and curricular materials were frequently mentioned as sites of tension for Math Crew participants during community meetings and classroom visits. These artifacts carried with them an implicit professional vision of mathematics teaching and learning that did not always align with the commitments held by Math Crew teachers. Teachers pointed to different aspects of these artifacts that did not support them to know their students well and to be responsive to their needs. For example, Lauren noted that the district assessments were "not a reflection of what you understand", Kara talked about "having to cover all of these things" in preparation for these assessments, and Selina spoke about choosing to deviate from the district pacing guide because place value is "just a really tough concept." Discussing these artifacts also offered teachers opportunities to re-articulate their commitments in contrast with the professional vision for mathematics teaching and learning in their school sites. For example, Kara described the "sad cloud of dismay" that fell over her students when they had to take individual district assessments and she contrasted it with how math was typically experienced by her students as social and fun. In addition to the challenges that arose in working with material representations of schooling, Math Crew teachers also surfaced moments when the discourse or actions of their colleagues implied a professional vision they did not share. The examples from Maritza and Tina were typical of how these issues were raised, with teachers expressing how it made them feel (Maritza: "I hate it", Tina: "It makes me feel really down sometimes") and wondering if and how they might interact with or contest the deficit-focused professional vision implicit in their colleagues' discourse or actions.

As teachers talked about the tensions that arose when they saw the differences between the types of math communities they were hoping to build and the ways of seeing the math classroom that were typical in their school sites, they also sometimes noted the tension they felt from not always living up to their commitments. This is evident in Kara's comment that, "there have been a couple periods where I haven't been the math teacher I want to be" as well as when Selina noted, "I did the first lesson talking about place value and I was like 'this is terrible.'" Surfacing tensions in Math Crew supported participants to make visible aspects of the professional vision they encountered in their

school sites, to re-articulate their own commitments in contrast to that vision, and to acknowledge the ways they were not yet able to realize their commitments in their classrooms. In the next section, I analyze an example of a conversation about tension to show how surfacing tensions in Math Crew provided opportunities to make visible tacit coding and highlighting practices at work in schools and to articulate alternative practices aligned with their shared commitments.

Tensions as opportunities to contest and articulate professional vision

One recurring theme that emerged across many different moments of tension discussed in Math Crew was seeing the possibility in what students are doing, in contrast to focusing on what students are not doing and then using these deficits to sort students into hierarchical categories. In the final monthly meeting of the year in May, we began the meeting by reflecting on the school year and on teachers' participation in Math Crew. A stretch of interaction during that discussion provides an example of how surfacing tension offered opportunities to contest and articulate an inclusive and empathetic professional vision in the Math Crew learning community. During the conversation, Selina shared a story about how her experiences being part of a teacher inquiry group in her school district drew her attention to the ways her developing professional vision was not held by all of her colleagues:

> Selina: I was telling Kara in the car on the way here, that in reflecting on the year, I think I've really held on to looking for kids' strengths and it really stuck out to me on Tuesday. For the past 8 weeks I've been doing this inquiry on the language used in math. So we've been, 3 teachers from my team and then a few teachers from another school, I gave the mock lesson that we're teaching on Tuesday to a room full of adults. And we were going to have a little math congress with kids sharing their strategies and we were going to choose an equity stick for a kid to share and one of the teachers was like 'well what if you choose somebody that has it completely wrong and they're totally lost and don't know what's going on?' Aaand that just felt so negative to me, like, 'what do you do with this kid that doesn't get it?' So I said, 'you know what, everybody has some kind of math thinking so we're going to tease out whatever it is that they're bringing and just talk about it. And, you know, at least in my classroom everyone has something to contribute' (*laughter from group*). And I think in that moment is really when I saw that clear division between my thinking and other people's thinking, which is crazy to realize that not everybody thinks like we do. Um, so I think that's been one of the greatest things that's happened this year, and just seeing that reflected in my classroom, like seeing who is raising their hand to want to come up now. Like Sergio, who before, he's coming up, and you can see him really thinking and trying to make sense of what is going on. So to have him, who would totally shut down and be disengaged, and now he's like completely excited to participate.

In telling this story, Selina articulated how she was seeing her students (as all having something meaningful to contribute) and contested the ways her colleagues were seeing students as "completely wrong" or "totally lost." She named this as a "clear division" and commented that it is "crazy to realize that not everyone thinks the way we do." Implicit in Selina's story are competing coding schemes, which serve to highlight different aspects of student participation. In stating that, "at least in my classroom everyone has something to contribute", Selina referenced the shared commitment of Math Crew that every student has mathematical strengths. Employing this coding scheme would then make salient whatever mathematical thinking a student shared as something to "tease out" so they could "just talk about it." Implicit in her colleagues' question about what to do if a student shared who was "completely wrong" or "totally lost" is an alternative coding scheme that some students have mathematical ideas that are productive to share and other students do not. This coding scheme would then highlight a students' contribution in relation to correctness and other aspects of what the teacher considered to be productive so that the teacher could sort the student into someone who is "totally lost" or someone who has something to contribute. For Selina, surfacing the sense of tension she experienced when hearing her colleagues' discourse about students' mathematical competence made visible competing coding schemes and created an opportunity for her to articulate an aspect of the professional vision she shares with Math Crew.

Building on Selina's story, Kara shared a story about filling out information about her students that would be used to help determine class composition for students for the following school year. Kara's story served as an opportunity to contest a coding scheme based on the hierarchical sorting of students and to offer an alternative way of seeing that centered what students are doing rather than looking for ways they might be falling short.

Kara: I was saying to Selina just on the way over, we have to fill out these classification cards for next year and we have to rate each of our students like high, medium, or low in math. And I'm just like, as soon as they showed that, and they just like glossed over, just based on your impression, it doesn't have to correspond to a score, its just like how you see this kid…

Mallika: Oh my god! (*laughter*)

Kara: And I was like, 'oh no, that's terrible.' It felt sad that that's how the school wants to think about students and that they would think about distributing kids based on that, like 'oh we don't want to give this teachers too many "low" (*air quotes with fingers*) kids' to like ease the burden but it also made me think about how I see my students, and the kids who I feel anxious about in math are the kids who do have trouble persevering or who, like kids who have low self esteem. Its not low based on any score, I'm looking more at their relationship to math and the way they see themselves as a math learner and that just makes me even more driven to set up my culture next year even more enforcing the expectation and the value that everyone is a math learner and has something to contribute…I also felt kind of like,

moral, do I stand up to the system and say 'I will not fill out these classification cards' or is it like, what do I look at to fill these out, what are you asking for?

Selina: It's not an option to not answer that, it won't let you like submit it unless you put a thing (*gesturing to show using drop down menu*).

Mallika: Oh wow. So interesting, huh? It's so interesting that it's also like just your gut feeling (*laughs*).

Kara: Yeah, they're like, not based on a score, it's not based on anything but your impressions of a kid. I'm like, aww (*makes sad face*). And yeah, the kids too, I feel like so many of my kids have made so much progress. Like Hector comes to mind, who's a kid who at the beginning of the year for addition and subtraction used his fingers and would do it under the table but felt super insecure about math. And now is just like an awesome partner to have in math and is seen as someone who has cool strategies and is seen as someone who participates in full group math thinking and is able to ask questions and get help. And I can't see putting him high, medium, low.

Mallika: It just doesn't even apply.

Kara: Where would I? I don't know, none of the above. He's just a cool kid.

Kara's telling of this story made visible the contrast between how she was being asked to see her students (to employ the coding scheme of high, medium, or low) and how she was actually seeing her students. When Kara shared about Hector she told the group about the progress that he had made, about how he was viewed in the class, and about the ways he participated in class. She concluded by noting that the rating system in no way applied to the complexity of what she was seeing: "I don't know, none of the above. He's just a cool kid." Surfacing her feelings of tension with the Math Crew community provided Kara with an opportunity to actively contest hierarchical ways of sorting students. Interacting with the classification card as a material representation of schooling also provided Kara an opportunity to articulate to the community an alternative way of seeing students that is not about sorting and is instead about noticing who each child is as a mathematical learner. Like Selina, Kara was working from the coding scheme that every student has something to contribute. This coding scheme highlighted what Hector was doing, not what he was not doing or might not understand. In line with this coding and highlighting, everything Kara chose to share about Hector was about what she had noticed about how he was participating (e.g. "someone who has cool strategies"). Seeing the classroom in terms of what students are doing as opposed to what they are not doing is integral to creating a community where everyone meaningfully contributes to the mathematical work of the classroom.

This conversation happened in the final meeting of the school year and thus represents participants' reflections after a year of collectively contesting and constructing

professional vision. In the next section I examine *how,* in interaction, teachers contested the focus on sorting prevalent in their school sites and collectively negotiated and constructed an inclusive and empathetic professional vision for mathematics teaching and learning. I provide an in-depth analysis of one 30-minute conversation from the monthly meeting in March to examine how surfacing tension provided robust opportunities for Math Crew participants to contest deficit ways of seeing students and to collectively construct alternatives that centered what students are doing and why their actions might be sensible in a classroom learning ecology.

Part 2: Leveraging Moments of Tension to Contest and Construct Professional Vision

In the previous section, the tensions surfaced by participants involved moments when they noted the ways that artifacts or discourse in their school sites carried with them tacit ways of seeing that were in conflict with the shared commitments of the Math Crew community. In these discussions, teachers named problematic ways of seeing they encountered at their school sites and articulated alternatives. However, it was not always easy for Math Crew teachers to see and understand the classroom from an inclusive and empathetic perspective themselves, particularly as they engaged with material representations of schooling designed to identify deficits and to sort students. In this section, I analyze one conversation that began with a Math Crew participant struggling to see one of her students from a strengths-based perspective to show how participants collectively contested and constructed a shared professional vision in interaction. I examine the nature of the interactional work involved in the collective practices of contesting dominant coding schemes and negotiating and co-constructing alternative coding and highlighting practices. I then provide a microanalysis of a one-minute stretch of interaction within the conversation to show the learning that can become possible for teachers when they come to see and understand the classroom in ways that center students as sensible actors within a complex learning ecology. I find that seeing the classroom from this inclusive and empathetic perspective supported teachers to collectively imagine the mathematical experiences of children, opening up more generative ways of understanding students, mathematics, and teaching grounded in connection.

This conversation took place in March when first grade teacher Selina brought a teaching dilemma to the group. Kara, Maritza, Selina, and Tina were present at the meeting, and I acted as facilitator (Lauren and Marie were not able to attend). Selina began the conversation by telling the group that she'd brought a district assessment about place value completed by one of her students, saying, "I do have concerns about this student, Antonio. He's one of my boys who doesn't talk. And won't engage with a partner. I'll pair him up with the nicest kid in class, with the most patient kid in class and he just won't work with them. He's always, like, completely disengaged across subjects. He will be like playing with his shoe and he sits right in front of me." She held up his assessment to show the group, which was filled with lots of writing, and said, "Some strengths that I do see is that he is making an attempt at solving…*some*thing." Selina continued with her concerns, concluding, "it's really hard for me to know, what does he know really well, that I can, like, build on?" In this articulation, Selina held on to the Math Crew shared commitment of building a math community where everyone meaningfully contributes to the mathematical work of the classroom by assuming that

Antonio does have strengths and that it was her job to find them and build on them. But she also surfaced her own limitations in actually applying that coding scheme to Antonio. In her description of Antonio, she named what she thought Antonio couldn't or wouldn't do, commenting that "he doesn't talk", "he won't engage with a partner" and is "completely disengaged across subjects" while naming nothing specific about what Antonio could do or was doing. Her talk functioned to code and sort Antonio into a particular kind of a student and her language choices implied that his belonging in these categories was static (e.g. "he **doesn't** talk" as opposed to 'he hasn't shared his math ideas much yet'). This description of Antonio created distance between Selina and Antonio by seeing him as a certain type of student rather than as a unique mathematical learner. However, in bringing this issue to the group, Selina also made it clear that this is not how she wanted to see Antonio. In contrast to the moments of tension shared in part one, the central tension Selina experienced in this dilemma with Antonio was due to the fact that she recognized that *she* could not yet see Antonio's mathematical strengths or connect with his mathematical experience in the classroom.

A roughly thirty-minute conversation ensued in which Math Crew participants dug into Antonio's work to investigate and problematize what Selina thought she was seeing and to support each other to see something different. Rather than accepting Selina's initial coding and sorting of Antonio into the category of "completely disengaged", Math Crew participants looked closely at his work and at the assessment questions and asked Selina about Antonio's participation in class. In interaction, participants collectively constructed an alternative way of seeing that focused on what Antonio was doing and on understanding why his actions might be sensible. Instead of trying to sort Antonio into categories, Math Crew participants worked to understand Antonio as a mathematical learner. The next section provides an analysis of the discursive moves participants used in this conversation to collectively achieve this new way of seeing.

Coding and highlighting with a material representation of schooling

As the group considered Selina's dilemma about Antonio, they passed around his assessment, looking closely at what he had written. To give the reader visual context for the analyses that follow of the conversation about Antonio's work, I provide an approximation of Antonio's assessment. Unfortunately, I do not have a copy of the assessment so this is a re-creation based on what is visible in the video, what participants said in conversation, and my own very imprecise memory of what this work looked like. The assessment was much longer than what is shown here. Here I include only problems that were discussed in the conversation. The big picture of this approximation is accurate in that Antonio's paper was filled with drawings and numbers that were related to the representations used in class. The details in terms of the exact numbers of different items are not representative of what Antonio actually wrote, given the limitations of the data.

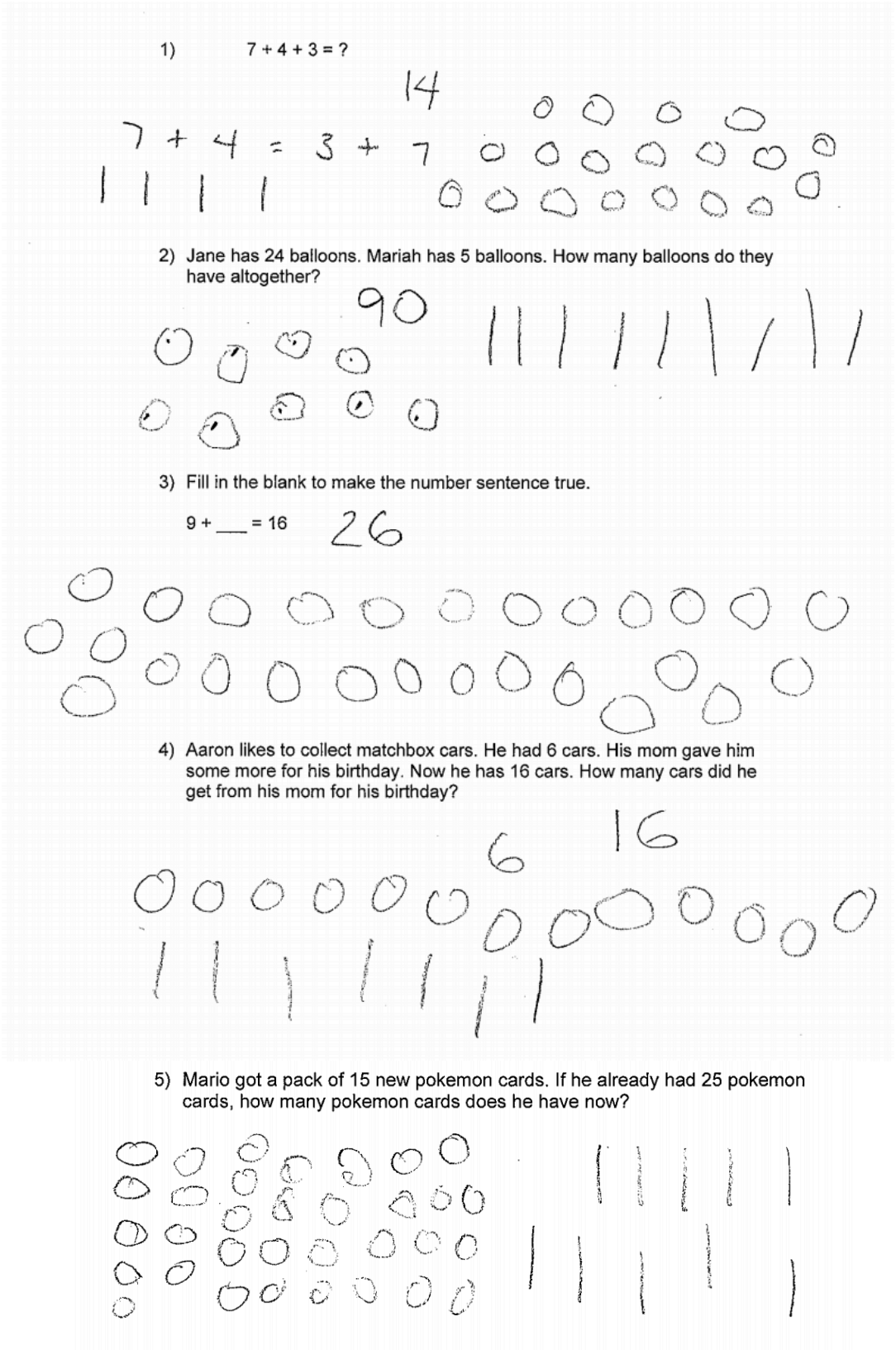


Figure 9. An Approximation of Antonio's Assessment

In analyzing the discussion of Antonio's work, several discursive practices were identified that functioned to investigate and problematize Selina's initial framing of the issue. These practices made visible an implicit coding scheme negotiated and co-constructed in interaction by Math Crew participants that highlighted particular aspects of Antonio's assessment.

Table 14. Investigating and Problematizing the Issue

Discursive Practice	Implicit Coding Scheme	Examples	Instances
Pointing out the mathematics in student work	All students have mathematical strengths	"I just feel like on his page he's doing so much. This is a lot of work! Whatever it is he's doing, this is a fat array!" (*referring to student work for #5*)	9
Unpacking the mathematical task	Making sense of mathematics is challenging	"It's really hard though. This math is really conceptual. Like 9 plus blank equals 16, that's not like super automatic for me"	13
Providing sensible reasons for student behaviors	Learners tend to act sensibly within a learning ecology	"If it seems to him like random marks on a board, it's hard to pay attention to that"	10

These three discursive practices worked together to support the group to dig deeper into Antonio's work and into the mathematics involved in the assessment. Pointing out the specific mathematics in Antonio's work, unpacking what the task was calling for in terms of mathematics and language, and naming sensible reasons for behaviors like "not paying attention", supported teachers to notice the details of what Antonio was doing and to engage in a deeper investigation of the reasons for Antonio's actions. Together, these practices problematized Selina's sorting of Antonio as a student who was "completely disengaged" and made space for further investigation and other interpretations of Antonio.

These practices also highlighted particular aspects of his assessment. Applying their coding scheme of all students having mathematical strengths to Antonio's assessment highlighted the subtle aspects of his work that they might otherwise not have noticed, such as the "fat array" he had drawn for problem number five. Assuming that making sense of mathematics is challenging highlighted specific features of the mathematical tasks Antonio was working on such as the structure of the missing addend problem 9 plus blank equals 16 for problem number three. The coding scheme of learners tending to act sensibly highlighted possible reasons why Antonio might sometimes appear not to be paying attention, shifting the story from one of Antonio being disengaged to one of Antonio trying to make sense of challenging mathematics. (A full transcript of the coded portion of the conversation is included in Appendix B.)

The discursive practices and implicit coding schemes Math Crew participants used in this conversation did not highlight some of the more typical features that are often taken to be most salient when looking at the material representation of mathematics

assessments in systems of schooling. Teachers did not focus on correct or incorrect answers or on what they thought Antonio did not know or could not do, although these were also readily available to be highlighted when looking at this assessment. Instead, they looked closely at what Antonio had produced to think together about what it revealed about Antonio as a mathematical learner. In this conversation, they re-articulated the district assessment toward their purpose of building a community where everyone meaningfully contributes to the mathematical work of the classroom. They used this representation to find evidence of Antonio's unique strengths and experiences as a mathematical learner, to consider together the challenges of specific mathematical content, and to understand why Antonio's actions might be sensible in the complex learning ecology of his classroom.

Contesting deficit-focused ways of seeing Antonio

The discursive practices participants employed as they looked at Antonio's work were used to construct and negotiate an inclusive and empathetic professional vision and also at times to contest the way Selina was seeing and understanding Antonio. Throughout the first 20 minutes of the conversation, Selina continued to alternate between noticing what Antonio was doing and naming what Antonio was not doing or what she thought he could not do. In contrast, all other participants only noted what Antonio was doing or asked questions about his participation. No other participants commented on anything that Antonio did not do or could not do. In noting this difference, I do not in any way intend to suggest that Selina did not adequately share Math Crew's commitment to developing an inclusive and empathetic professional vision. In fact, other participants voiced similar challenges in seeing the strengths of their own students in other Math Crew conversations, interviews, and classroom visits. This suggests that it may be hardest to see strengths in the students teachers work with every day, that fresh eyes can offer new perspectives, and that seeing in a way that is counter to what is typical in systems of schooling is a collective project not an individual one (I return to this theme in Part 3 and in the conclusion of this chapter).

Table 15 shows moments throughout the conversation when Selina commented on what Antonio was not doing or what she thought he did not understand. In each of these moments, this way of seeing Antonio was contested in the subsequent talk turn. In analyzing these moments I found that almost all of the responses directly following and contesting Selina's deficit-oriented comments came from me as facilitator. I will provide further analysis of my role as facilitator in the construction of professional vision at the end of this subsection.

Table 15. Contesting Deficit-focused Ways of Seeing

Selina notices what Antonio isn't doing	Contesting what Selina sees	Discursive Practice
So it's a lot of this writing and often times he doesn't count them all.	Mallika: He is trying to use the representations that you guys were using, right? He is using number bonds and tens.	Pointing out the mathematics in student work
His thinking is just like all over the place. And even with basic	Mallika: Sometimes I really feel like it's so hard to get kids to show what	Providing sensible

math facts he struggles… He is just like sitting there playing with something or he won't like talk with a partner.	they know…I feel like he is trying a lot of stuff there, so there is a lot that is going on. But, it's really hard to know in that situation where kids don't feel confident.	reasons for student behaviors
I showed him a two digit number and I asked, 'what does this digit mean?' For example, I gave him 16, 'what does the one mean?' He says, 'one.'	Mallika: Which is really hard. It's really hard.	Unpacking the mathematical task
I have had them like double check, triple check, because a lot my kids mess up, because they are just not paying attention to what they are doing. So I need to tell them…'check your work and your answer, make sure it says what you want it to say.' And [Antonio] didn't make any changes, so to him that made sense. But then if I ask him, 'okay what did you do? or what happened here (*shakes head no*).	Kara: I feel like I have kids who I tell to double check when I think they are missing something that I think they could figure out and they say 'yeah it's fine', but it doesn't actually make sense to them. They are kinda taking a stab in the dark and trying things, but not really feeling confident with their first try. So looking over again is kind of like starting from scratch. Just like 'well I thought I understood this, but maybe that's wrong, but I don't want to try again because it's hard and stressful.'	Providing sensible reasons for student behaviors
And a lot of my kids see text and they are focused on reading it and a lot of them are still decoding. So even though I read it to them, they will go back and read it themselves. And use up all that energy.	Kara: Of course. Cus that doesn't stay in your head.	Providing sensible reasons for student behaviors
When he is on his white board, he is doing a lot, but then throughout the rest of the lesson, 'what are you doing!? Look up here!'	Mallika: Yeah I mean, I can also relate to that. If it feels like random marks, it's hard to pay attention to that. 'I would way rather be pretending to tie my shoe, because she's writing random things.'	Providing sensible reasons for student behaviors
And that makes me think of like he was drawing on his white board and I could see that he didn't understand that a quick ten, that's ten, cus he would go ahead and draw all of the circles.	Mallika: It's really abstract. A line being worth ten.	Unpacking the mathematical task

In each of these examples, Selina named something that Antonio wasn't doing or that she thought he couldn't do or didn't understand, and in each case an alternative way of seeing Antonio's actions was offered. As facilitator, I did more of this direct form of contesting than other participants. This makes sense given that directly countering what someone says is laden with power implications. My role as facilitator and my previous relationship with participants as their instructor granted me some authority to intervene in conversations in ways that might have been more challenging for other participants. The only other participant who contested in this way was Kara, who taught at the same school site as Selina, and thus had a closer collegial relationship with her.

Though I did most of the direct contesting, analysis across the 30-minute conversation reveals the ways that contesting deficit-focused ways of seeing Antonio and negotiating alternatives was a collective interactional project in which all participants, including Selina, contributed meaningfully. To give a sense of how these interactions unfolded to problematize and investigate Selina's initial way of seeing and understanding Antonio, I provide transcript and analysis of a few minutes of the conversation. This stretch of interaction occurred about 15 minutes into the conversation, beginning with a moment when Selina named something that Antonio was doing.

Selina: He's like looking for something predictable like 24 plus 5.

Mallika: Right, right.

Selina: He gravitated to that 4 and the 5 and that's 9. 'And I am just going to put a 9 somewhere. Because there is supposed to be a 9 here.'

Kara: Yeah, I mean I just feel like on his page he is doing so much.

Mallika: Right, right

Kara: Like this is a lot of work (*holds up Antonio's paper to show)* (*laughter from group*) Like whatever it is he's doing, this is a fat array. I don't know if this equals 40 (*referring to #5 in figure 9*). But just like with this one (*turning to different problem in the assessment*), I don't know how he got it or what he was trying to do exactly. This has 26 circles, and his answer here is 26 (*referring to #3 in figure 9*). This is, umm, unrelated (*pointing to other writing on Antonio's paper*).

Selina: (*looking at #2 on Antonio's assessment*) The tens are, there are nine tens, I am guessing pertains to that nine.

Mallika: I mean I am wondering if he was adding 9 to 26, I mean 9 and 16 and was just off one, you know which feels like a kinda sensible thing to do. (*referring to #3 on assessment*)

Kara: 9 circles and 9 rods (*referring to #2 on assessment*). (*long pause as*

Kara looks at assessment) It's really hard though, like I feel like this math is really conceptual. Like 9 plus blank equals 16. That is not like super automatic for me. You know it's not like 'oh of course.'

In this stretch of the conversation, Selina's comment about what Antonio did and what he might have been thinking ("he gravitated to that 4 and 5 and that's 9") led Kara to look more closely at what Antonio had produced, pointing out all the work he was doing with his "fat array" and the "26 circles" he had drawn. This prompted other participants to look for the mathematical sense in Antonio's work. Selina noticed that he had drawn 9 tens and there was a nine in the problem and I suggested it was possible Antonio arrived at the answer of 26 for the problem 9 + ___ = 16 by adding nine and sixteen and miscounting by one. As the conversation continued, participants continued to think about the mathematics of that particular problem and what students might need to make sense of to solve it.

Selina: One, you have to know you're either counting on or subtracting, and two, you got to cross the ten. And a lot of my kids are still adding, so a lot of them added 9 and 16.

Mallika: And just even knowing that question, like 'what is that problem about?'

Kara Yeah, we had one of those where it was like, k plus 200 equals 392 (*writing problem on paper as she talks*). And like yeah, I mean my kids got it, but I remember first looking at it and being like, 'huh. That is tricky to explain.' Like just conceptually, they could get there, but it was still like 'what is k?' those variables are just so random. It's just a random letter that means question mark. That means you figure out what needs to go there.

Selina: Yeah it just gets worse because I mean this question is uhh 'what's his name had six cars, his mom gave him some more, on his birthday, and now he has 16 cars. How many cars did his mom give him?' And there is a bunch of information that you don't need in there. You could just say 'Aaron had six cars. His mom gave him four. How many cars does he have now?' It's like no, 'he likes to collect cars. And he had six.'

Kara: It's his birthday so his mom gave him more (*said in a mocking voice*)

Selina: And it's like 'why are you doing this?' And a lot of my kids see text and they are focused on reading it and a lot of them are still decoding. So even though I read it to them, they will go back and read it themselves. And use up all that energy.

Kara: Of course. Cus that doesn't stay in your head.

Selina: It's just like who is making these tests?

Kara: They're evil. They're so evil.

In this section of the conversation, Selina noted the specific mathematics involved for first graders in solving 9 + __ = 16. Kara and I further unpacked the mathematical task by talking about the challenge of making sense of the structure of the missing addend problem in terms of figuring out what is to be solved. This led Selina and Kara to reflect on the language challenges of the assessment. All of these contributions served to unpack the mathematical task to consider the specific reasoning that might be called for in making sense of the different problems. As Selina and Kara began to focus on assessments more generally, I directed the conversation back to Antonio:

Mallika: I think he is doing a lot though. Like that feels really clear. He is not, not, he is not checking out. And the stuff he is doing is connected to what you've been doing in class.

Tina: (*leans over to point to Antonio's work on #2 on assessment*) You can tell he was trying to count them.

Kara: Oh yeah, the pencil marks too (*gesturing to show marks on each circle*). He is counting them up after he's drawn them.

Selina: Yeah and on paper when you see them and when he is on his white board he is doing a lot. But then throughout the rest of the lesson (*acts out looking down and fiddling with clothes*) 'What are you doing!? Look up here'

Mallika: Yeah I mean, I can also relate if it feels like random marks, it's hard to pay attention to that. I would be like, 'I would way rather be pretending to tie my shoe, because she's writing random things.' (*laughter from the group*)

Selina: There's no way your shoe can be untied for the fifth time. In the last ten minutes!

Mallika: Even at the beginning of the [math methods] course, some people were choosing to move their car during math time every time. And I finally just said something to the whole class, like 'can you just not, math time I want to hold." I literally said it that way because, I feel like, some people just wanna check out, like what is a way to not have to be present for this. Because 'I don't actually want to do the math because I don't feel like I know what is going on.' So I feel like there are a lot of those kinds of things and, I don't know, in first grade it's like looking at your shoelace.

Selina: Or going to the bathroom.

Mallika: Right, right. But yeah, there are those kids who are like, you know this doesn't feel good, so how can I escape it. But I do feel like so much goes by so quickly in elementary school math and you know for first graders, there is a lot going on, for every grade. But umm so like ways to, something like the silent math or number talks or some sort of way to hold something that is stable for them that they can you know, even if that looked really similar for a while, you know, it would be interesting to see does his participation change at all, or like, umm yeah, because I think it can feel like everyday is like a new, right? A new thing.

Selina: I feel like I can imagine just seeing a bunch of words, which he is not one of my strongest readers, and at first we figured, part of the problem, 'you need to wear your glasses.' So he has them now, but its still lots of black squiggly lines that he is supposed to makes sense of, he is like (*Selina shrugs shoulders*). So I'll try silent math and do more things with patterns.

In this part of the conversation, Selina again voiced her frustration with Antonio and what she was interpreting as his lack of engagement, with comments like "There's no way your shoe can be untied for the fifth time!" Following these comments, I took a heavier hand in the conversation as facilitator, talking more frequently and for longer stretches. With these contributions, I offered an alternative way of understanding what Antonio was doing, not as disengaged, but as responding to the challenges he might be experiencing in the classroom learning ecology. I commented, "I can also relate if it feels like random marks" and then shortly after referred to the methods course they had all taken to draw a parallel with adults that when math is uncomfortable and inaccessible, learners find ways to try to escape the discomfort (in the math methods course this involved adults choosing to move their cars to different 2-hour parking spots during the middle of math tasks). In Selina's comment at the end of this four-minute stretch of interaction, she began to imagine what it might be like for Antonio to try to make sense of a bunch of symbols on the board ("lots of black squiggly lines that he is supposed to make sense of"). She also indicated that she would try some new teaching practices in the classroom to provide more points of access into the content. Her comments suggest that she was beginning to see Antonio in new ways and to consider that the behaviors she was finding so frustrating might be sensible responses to his experiences in the classroom learning ecology.

Supporting Selina to see Antonio from a strengths-based perspective that recognized his unique mathematical contributions and took seriously the challenges he might be experiencing in trying to make sense of complex mathematical ideas was a collective project that unfolded in interaction. We all repeatedly pointed out the mathematical work Antonio was engaged in ("You can tell he was trying to count them", "He is counting them up after he's drawn them"), offering a counter narrative to the initial framing of Antonio as "disengaged." Collectively, we considered what exactly

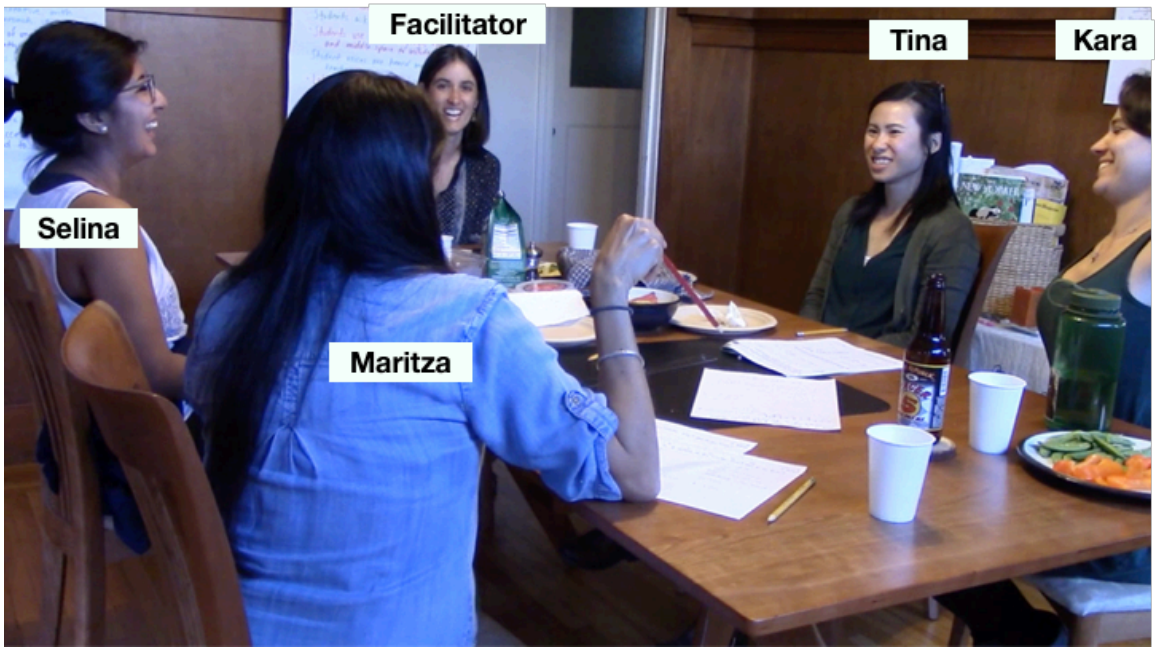
Antonio was being asked to make sense of and named these ideas as conceptually challenging. This problematizing and investigating of Selina's initial way of seeing was a collective accomplishment in that each member of the group contributed to the conversation in ways that contested deficit ways of seeing Antonio and offered alternatives. The ways Selina began to imagine Antonio's experience at the end of this part of the conversation were built on and extended two minutes later, as the group began to think more deeply about one specific challenge Antonio might be facing in trying to make sense of our base-ten number system in the classroom.

Deeper investigation leads to a collective imagining of student experience

As participants continued to investigate the assessment and Antonio's mathematical experience using their coding schemes, they began to think together about the representations for quantity used in first grade. Kara commented, "It just seems like, figuring out for him how he can like understand correspondence between the number in its numeric form and whatever symbols you're doing…It seems like he doesn't have a system to fall back on that makes sense to him that's actually like grounded in the numbers that are in front of him. Does that make sense?" Selina responded, "That makes me think of", she then put her hands up to her cheeks in seeming consternation, "when [Antonio] was drawing on his white board, he didn't understand that a quick ten", as she drew a vertical line in the air with her hand, "that's ten. Because he would go ahead and draw **all** of the circles and then just count." Selina's use of the term "quick ten" refers to a representation sometimes used in primary grade classrooms of a vertical line being used to represent 10 and dots or circles being used to represent ones. The group then launched into a discussion about how abstract it is for a vertical line to represent the quantity of ten and why this representation might be particularly challenging for first graders.

The discussion of representation culminated in a one minute stretch of interaction where participants collectively imagined what it might *feel* like to be a first grader in the classroom trying to connect the representation of a "quick ten" to an emerging understanding of place value. This moment was one of the most animated stretches of interaction across all Math Crew meetings, with a high degree of overlapping talk, gesture, and laughter. I first present a narrative vignette to give an overall sense of the moment and then point out the ways that the group accomplished a collective imagining of the experience of a first grader during this interaction. This moment represents a radically different way of seeing Antonio than the sorting into categories that Selina first offered. Not only did participants come to see and make sense of what Antonio was doing and why it might be sensible, in this interaction, Selina actually stepped into *being* a first grader in her classroom. This new form of activity represents a powerful expression of what can become possible when teachers collectively construct a shared professional vision that centers students' mathematical experiences and closes the distance between teacher and students.

A narrative overview



Four teachers and a facilitator sit at a rectangular dining room table. There is food and drink on the table, as well as papers from math work the teachers had engaged in together earlier in the evening. Antonio's assessment sits towards the middle of the table, open to a problem the group had been discussing. As Kara finishes sharing a thought about creating a chart for Antonio helping to connect numbers and quantities, Maritza leans forward across the table to point to Antonio's assessment and comments, "As it is, they **just** learned that those symbols mean numbers." She draws spirals in the air with her pencil, adding, "Now they're having to learn that they also mean dots and lines." Kara and Mallika nod and respond, "right, right". Maritza continues, drawing a vertical line in the air with her pencil, "and that line, that's I." Selina and Mallika make eye contact, smile at each other, and begin to laugh. Maritza adds, "which also can be L". Tina, Kara, Mallika, and Selina all laugh at this, as Maritza continues, "and also one" which prompts a loud "ha, ha, ha" laugh from Selina. Maritza concludes with a shrug of her shoulders "and sometimes, it's 10". At this, there is nodding and loud laughter from everyone in the group and Kara responds loudly "yeah, yeah!" Mallika talks over the laughter, saying, "When you think enough about it, it's like a miracle that anyone ever figures anything out. What?!?" Maritza says, "Totally." Selina draws a vertical line in the air and pretends to be a teacher, saying, "What does **this** mean?" She then acts out kids calling out possible answers, raising her voice and saying, "**1**", "**L**", "**A 10**?" The other four participants laugh loudly at Selina's rendition of this classroom scenario, with Kara commenting, "That's so true!" Kara then draws a vertical line on a piece of paper and holds it up to show the group, saying, "**This** (*pointing to the vertical line*) totally means one o:::r 10." Tina and Selina add, "Or L." Kara nods, saying, "Right. Or L. Or I." Tina smiles, puts her hand up to her forehead, and says, "Oh my goodness!" Kara then adds, "But really the one or ten, like that's messed up." A look of concern crosses Tina's face as she comments, "Ooh." A brief quietness settles over the group as they consider Kara's comment. Kara adds, still holding up her paper and pointing to the vertical line she drew,

"Like sometimes, **this** totally mean ones." Selina jumps in, adding, "And it gets crazier if you're doing tally marks." Kara responds with a loud "YEAH", adding "Cuz I do those, that's table", Selina finishes her sentence, saying, "That's table points" which Kara then repeats again as she draws tally marks on a paper. Maritza reaches across the table to also draw tally marks on a paper, counting as she draws, "And right here. One. Two. Three. Four." As Kara points to the tally marks she just drew she comments, "This is five. This isn't fifty." Mallika responds, "right, right" as Tina again looks concerned and says, "Ooohh."

An analysis of the activity of collective imagining

The idea that a vertical line could represent 1 or 10, or an upper case letter I, or a lower case letter L, all depending on context, was referenced in subsequent conversations by several participants as an eye-opening example of the complexity of elementary school mathematics. Maritza's comment about what learning this content entails placed the student perspective as central by pointing out the ways that this symbol, with its multiple meanings, is very new for first graders. Selina then acted this out in an imaginary classroom, pretending to be a teacher and then pretending to be students answering the question "what does this [vertical line] mean?" Maritza's comments transformed that question from a routine one to a difficult task of bringing meaning to abstract symbols. Kara's comment of "But really the one or ten, that's messed up" drew attention to the fact that for first graders trying to make sense of place value, the very same symbol being used to represent one or ten is particularly problematic. Selina and Kara then offered tally marks as yet another example of the multiple meanings of this abstract representation. This stretch of conversation took place both in talk and in action, with Maritza drawing symbols in the air, Selina acting out the parts of both teacher and students, Kara writing a vertical line on a paper, and Kara and Maritza both writing tally marks.

In this episode, each new contribution of talk and action added to a rich imagining of what it might *feel* like to be a first grader looking at a vertical line. Implicit in this imagining was some critical reflection on teaching. By pointing out the multiple meanings of the vertical line, Maritza was helping to make something familiar strange again, which then made space for Selina to act out this strangeness in a classroom where both teacher and students are acting sensibly but also missing each other. When Kara pointed out the problematic nature of a vertical line meaning sometimes one and sometimes ten, and Kara and Selina added in tally marks as another use of the vertical line, they further elaborated how school sometimes makes mathematics incredibly challenging for children. Through this process of imagining the student perspective and critically reflecting on teaching, Math Crew collectively accomplished the difficult feat of empathizing with, and even at times embodying, the experience of being a first grader trying to learn and apply abstract symbols.

Collective Imagining and Professional Vision

This one-minute stretch of interaction was pivotal in supporting participants to see anew. Selina's initial framing of the issue and her coding and sorting of Antonio into a particular kind of student served to create distance between them. When he was "playing with his shoe, and he sits right in front of me" Selina saw Antonio as "completely disengaged", implying that he was doing something counter to what she was trying to accomplish. When Selina later stepped into being both teacher and students as she acted

out asking what a vertical line means and then answering her own question, she closed that distance. In her imagining of this moment in the classroom, both teacher and students are "engaged" and working hard while still missing each other. 80-seconds after this stretch of interaction, Selina commented, "I really don't know what's harder, teaching first grade or being in first grade. I really don't know. Literally, we ask **so** much of these tiny humans." With this comment, instead of sorting students into categories that emphasize what they are not doing ("he won't engage with a partner") she invoked the category of human, which includes not only all of her students, but also herself. This represents a substantial shift, and one that is consequential for equity-oriented teaching.

The collective imagining of what it might feel like to be a first grader offered Selina a new way of seeing and understanding Antonio (and the rest of her first graders) that recast him from "completely disengaged" to a tiny human working hard to make sense of complex ideas. Selina brought up this conversation in her closing interview when asked what activities were most important for her learning in Math Crew, saying, "looking at student work, looking beyond what aren't they getting…like when we figured out with Antonio it was the visual representations that were very hard…I don't think I would have gotten to that point if I didn't have everybody looking at the same work with me. Because I was such in a box." Here, Selina explicitly named investigating teaching with colleagues as a way to get somewhere new in how she was seeing and understanding her students.

Although Selina got somewhere new in seeing and making sense of Antonio's actions in the classroom, this does not suggest that she is now done developing professional vision and will see all of her students from this perspective from now on. Given that professional vision is socially and culturally constructed and constantly negotiated and contested, seeing in ways that disrupt the tacit professional visions in systems of schooling is an ongoing collective and individual project. It took 30 minutes of conversation in a community of professionals with shared commitments to come to a collective way of seeing Antonio that focused on what he was doing and on why his actions made sense in the classroom learning ecology, and it will take ongoing work to continue to see students from this perspective as teachers encounter new tensions in their work. In offering an analysis of this conversation I do not intend to provide a "how-to" guide for developing an inclusive and empathetic professional vision. Instead, this conversation offers a window into how teachers can collectively support each other to create, negotiate, and apply coding schemes that highlight what students are doing and why their actions might be sensible in a classroom learning ecology. As the discussion of Selina's dilemma demonstrates, coming to understand Antonio as a unique mathematical learner supported teachers to see the classroom anew and to contest deficit narratives about students. Seeing each student as a sensible actor in a complex learning ecology is a form of professional vision that contests racialized and hierarchical ways of seeing that function to sort and distance rather than to connect. When Selina acted out being a student in the classroom and then referred to Antonio and her other first graders as "tiny humans", she invoked her shared humanity with her students to empathize with their experiences as mathematical learners.

The perspective that developing professional vision is a collective practice that takes ongoing work calls for us to consider how we can create spaces that foster generative and empathetic forms of activity such as the collective imagining of students'

mathematical experiences. For Math Crew teachers, coming to see their students as individual mathematical learners working within a complex learning ecology became possible because of the intentional design of the learning space as an activity system oriented toward a shared commitment. In the next section I identify several features of the Math Crew activity system that analysis revealed to be integral to creating a space where teachers brought their tensions and took them up together in ways that supported the collective construction of an inclusive and empathetic professional vision.

Part 3: Designing an Activity System for Productive Engagement with Tension

Supporting teachers to come to see the classroom through the lens of focusing on what students are doing and investigating why their actions might be sensible requires design thinking at the level of the activity system. As I argued in Parts 1 and 2 of this chapter, collectively constructing an inclusive and empathetic professional vision requires that teachers working in traditional settings surface and productively engage with the tensions they encounter in their work. Engaging with these tensions makes visible tacit ways of seeing so they can be contested and renegotiated in joint activity. In this section, I analyze key design features that created Math Crew as a space where teachers surfaced the tensions in their work and collectively engaged with these tensions in ways that maintained and furthered their shared commitment to creating classroom communities where everyone meaningfully contributes to the mathematical work of the classroom.

In watching the video of the conversation about Antonio, it is evident that the conversation was comfortable and at times even joyful for participants. Smiles and laughter spread through the group as Maritza pointed out the multiple meanings of a vertical line. Selina laughed loudly as she acted out being a teacher and being students. The content of this conversation was heavy in many ways. Selina brought a tough question about a student she didn't think she was serving well. Yet in the space that was created in Math Crew, this heavy dilemma was taken up joyfully and with care both for Selina as a teacher and for her students as tiny humans. It took intentional design choices and ongoing interactional work from all participants to continually construct Math Crew as a space where teachers could share their teaching stories openly and honestly, trusting that the group would respond in ways that respected them as professionals and pushed them to new places in their mathematics teaching.

In what follows I elaborate on two of the Math Crew design principles outlined in Chapter 3 that emerged in analysis as integral to creating a space where teachers could engage with the tensions in their work to collectively construct an inclusive and empathetic professional vision: maintaining a shared orientation toward strengths and taking an expansive view of mathematical activity. Although each of these design principles laid important groundwork for the conversation about Antonio's assessment, they do not fully account for the joyful and caring ways of being together in Math Crew that supported participants to step into what it might feel like to be a first grader in a math classroom. In addition to these design principles, creating a caring learning space where teachers could bring their toughest dilemmas and trust that the community would provide a generative space to learn together required the ongoing construction of supportive norms of interaction. Analysis of participants' interactions during community meetings revealed two interactional norms as essential to constructing Math Crew as a caring community where teachers could bring their toughest questions; inviting vulnerability into conversations of teaching and learning and holding space for deep investigation.

In this section I first describe the ways the two design principles named above were attended to across the Math Crew Activity System and supported the collective construction of an inclusive and empathetic professional vision for mathematics teaching and learning. I then analyze how participants collectively created Math Crew as a community that supported deep investigation and invited vulnerability.

Design Principle: Maintaining a shared orientation toward strengths

An intention of the design of Math Crew was to immerse participants in an activity system where focusing on strengths became a guiding feature of how we engaged in joint activity. The new ways of seeing that became available for participants during the conversation about Antonio became possible in part because teachers engaged in the joint activity by consistently looking for the strengths in Antonio's work. Designing an activity system where a strengths-based perspective became typical entailed making sure that multiple aspects of the activity system aligned with this perspective, from the representations and routines we used, to how we divided our work together, to the implicit norms in the group. This design principle guided not just how we talked about students, but also how we reflected on teaching. Participants named the focus on teacher strengths and the focus on student strengths as integral for their learning in Math Crew. In this section, I first describe the specific ways different aspects of the Math Crew activity system were saturated with a focus on teacher and student strengths and then provide evidence of how teachers spoke about the importance of this design principle for their learning.

Strengths across the activity system

The routines and representations used in Math Crew community meetings and classroom visits were designed to align with a strengths-based perspective toward students and teachers. Table 16 provides a summary of these design choices across different activities and how they connect to the design principle of maintaining a focus on student and teacher strengths.

Table 16. Routines and Representations Focused on Student and Teacher Strengths

Routine/Representation + Brief Description Connecting to Design Principle	When + Frequency
Routine for looking at student work • Start by naming specific mathematical strengths in the work	Every time we looked at student work
Doing math together with a focus on strengths • Debrief by naming the mathematical strengths they noticed in each other as they collaborated	3 community meetings
Facilitator activity during classroom visits • Look for students' mathematical strengths	Every classroom visit
Facilitator email after classroom visits • Name student strengths and teacher moves that made those possible	Every classroom visit
Sharing positive stories from the classroom • Each month one participant shares a success story	6 of 9 community meetings

about their mathematical community	

As is evident in the table above, a focus on strengths was incorporated into multiple activities in Math Crew during community meetings and classroom visits. Participants had repeated opportunities to practice noticing and naming mathematical strengths in written work and during observations of mathematical activity (their own and that of students). The stories teachers shared from their classrooms gave participants opportunities to notice and name what was going well in their classrooms and in their teaching. My emails after classroom visits reinforced these same emphases, and provided a material representation of the design principle of focusing on strengths. Here is an example of the student and teacher strengths from an email I sent to Lauren in October 2016, focusing on two students (Johnny and Malaya) who she was concerned about:

> Student strengths:
> *At Johnny's group, he and Nori were working on white boards on solving the problems while Ava and Danielle were working on the poster. Johnny figured out the first problem on his white board using the standard algorithm and then said "I got the answer, I'm pretty sure. I'm going to check it real quick". He checked it using subtraction and got the same answer. A moment later he told Nori, "now you need to check it" and then Nori checked his work also using subtraction. For both problems and for the two strategies they used of doing the standard algorithm and converting to fractions both Johnny and Nori checked their work using subtraction. I think this interaction showed several strengths: an understanding that addition and subtraction are inverses, and attention to precision, and attending to each other's learning. I also noticed that when Johnny was explaining his group's thinking his explanation of 0.91 + 0.69 showed a deep and flexible understanding of regrouping. He explained that after he had added the hundredths and had 1, 9, and 6 in the tenths column, he added the 9 and 1 and "there's nothing left here because that turned it into a one" and then put the 6 in the tenths and the 1 in the ones without going through the more standard (but unnecessary) step of adding 1 + 9 + 6 to get 16 and putting down the 6 then writing the one above the ones place. This shows not only that he can use the procedure but that he understands what is happening rather than just following a memorized set of steps.
> *Malaya represented her strategy for converting to fractions and then adding the fractions really clearly, showing each step along the way. I especially appreciated how she showed 62/100 + 24/100 as equal to ?/100 showing that she knew that it would be 100ths and the only part that needed to be added were the numerators. This showed both that she understands adding fractions and that she was attending to communicating her thinking clearly for an audience. I think her communication of this strategy was one of the clearest in the class.
>
> Teacher moves:
> *I think the way you set up the task without any modeling of the mathematics, with choice in materials, and by asking for more than one strategy supported Johnny to get to show his strengths. He was able to bring his own focus of checking over work and connecting addition and subtraction and have it taken up by the rest of the group.
> *I saw you consistently intervene at groups about how they were working together rather than how to do the math. This supported students to have plenty of space to make sense of the mathematics themselves and it encouraged all students

> at the group to engage with the math. I also think your intervention of giving Malaya a white board was just right- it helped her get over the hump of participating in her group and made space for her to think about the math herself and then to bring her own particular strengths to her group.
>
> Mallika, email communication with Lauren, 10/24/16

In addition to these routines and representations, a strengths-based perspective was incorporated into the ways we distributed roles in our community. I enlisted participants as co-designers of Math Crew as a way of organizing our collaboration around the premise that we all have important strengths to contribute. Rotating who shared stories and dilemmas from the classroom and who brought student work to each meeting provided opportunities for us all to learn from each other's strengths. Organizing our community so that all members were included as active contributors with diverse strengths to offer may have been especially important for first-year teachers, who are often positioned as not having enough experience to contribute meaningfully to conversations about teaching.

Although an orientation toward strengths was a shared commitment and the responsibility of all Math Crew participants, my role as facilitator was critical to maintaining this focus. I engaged in intentional work to construct Math Crew as a space where everyone had something meaningful to contribute. As I was their instructor during their Math Pedagogy course before facilitating Math Crew, it took active work to set up a collaborative space that focused on making sense of teaching *together* rather than positioning me as the sole expert and leader. In video recordings of early Math Crew meetings participants turned to me frequently to respond to questions or comments. In those moments I frequently opened the conversation back to the group. By the last few Math Crew meetings, this dynamic had shifted (as is evident in the conversation about Antonio's assessment), with participants looking to each other as well as to me. I also invited everyone to bring stories and artifacts from their classrooms throughout the year so that we would have opportunities to learn from each participant. I designed some of the representations and routines to highlight strengths such as my emails after classroom visits and our routine for looking at student work. I also chose to sometimes intervene and ask a re-orienting question if it seemed that a conversation was turning toward deficits. These facilitation moves helped to create a space where each person was able to bring their strengths to leverage for the learning of the community.

Focus on strengths as supporting professional vision

In the focus group interview and in closing interviews, all six participants spoke about how the orientation toward strengths in Math Crew mattered for their learning. In their comments about a strengths-based perspective, they talked about the importance of the general approach of looking for strengths rather than looking for deficits and they spoke specifically about how important it was for them to have opportunities to do this with their own students. There were three central reasons that participants gave for why the focus on strengths mattered to them: 1) it helped to keep them motivated and inspired in their teaching, 2) it provided resources for them to counter the deficit-focused ways of seeing they encountered at their school site, and 3) it helped them see what they could not yet see on their own.

To provide evidence for the ways participants talked about strengths as connected to their learning, I provide transcript from the focus group interview conducted in February because an extended part of the conversation addressed this design principle. Kara brought up the importance of a strengths-based approach in the first few minutes of the interview, when participants were asked why they decided to join Math Crew. In the conversation participants talk about the themes described above and attend to the importance of centering both teacher strengths and student strengths.

Kara: A thing that I felt was really transformative was this strengths-based mindset. That was not often named for us, we didn't always have a space [in the rest of their teacher preparation program]. It was **always** reflect on what you could be doing better or what's not going well or who is struggling and how you can support them.

Lauren: And its always **you**, something you need to be doing

Kara: It's always yourself and how could you better support this learner. And it was like really refreshing just like as 'oh wow I'm doing something right', it was really uplifting. We read one article about how our culture really reinforces deficit thinking…we're very rarely encouraged to name what we're doing well and to embrace that as teachers and to name for our students. And to really buy into that is powerful and creates positivity in a way that I just had never realized and it was a pretty huge shift in the way I thought about all that stuff.

Selina: And having someone in the classroom helping you see that because you're always running around and putting out fires and you miss all these wonderful things, and when you name them for the kids, its life changing.

Lauren: Its so helpful to have that reminder, even in the craziest of moments that there are things going well all over the place and there are things that kids are learning and making sense of that we just don't notice.

Maritza: Its just incredibly supportive to have Mallika come in and like point out the strengths that are so easy to miss when you're just, I don't know, trying to 'teach them and make them understand by this date'. Having, seeing the bigger picture, I wasn't jaded by the other teachers saying that "some of the kids just aren't gonna get it and that's okay." Its been really uplifting to be able to have [Mallika] support you in doing it the right way, like for the kids to figure it out and actually conceptually understand, they're on their way, watching them grow and feel good. I feel like I've left that weight off my shoulders when talking to other teachers, I just let it slide. And I feel bad for their students with some of the things they say, but I feel justified in what I'm doing in the classroom with math.

Kara: There is a lot of pressure from administrators and coaches to identify which of your kids are struggling and what you could do more to support those kids and there is a lot of looking at data to see who isn't getting it, and rarely to understand why or to look at other elements of them as a learner. Its really powerful to feel like, Mallika has given me a language to combat that pressure and to celebrate kids' strengths who maybe on paper are underperforming in the eyes of my admin, so that feels like I'm being an advocate for those students and also checking myself on not seeing certain kids as like, I hold all kids to high expectations, and also want to support them all to reach those expectations.

In this discussion, both Kara and Maritza used the word "uplifting" to describe how an orientation toward strengths impacted how they felt in the classroom. Later in the focus group interview, Lauren also spoke about the importance of strengths for how she felt about teaching, saying, "I feel reinvigorated after coming to the meetings. It's been a rough first year of teaching. If I'm feeling like nothing is going well, coming here and talking about our students together, its really proactive. I always come away feeling better about my classroom and even if I'm really worn out, I'm inspired to try something new or to try again or keep trying."

In addition to the focus on teacher strengths supporting participants to feel motivated and inspired about their teaching, participants also named how the emphasis on student strengths helped them counter the tendency to look for deficits they encountered in their school sites. In the transcript above, Kara named the pervasive emphasis on deficits she encountered during teacher preparation and at her school site and connected this to "how our culture really reinforces deficit thinking." Maritza spoke about the deficit discourse she encountered from colleagues and went on to say that being part of Math Crew helped her feel "justified in what I'm doing in the classroom with math." Kara spoke about how the focus on strengths in Math Crew supported her to "combat that pressure" and to be "an advocate for those students", themes echoed by other participants in this interview and in closing interviews.

Another theme evident in this section of transcript and across community meetings and classroom visits, was that the consistent emphasis on strengths in Math Crew helped participants see what they could not yet see on their own. Selina commented, "having someone in the classroom helping you see that because you're always running around and putting out fires and you miss all these wonderful things." Lauren added, "its so helpful to have that reminder, even in the craziest of moments that there are things going well all over the place and there are things that kids are learning and making sense of that we just don't notice." Maritza echoed their words, saying, "it's just incredibly supportive to have Mallika come in and like point out the strengths that are so easy to miss." Across these comments, participants noted the challenges of seeing the strengths of their students, even with their deep commitment to doing so, and the power of learning to see alongside someone else.

Being immersed in the Math Crew activity system offered participants many different ways to practice seeing strengths rather than deficits. Participants could practice

looking for strengths when doing mathematics with each other, when looking at student work, when watching their students during classroom visits, and when reflecting on their own teaching. As is evident in the transcript from the focus group interview, participants found the side-by-side learning available in classroom visits of looking for strengths with their own students to be powerful. This activity allowed for a form of apprenticeship as teachers learned to see the strengths in particular mathematical actions in real time in a complex classroom learning ecology. Teachers practiced this way of seeing not only with their students, but also with themselves. As teachers shared their successes and their challenges in community meetings, we chose to keep looking for what was working and to consider together how to build on it.

The consistent incorporation of a strengths-based perspective across different aspects of the Math Crew activity system gave teachers multiple opportunities to practice new forms of coding and highlighting across different activities. Throughout these activities, applying the coding scheme that we all have important strengths to contribute served to highlight what teachers *are* doing and what students *are* doing rather than to look for what was not going well and to try to fix it. The new ways of seeing that became possible in the conversation about Antonio were directly related to the design principle of maintaining a focus on student and teacher strengths. Looking for what Antonio was doing opened up new opportunities to think deeply about specific mathematics content and to connect with the experience of doing mathematics as a first grader. In the next section I take up the design choices that worked in concert with the focus on strengths to support teachers to consider and then to collectively imagine the mathematical experiences of a first grader.

Design Principle: Grounding our work in an expansive view of mathematical activity

In the conversation about Antonio described in detail in this chapter, taking an expansive view of mathematical activity was central to participants coming to see Antonio in more generative and empathetic ways. I use the term "expansive" to draw attention to the fact that in Math Crew we attempted to consider the complexity of the experience of doing mathematics from the challenges of specific content to the relative status positions of the different people doing mathematics together to their prior experiences and histories doing mathematics. Taking an expansive view of mathematical activity across the Math Crew activity systems entailed providing teachers with opportunities to do mathematics themselves and to reflect on their experiences, as well as establishing routines and norms of discussing mathematical teaching and learning that supported us to consider the complexity of each student's mathematical experience. As with the focus on strengths, the parallel nature of attending to doing mathematics as teachers and to considering what it might be like for students to do mathematics was integral to constructing an inclusive and empathetic professional vision. As with the previous section, I begin by providing an overview of how this principle was designed for in the routines and representations of Math Crew. I then provide evidence for the role this principle played in teachers' learning.

Mathematical experience across the activity system

Across the design of the activity system, mathematics was a central part of our work together. This included doing mathematics ourselves as well as thinking together about the specific mathematics we saw in student work and sharing the details of how students

participated during different mathematical activities. Throughout these activities, we discussed different dimensions of our own and students' mathematical experiences, considering diverse mathematical strengths and preferences, individual histories with mathematics, and the ways different people were positioned with respect to mathematics.

Table 17. Routines and Representations Supporting Mathematical Experience

Tool/Artifact + Brief Description Connecting to Design Principle	When + Frequency
Doing math together • Engage in mathematical tasks with peers, reflect on those experiences	7 of 9 community meetings
Sharing stories and dilemmas from the classroom • Share details of how students have participated in mathematics over time	Every Math Crew meeting
Choosing focal students • Choose students whose mathematical participation interests you	January Math Crew meeting
One-on-one conversations before classroom visits • Discuss focal student participation, attend to these students in planning a lesson	Every visit after January
Facilitator activity during classroom visits • Watch focal students closely and take detailed notes on their experiences	Every classroom visit after January
Facilitator email after classroom visits • Name specific strengths of focal students	Every classroom visit after January

These different routines and representations in Math Crew provided opportunities to stay connected to an expansive view of mathematical activity. Doing mathematics and reflecting on the process supported participants to experience what it feels like to do mathematics in the ways they were asking their students to do math. Choosing focal students, watching those students closely in the classroom, discussing them in planning conversations, and sharing about them in community meetings provided opportunities to think deeply about the mathematical experiences of individual students. Across these activities, doing mathematics was taken to be a complex social activity with many dimensions.

An expansive view of mathematical activity and professional vision

In closing interviews and community meetings, participants shared how important it was to them to be able to stay connected to their students' experiences as mathematical leaners. In particular, participants spoke about the importance of doing mathematics in Math Crew as a way to remember what it feels like to be a student and to hold on to a more expansive view of doing mathematics. In her closing interview, when asked what she thought were the most critical components of Math Crew, Maritza's first response was "I think the doing math together is one of the most important things to keep us grounded to how it feels to be a student, doing math, and trying to figure things out."

Tina also named this as the most important part of Math Crew and spoke at length in her closing interview about why she thought it was so important:

> "Having us do math was so powerful because I couldn't remember the last time I did math before that, because I didn't major in math. I mean, my last memories as a math student were rather painful. It was calculus and econ and I was like, unhhhh. So, I don't know, just some way for teachers to remember what its like to do math and be a student and push themselves to do something they weren't taught before or do math in ways that we didn't learn it. Because I know a lot of what my colleagues and my teaching partner struggle with in teaching math, they're like 'I don't know how to do this because I wasn't taught this way. I never learned it this way, I don't know what these terms are.' So we have to be really willing to learn and I think many teachers once they've gotten into the groove of things they're on the teaching side rather than the learning side. Um, so we need to be humbled and to remember what its like to not know anything. I think that's really important. Um, and to see that it is exciting, it can be exciting."

Here Tina expanded on the theme Maritza raised of staying connected with what it feels like to be a student, naming the importance of being "willing to learn", being "humbled", and remembering "what its like to not know anything." She closed with the reminder that learning mathematics "can be exciting." The theme of doing mathematics to stay connected to what it is like to be a student also came up during our community meeting in February. I checked in briefly with participants about what they saw as the purpose of doing math together to make sure that I was selecting math tasks that aligned with their purposes. The responses participants gave were about taking an expansive view of the experience of doing mathematics and the ways this view helped them to connect with their students:

Tina: For me it's just been a really **fun** thing to do, to do math together. Because in my experience as a math learner it was just like, okay, algorithms, math steps, worksheets and it wasn't very fun (*laughter*). So just knowing that it can be fun and trying to bring that into the classroom, just that attitude, even if its not the exact tasks, it helps to be in that mindset.

Kara: I think for me, also an awareness of myself as a math learner, and like my go-to first step of solving a problem and just as a learner in general I am like 'wait let me just try to figure this out on my own' and that's not what I want my kids to do. But that's my first step, is, like let me make sure I understand this and also just like tend more towards numbers and algorithms than others even in this group. So I think it's important for me to reflect on that for myself and how that influences my teaching and how I treat kids who are like me.

Lauren: I also think that the idea of different learners and different strengths is what it reinforces for me. Like working with other mathematicians,

> we're all thinking about this in a different way, and that's great and really helpful but also when you're teaching lessons where kids are expected to do it one way and do it silently, its just nice to think about the fact that there are all these different things going on in all the different kids' brains in how they're thinking about it and the power of that if you were actually productively talking about it and listening, what different strategies you can learn is helpful.

Across these comments, participants emphasized that doing mathematics themselves was a way to relate to their students and to stay connected to their shared commitment to creating ambitious and equitable mathematics communities. They did not talk about some of the more typical reasons often given for having teachers do mathematics themselves such as building content knowledge or pedagogical content knowledge or trying out specific tasks for the classroom. Though these reasons may also have been important to participants, when they had opportunities to reflect on the role of doing mathematics, they consistently spoke about it in terms of staying connected to an expansive view of mathematical activity and to the experience of being a learner.

Developing an inclusive and empathetic professional vision for mathematics teaching and learning depends on participants noticing and valuing diverse ways of engaging with mathematics and staying connected to what it might *feel* like to be a child in a classroom. Math Crew offered participants many opportunities to think deeply together about the experience of doing mathematics as learners and to bring this experience to their conversations about their students. In the conversation about Antonio, taking seriously the complexity of the experience of learning place value laid the foundation for the activity of collectively imagining what it might feel like to be a first grader in the classroom. In this moment, participants lived up to Tina's exhortation for teachers to be "humbled" as they remembered what it is like to be a student. By focusing on what Antonio was doing and why his actions might be sensible and considering the complexity of his mathematical experience, participants were able to come to see Selina's classroom from the perspective of her first graders.

Co-constructing a caring community

The design principles of maintaining a shared orientation toward strengths and grounding our work in an expansive view of mathematical activity provided a necessary foundation for teachers to collectively construct an inclusive and empathetic professional vision. However, these principles alone do not sufficiently account for the caring and joyful ways that participants engaged with the tensions Selina surfaced in her dilemma about Antonio. In this section I consider the interactional norms that helped to create a space where participants chose to bring their most difficult moments of tension, trusting that the community would respond in ways that valued and cared for both teachers and students as human beings and pushed teachers to new learning. The two norms that emerged in analysis as most supportive of productively engaging with tension are 1) inviting vulnerability into discussions of teaching and learning, and 2) holding space for deep investigation. In this section, I describe the ways each of these norms relate to the design principles described above and then briefly examine the ways these norms were constructed in interaction.

Interactional norm: Inviting vulnerability

Inviting vulnerability was a key aspect of how Math Crew participants engaged in collectively thinking about teaching and learning. The conversation about Antonio became possible because Selina felt comfortable bringing a dilemma to the group and speaking honestly about her limitations in seeing Antonio's strengths. Working toward a commitment to ambitious and equitable mathematics teaching that runs counter to common discourse and practice in schools requires constant reflection and improvisation, and also inevitable failure. Welcoming vulnerability was a necessary part of creating a space where teachers could be honest about the ways they were not yet living up to their commitments, knowing the community would care for them as they tried and failed and tried again.

The design principles of focusing on student strengths and taking an expansive view of mathematical activity were integral to fostering the interactional norm of inviting vulnerability into discussions of teaching and learning. By focusing on teacher and student strengths across the activity system, we built a community where teachers came to trust that members would listen for what was generative and hopeful in the stories they told and help them figure out how to recognize and build on those productive beginnings. Doing mathematics together and reflecting on the experience provided participants with repeated opportunities to be vulnerable with each other as they acknowledged what they did not know and worked together to make sense of challenging mathematical ideas. Deeply investigating the mathematical experiences of focal students both in community meetings and in classroom visits helped participants see the vulnerability in their students and relate to it themselves. In the conversation of Selina's dilemma about Antonio, these different aspects of vulnerability were key features of the activity. Selina shared openly about the distance between what she was committed to doing (seeing strengths) and what she was able to do with Antonio. Other participants helped Selina see the mathematical strengths in Antonio's work and to recognize and relate to Antonio's vulnerability in the classroom as he worked hard to make sense of challenging mathematics. A sense of shared vulnerability is at the heart of Selina's comment that "I really don't know what's harder, teaching first grade or being in first grade." The norm of interaction of inviting vulnerability into our discussions of teaching and learning was made possible because of the design choices described above, and it was continually constructed in interaction during our conversations. In the next section, I analyze a short stretch of interaction as evidence that this norm was a pervasive feature of the Math Crew activity system and as an illustrative moment of how this norm was collectively constructed in interaction.

Co-constructing the norm of inviting vulnerability

One moment from analysis of Math Crew community meetings stands out as both indicative of the ways vulnerability was invited into the space we created together and of how participants co-constructed this interactional norm. Similar to the moment of collective imagining of Antonio's experience, this moment was one of the most animated interactions across the data corpus in terms of talk, gesture, and laughter. It occurred during the November Math Crew meeting. Maritza had just shared a story about how I had visited her classroom and helped her to notice the strengths of one of her students. After Maritza finished her story, I asked if anyone had any questions, comments, or connections. Kara jumped in immediately:

> "I have a connection. It was so helpful to have you in the classroom just cause I was **so** scattered when you came. It was after the bulldog bash and just like the groupings felt crazy and I had a kid yelling at me 'Why am I in a group with only boys? Why do you never put me with girls?' 'Because we have nine more boys than we have girls, (*laughter*) its a crazy classroom gender imbalance, I'm sorry. Um and you bully the girls', so. But yeah, Mallika was like 'it would just be nice for you to be able to take notes on strengths.' Literally the only thing I had on my notepad at the end of that session was (*draws with her hands as she speaks*) a rectangle."

As soon as Kara finished this sentence, the rest of the group erupted in loud, raucous laughter and Lauren used a hand signal to show her agreement.

Kara went on to explain, "One kid asked 'what's a rectangle?' and it was a little blue rectangle. I was like 'this is a rectangle.'" Kara continued, "That's all I had taken (*using air quotes*) 'note' of." Maritza laughed loudly and Marie put her head in her hands, continuing to laugh.

Selina responded, “Oh my god, that is amazing.”

In watching the video of this moment (and having been there myself when it happened), there was a palpable sense of relief in the eruption of laughter. When Maritza initially told her story, she touched on the difficulty of noticing strengths, commenting that I had pointed out something to her that she had not noticed about one of her students. Kara took this further, explicitly naming her own failure to take note of any strengths, something Math Crew participants were all trying to stay committed to doing. The immediate loud response of laughter made it clear that Kara was not alone in this failure. The animated reaction from the group indicates that participants may have each been feeling this individual failure strongly and that Kara’s story provided relief because it created a space to share their failure collectively. In this moment, it was okay to admit the reality of their teaching and to notice the vast space between what they hoped to do and what they were able to do in the moment in their classrooms. The laughter appeared to function as a form of solidarity (Takeuchi, 2016), connecting participants in their shared struggles to enact their commitments. Kara’s willingness to share and participants’ immediate and vocal willingness to hold this challenge with her are indicative of the sense of community that was created in Math Crew. In sharing this moment, they collectively invited vulnerability into the space and even celebrated it.

Interactional norm: Holding space for deep investigation

In addition to inviting vulnerability, the norm of holding space for deep investigation was an important part of creating a space where teachers could surface and engage with their toughest issues together as a community. In the conversation about Antonio, participants spent 30 minutes talking about one of Selina’s students without anyone ever attempting to hurry the discussion along or to quickly resolve Selina’s feelings of tension. This is not typical of conversations about teaching in schools. Time is an ever present pressure in schooling, and just as students’ days tend to be composed of highly scheduled blocks of learning, teachers’ conversations in professional development sessions or staff meetings

are often highly constrained by time. In Math Crew, it took intentional work to create a space that minimized the pressure of time as a constraint on learning to support deep investigation.

The design principles of orienting toward strengths and grounding our work in mathematical experience provided an important foundation for the deep investigation participants were able to engage in when discussing Antonio's assessment. Focusing on student strengths supported teachers to look more closely at Antonio's work to try to make sense of what he might have been thinking. Focusing on teacher strengths and on what was working in the classroom opened up space to critically reflect on teaching, knowing that critique was not about judgment or evaluation but instead for the purpose of collective learning. Taking an expansive view of mathematical experience supported participants to investigate why Antonio might be appearing to be disengaged not as a problem with him but as an issue of the learning ecology. The focus on strengths and this expansive view of engaging with mathematics provided a necessary foundation the moment of collectively imagining the experience of being a first grader in a math classroom. However, this moment would not have been possible without intentional work to disrupt the ways that time often operates as a constraint on learning. In the next section I provide an example of the interactional work participants engaged in to construct Math Crew as a community that would hold space for deep investigation, even when it took a long time.

Co-constructing the norm of holding space for deep investigation

Later in the same conversation described above where Kara talked about drawing a little blue rectangle, the norm of holding space for deep investigation was both tested and explicitly affirmed. Math Crew participants had discussed Maritza's story from the classroom for eight minutes, and the conversation had begun to wind down a bit. After a brief moment of silence, Maritza said, "Um…do I have room for a question?" She looked at me as facilitator as she asked the question and raised her eyebrows. Kara nodded immediately, and I answered "yeah", laughing as I responded. Other participants also laughed and Marie, adopting a serious voice in jest, turned to Maritza, saying, "No. Your time is over." Lauren said, "You have 30 seconds." Kara chimed in, "Put it in the parking lot Maritza" and Marie added, "We'll get to it next month, maybe." Throughout this exchange, all participants were smiling and laughing. As the exchange concluded, there was a very brief silence, and then Maritza began voicing a tension she was feeling at her school site about a special education teacher who was coming in to "help" some of her students by doing the math for them.

This exchange is notable in the ways that participants explicitly pushed back on the norms of systems of schooling where learning is supposed to take place according to prearranged timelines. In their joking responses to Martiza, teachers echoed the same language that is commonly used in classrooms whether those classrooms are full of children or teachers, saying, "your time is over", "you have 30 seconds", "put it in the parking lot", "we'll get to it next month." It is evident from Maritza's laughter and the way she jumped into voicing her tension right after this exchange that she took their responses to be a clear statement that she had whatever time she needed to think more deeply with the community about her classroom. In this interaction, participants deliberately co-constructed Math Crew as a space where conversations could take as long as they needed to take, rather than needing to fit into time slots on an agenda. In my role

as facilitator, I created tentative agendas before each meeting. I did not put times on the agendas and I stated that they were tentative and could change depending on the needs of the group. This explicit attention to mitigating time as a constraint on learning both in design and in interaction was a fundamental part of the deep investigation that became typical in Math Crew. It was not until 22 minutes into the conversation about Antonio that Selina stepped into imagining being a first grader in her classroom. If time had functioned as it typically does in school learning environments, it is unlikely the group would have spent so long discussing one student and investigating this students' experience in the classroom. Holding space for deep investigation took both intentional design and ongoing interactional work to continue to invite teachers to share openly and honestly about their needs as they emerged and to take as long as they needed to investigate the issues they surfaced.

Summarizing connections between design and professional vision

The design principles of maintaining a shared orientation toward student and teacher strengths and grounding our work in an expansive view of mathematical experience, and the norms of inviting vulnerability and holding space for deep investigation, worked together to create a space in Math Crew where teachers could support each other to surface tensions and engage with them productively. Creating this space required designing from the perspective of immersing participants in an activity system where new cultural practices could become typical. Learning to see what students are doing and investigating the reasons their actions might be sensible in a classroom learning ecology is a form of professional vision that requires constant contestation and negotiation and close attention to the complexity of the experience of learning mathematics. In order for this contesting and negotiating to occur, participants had to surface the tensions they experienced in their work, and they had to develop tools and ways of interacting that allowed for deep engagement with these tensions.

Being part of Math Crew offered participants new tools and activities to practice noticing and naming mathematical strengths and to dig into mathematical content both as learners and as teachers. In Math Crew, teachers looked closely at student work, engaged in and reflected on math tasks as learners, practiced noticing strengths in the classroom with me, and discussed stories from the classroom with a focus on building on what was working. Across these activities, participants were immersed in a system that afforded new ways of thinking about students and about the classroom. As is evident in the conversation about Antonio, teachers made robust use of the new tools and routines from Math Crew, and repurposed artifacts from their school activity systems (such as the district assessment completed by Antonio), as they engaged in contesting the coding schemes they encountered in their school sites and collectively constructed new coding schemes.

These design principles laid important groundwork for Math Crew to become a space where teachers collectively constructed an inclusive and empathetic professional vision for mathematics teaching and learning. In addition to these principles, inviting vulnerability and holding space for deep investigation were essential to creating a space where teachers could share honestly about their tensions and their shortcomings and trust that the community would provide a caring space for them to engage with these productively. Beginning teachers have an overwhelming number of new things to learn in the classroom all at once, no matter how well prepared they may have been. Trying to

enact a commitment to ambitious and equitable mathematics teaching in schools organized around different commitments makes that job even more challenging. Being able to be vulnerable and to have the space to engage deeply with the issues that mattered to them was an important part of building the Math Crew community as one where teachers stayed motivated and inspired to continue to learn toward their commitments.

One participant, Marie, had a very different experience in Math Crew, described briefly in Appendix C. Her experience suggests some of the limitations of the design of Math Crew and the ways in which the design principles and norms described here did not support all participants in the same ways. In future analyses, I intend to take up a more detailed examination of these limitations as they relate to Marie's participation in Math Crew and to the tensions and contradictions she experienced in her school setting.

Conclusion

Learning to see and make sense of the classroom from a strengths-based perspective while working within deficit-focused systems of schooling is a project that takes ongoing contestation and negotiation and, especially for new teachers, requires the support of a community of like-minded colleagues. In this chapter, I provided evidence that being immersed in the Math Crew activity system created a space for teachers to surface and engage with the tensions in their work to collectively construct an inclusive and empathetic professional vision for mathematics teaching and learning. This way of seeing the classroom supported Math Crew participants to connect with their students as individual mathematical learners and to imagine the classroom from their perspective. This fostered greater connection with their students, as when Selina came to see her first graders as tiny humans. Developing a professional vision that focuses on what students *are* doing and why their actions might be sensible in a classroom learning ecology provides a way of countering deficit perspectives of students from nondominant communities by offering an alternative to racialized systems of sorting that function to distance teachers from their students.

The central argument of this chapter is that developing this type of professional vision entails surfacing the tensions of equity-oriented teaching and then collectively engaging with these tensions to contest hierarchical ways of seeing and to construct new ways of seeing. Part 1 of the chapter outlined the tensions participants surfaced in Math Crew. I showed what these tensions made visible about the tacit professional vision at work in systems of schooling and how participants leveraged the surfacing of tensions as opportunities to articulate alternative ways of seeing the classroom. In the key episode of the chapter, in part 2, I analyze the nature of the interactional work involved in contesting hierarchical and deficit-focused ways of seeing, and constructing alternative ways of seeing the classroom that are grounded in a strengths-based perspective. In the conversation about Antonio's assessment, teachers dug deeply into Antonio's work to contest the view of Antonio initially offered by Selina as disengaged. Participants negotiated and employed coding schemes that highlighted the mathematics in the work Antonio had produced, unpacked the mathematical ideas he was working hard to make sense of, and sought to understand why his actions might be sensible in the classroom learning ecology. By coding, highlighting, and re-articulating his district assessment from an inclusive and empathetic perspective, participants collectively came to see Antonio as a unique mathematical learner and to relate to his experience in the classroom. This

collective interactional work made it possible for Selina to step into *being* a first grader in a math classroom trying to make sense of the multiple meanings of a vertical line.

Developing an inclusive and empathetic professional vision that differs substantially from the hierarchical ways of seeing typical in systems of schooling became possible because participants were immersed in an activity system oriented toward a shared commitment. As I argue in part 3, the consistent focus on strengths and mathematical experience, along with the creation of a space where teachers could be vulnerable and hold space for each other, supported teachers to take up new practices and forms of activity. Creating a space that invited participants to surface tensions and engage with them in ways that were generative took intentional design choices and ongoing interactional work. These findings suggest that it may be productive to reconsider the forms of support we provide to beginning teachers. Currently, the main form of support offered to beginning teachers tends to be in the form of one-on-one mentorship. Given the cultural nature of learning to see, community-based supports such as Math Crew offer rich opportunities to collectively develop an equity-oriented professional vision that may not be as available in one-on-one mentoring relationships.

In Chapters 4 and 5, I focused on teacher learning toward ambitious and equitable mathematics teaching, looking first at what teachers learned over time in Chapter 4 and then examining *how* teachers learned in interaction in this chapter. In Chapter 6 I reflect on the findings and implications of the dissertation, discuss limitations of the study, and suggest possible directions for future research.

Chapter 6: Discussion

The story of Math Crew as told in this dissertation represents one attempt at disrupting dehumanizing aspects of systems of schooling to create new possibilities for ambitious and equitable teacher learning. In this final chapter I reflect on several themes from this research project that I hope will contribute to our understanding of the conceptualization, design, and study of equity-oriented teacher learning. I consider the implications of these contributions for research and for teacher education. I then discuss some limitations of this study and suggest possible directions for future research.

Reflections across Findings

In this section I highlight several themes that serve as contributions to the field of teacher learning. I connect each theme to the findings offered in the dissertation and discuss implications for the design and study of teacher learning spaces.

Conceptualizing teacher learning as mediated within figured worlds

The disconnect between teacher preparation and the first years of teaching, in terms of support for teacher learning and teaching practice, continues to be a central issue plaguing teacher education. Many efforts have been made to improve teacher preparation programs to better prepare candidates for the actual work of teaching (Ball & Forzani, 2011; Gutierrez & Vossoughi, 2010; R. Gutiérrez, 2013). However, given that the transition into teaching entails moving between figured worlds that are oriented toward very different goals and that learning to teach is an ongoing process, it is also imperative to provide support for equity-oriented teacher learning beyond pre-service preparation. As elaborated in Chapters 4 and 5 of this dissertation, creating classroom math communities founded on care, dignity, and connection involves a constant process of trying to solve fundamentally unsolvable problems as teachers work within systems of schooling whose organization lies in opposition to this aim. The figured world of schooling is pervasive and provides numerous tools and artifacts that mediate teacher learning in ways that tend to reproduce social hierarchies.

A key implication of this study for the design of teacher learning spaces is that immersing teachers in a figured world saturated with new tools and with opportunities to re-articulate existing artifacts of schooling can mediate robust learning toward an equity-oriented shared object. This approach to design represents a contribution to how we conceptualize supporting ongoing teacher learning. Currently, much of the support for beginning teachers is provided either in the form of professional development sessions on a particular topic that may provide valuable new ideas but do not necessarily connect closely to the daily work of teaching, or through one-on-one mentoring that is specific to a teacher's classroom practice but may not connect to a larger professional vision (Kathleen|Yoon Fulton, 2005; Ingersoll & Strong, 2011; Wang & Fulton, 2012). In addition, professional development and mentoring have limited purchase in terms of supporting the cultural work of disrupting systems of schooling as they place a heavy onus on individual teachers to "teach against the grain."

Conceptualizing the support of teacher learning as a collective project of co-constructing an equity-oriented activity system provides one way of attending to the cultural nature of learning to teach and the need for close connections between an expansive vision for math classrooms and the daily work of teaching. The shift to

relational investigations of teaching and learning and the co-construction of an empathetic and inclusive professional vision that occurred in Math Crew suggests that it may be fruitful to approach teacher learning from this perspective of designing an activity system oriented toward a shared commitment and encouraging travel across systems. This approach necessitates considering the ways that tools and artifacts, participation structures, distribution of roles, and explicit and implicit norms of interaction all function to mediate teacher learning.

Several aspects of the Math Crew activity system emerged as particularly consequential for participants' learning. As discussed in Chapter 5, Math Crew teachers emphasized the importance of classroom visits in addition to community meetings as it gave them opportunities to make sense of and practice what they were learning with their own students. In terms of coming to see their students from the perspective of what those students are doing and why it might be sensible, having support in their own classrooms to see their students in new ways provided rich opportunities for learning. Another feature of the activity system was the creation of new tools and artifacts oriented toward strengths rather than deficits, such as the emails I sent after classroom visits describing student and teacher strengths. These tools and artifacts were leveraged both in community meetings and classroom visits and in participants' school contexts to support new ways of making sense of students. For example, participants reported that they used my strengths-based emails in parent-teacher conferences, in student-study team meetings, and in their communication with principals and resource specialists both to highlight the mathematical strengths of individual students and to provide evidence of the efficacy of their teaching. The ways that these emails were used by participants to mediate their own learning about their students and to communicate with members of their communities suggests the importance of creating equity-oriented artifacts that can mediate teacher learning and provide a counterweight to the numerous deficit-oriented artifacts of schooling. These findings indicate designing at the level of an activity system and attending to travel across systems opens up new forms of mediation, which can then support robust teacher learning.

From an analytic perspective, conceptualizing teacher learning as an ongoing process that is mediated by the tools, artifacts, roles, and discourse of figured worlds has affordances for uncovering more of the complexity of teacher learning. The analyses of learning over time presented in this dissertation, spanning both community conversations and classroom teaching, represent an attempt to capture learning over time and in interaction as teachers navigate different figured worlds. My analysis of Tina's case revealed the ways that her learning was mediated and amplified as tools, artifacts, and people traveled between Math Crew and her classroom. Studying teacher learning as a process that is mediated by different tools and artifacts as teachers travel through figured worlds offers a way to more fully attend to the complexity of teacher learning as it happens across time and space.

Centering tensions and contradictions in teacher learning

As discussed throughout this dissertation, moving from teacher preparation into the first years of teaching brings many new dilemmas as teachers become immersed in the world of schooling. Scholarship has documented the many challenges that teachers working toward ambitious and equitable teaching encounter as they attempt to put their commitments into action in settings where those commitments are not widely held or

practiced (McGinnis et al., 2004; Stillman, 2009; Stillman & Anderson, 2011). Some teacher educators and preparation programs attend to supporting teachers to navigate these tensions by creating spaces where teacher candidates can collectively engage with tensions as a central part of the work of learning to teach (e.g. Gutiérrez, 2013; Willey, 2013). However, once teachers complete their preparation programs, they are often left on their own to figure out how to deal with the many contradictions and tensions they face in their daily work.

Math Crew was designed as a space where surfacing tensions and discussing how to navigate them was taken to be a core component of ongoing teacher learning. As I argued in my analysis of the co-construction of an empathetic and inclusive professional vision, Math Crew became a space where participants learned to leverage the tensions in their work to think deeply about the mathematics classroom from the perspective of their students. The frequency with which tensions were voiced and the robust learning opportunities that arose from those discussions suggest that it may be beneficial to rethink the role of contradictions and tensions in teacher learning, particularly as teachers move from the figured world of teacher preparation into the figured world of schooling. The world of schooling has a strength and dominance that is difficult to counteract given the pervasiveness in schools of discourse, tools, and artifacts that are organized to construct difference and hierarchy. The continued chasm between the ambitious view of mathematics teaching being offered in teacher preparation and typical practice in mathematics classrooms, despite decades of effort in preparation programs, provides ample evidence of the difficulty of resisting systems of schooling as an individual. The findings of this dissertation indicate that treating tensions as productive sites for discussion, rather than as challenges for individuals to navigate or as barriers to be overcome, can support rich collective learning. Building communities that support teachers to engage with tensions with like-minded colleagues offers one productive avenue for supporting teachers to move between contradictory figured worlds without giving up their commitments.

Analytically, discussions of tensions in the work of teaching serve as a productive site to examine teacher learning. As discussed in Chapter 5, the ways that Math Crew participants engaged with moments of tension provided a window into the interactional work involved in learning to see the classroom from a strengths-based perspective that centered students' mathematical experiences. The methodological approach of treating the collective navigation of tensions as a place to look for learning represents a contribution to how we study teacher learning at an interactional level. Some studies of teacher learning in community have taken a similar approach, focusing on teaching dilemmas or problems of practice as a unit of analysis (Ilana Seidel Horn, 2007; Ilana Seidel Horn & Little, 2010; Ward, Nolen, & Horn, 2011). These studies have highlighted the ways that interactional routines and norms afford and constrain opportunities for learning but have not focused as intently on what exactly teachers learned. Analyzing the co-construction of professional vision represents a contribution to the field in that analyses reveal both the "what" and "how" of teacher learning as it happens in interaction. Using professional vision as an analytic lens is one possible approach to studying equity-oriented teacher learning through investigating how teachers collectively come to see and make sense of the classroom.

Re-thinking the positioning of beginning teachers

As discussed in depth in Chapters 4 and 5, Math Crew participants took up ways of seeing the classroom and enacted teaching practices that disrupted the deficit-oriented professional vision for mathematics teaching and learning that is pervasive in systems of schooling. This type of learning tends to be considered an overly ambitious agenda for beginning teachers, who are often expected merely to "survive" their first year of teaching. The findings presented here suggest that we may underestimate what is possible in terms of equity-oriented learning for beginning teachers. At the outset of this project, I fell prey to the same narratives, telling my faculty mentors that I did not expect Math Crew participants' teaching to be particularly ambitious since they were first-year teachers, but that I hoped to support them to maintain their commitments. In my previous work as a mathematics instructional coach I spent hundreds of hours observing instruction in classrooms across different school contexts, and it still remained an uncommon experience to visit classrooms where students regularly worked on challenging mathematical tasks and engaged in rich mathematical discussions. When I visited Math Crew teachers' classrooms toward the end of the school year, I was amazed at the depth of mathematics I saw students engaging with and at the quality of the discussions students had about each other's mathematical ideas. Being part of this teacher community taught me that first-year teachers can create rigorous and caring classroom communities that value the mathematical contributions of each of their students. These findings suggest that we can and should expect much more from beginning teachers and from ourselves as teacher educators who support the transition into teaching.

Our expectations of beginning teachers are intertwined with the positions made available to teachers. So often, whether in staff meetings, in mentorship relationships, or in conversations with administrators, first-year teachers are positioned as people who have much to learn and very little to offer. I consider re-positioning beginning teachers as valuable contributors to discussions of teaching and learning to be intertwined with a shift in how we conceptualize what might be possible in the first year(s) of teaching. Just as it matters for student learning that students feel as though they have something to contribute in the mathematics classroom, it matters for teacher learning that teachers feel they can make meaningful contributions to the work of teaching. As Marie's case suggests (elaborated in Appendix C), when beginning teachers are constantly evaluated and under pressure, barriers can be created to the investigation, reflection, and experimentation that was integral to the robust learning other Math Crew participants experienced. Alternatively, as documented in this dissertation, when beginning teachers are members of communities that value their contributions rich investigations of teaching and learning can become possible. In addition, when teachers are positioned as active contributors (or as co-designers as they were in Math Crew) whose voice is valued, their emerging needs can shape conversations about the classroom so as to better support ongoing learning in ways that are responsive to the needs of beginning teachers. One key contribution of this work is an existence proof that when we create spaces where beginning teachers are positioned as sense makers and active contributors to conversations about teaching and learning, they can take up and learn toward an ambitious equity-oriented agenda for mathematics teaching and learning.

Creating humanizing spaces for teachers and for students

Here I return more centrally to the theme of closing the distance between ourselves and others as an integral aspect of designing learning spaces that disrupt dehumanizing aspects of systems of schooling. Creating caring and expansive learning spaces for students that emphasize relations rather than difference has been a theme of equity-oriented education research. This attention to relationships and care does not always carry through to how we conceptualize learning spaces for teachers. However, systems of schooling are not just dehumanizing for children, they are dehumanizing for all of the human beings working within them. The experiences of Math Crew participants suggest that creating caring spaces for teachers has rich potential to support teachers to create caring spaces for their students. Engaging in relational investigations of teaching and learning, and developing an empathetic and inclusive professional vision for mathematics teaching depended on teachers coming to see their students more fully as tiny humans acting sensibly within a given learning ecology. I argue that it is not coincidental that teachers developed this way of seeing in a teacher community where they were cared for and seen as human beings doing their best under difficult circumstances.

One key design feature of Math Crew that seemed integral to helping participants connect with each other and with their students as human beings was the ongoing activity of doing mathematics as a learner during community meetings. As argued in Chapter 5, working on mathematical tasks helped teachers stay connected to the experience of what it *feels* like to be a mathematical learner and, in Tina's words, to "be humbled." A sense of humility in the face of teaching and learning is not always something we emphasize in teacher learning. However, the collective imagining of students' mathematical experience that became possible in Math Crew suggests that increasing opportunities for teachers to connect with what it feels like to be mathematical learners may be a generative direction for the support of equity-oriented teacher learning.

As evidenced in this dissertation, designing from the perspective of creating parallels between teacher learning communities and student learning communities, particularly toward the aims of constructing relations rather than difference, can support robust teacher learning. The analyses of learning in Math Crew suggest that creating spaces for teachers where laughter and joy are part of conversations about the emotionally draining work of teaching matters for sustaining this work, with all its dilemmas and tensions. As I argued, this ethic of care was a feature throughout the designed activity system from hosting meetings at my home to inviting vulnerability into discussions of teaching and learning and letting conversations take as long as they needed to take. Creating a space where teachers felt cared for as they engaged in the hard work of trying to disrupt some of the dehumanizing aspects of mathematics classrooms helped to foster a sense of hope and possibility that teachers could then bring to their classrooms.

Limitations and Suggestions for Future Research

I begin this section with a brief story of what happened with Math Crew after the 2016-17 school year. I use this story to highlight a central limitation of the research presented in this dissertation and to suggest next steps that could build on the productive beginnings offered here and address this limitation. I then discuss several other limitations and suggest possible future research directions. As Math Crew was a design-based study, this section focuses intentionally on suggestions for design-based research, in addition to ideas for future research on teacher learning.

At the final Math Crew community meeting in May of 2017, participants discussed whether and how to continue meeting the following school year. Teachers were enthusiastic about sustaining the learning community and came up with some tentative plans for what that might look like, given that I would be analyzing and writing and would no longer be able to take on the role of organizer and facilitator. Two of the participants who would be roommates the following year offered to host, and one offered to take the lead on organizing the logistics. We also brainstormed types of activities for meetings such as bringing a math task from the curriculum to try out and then reflect on together as a group, and choosing a topic for the month such as "building math norms" and having everyone bring examples from their classroom to share. My intention was to join these meetings as a participant but to step back as organizer and facilitator. None of these plans came into being. Math Crew teachers met once during the 2017-18 school year, and that meeting occurred when I took the initiative to organize a reunion. Math Crew was made possible because I had a flexible schedule as a graduate student and could spend time facilitating the logistics and the content of our meetings and visiting classrooms. I also hosted the meetings at my home and provided food and drinks for each meeting. Moving forward with Math Crew would have necessitated distributing these roles to second year teachers who were busy and often overwhelmed with the daily work of teaching.

The failure of Math Crew to sustain itself as a learning community highlights some of the limitations of this study. Math Crew was designed as additional voluntary support for beginning teachers, and not as part of an existing structure or institution. As a result, it was entirely dependent on me as an individual, with no plans for sustaining the project over time. In addition, I took on all facilitation and organizational responsibilities, rather than distributing these roles across participants. This meant that we had no sustainable structures to fall back on when I could no longer maintain those responsibilities.

Future research could productively build on the findings from this study about design and teacher learning with an intentional focus on sustainability over time. One approach to attending to sustainability would be to build community-based support similar to Math Crew into an existing structure. For example, some universities have begun partnering with school districts to take on some responsibilities for beginning teacher induction support. Designing these programs with a focus on positioning first year teachers as valuable contributors, centering the navigation of tensions, and immersing teachers in equity-oriented activity systems, could build on the beginnings of Math Crew in ways that are more sustainable over time. Alternatively, projects like Math Crew that are created outside of existing structures could be designed from the outset with an eye toward sustainability. The community could be involved from the beginning in distributing the organizational and facilitation work so that it would not be dependent on any one person. Designing and researching community-based approaches to supporting beginning teachers that hold sustainability as a core goal has the potential to offer more enduring changes to how we support equity-oriented teacher learning across the transition into teaching.

In addition to the issue of sustainability, there are several other limitations of this dissertation that deserve attention. Math Crew was formed as a community of like-minded educators committed to a shared object of creating ambitious and equitable

mathematics communities. All participants opted in to this project. However, in many contexts, supporting teacher learning requires working with teachers who may or may not share the same commitments and who do not have the choice of whether or not to participate. One possible next step for future research would be to examine university-district partnerships in which universities take on the responsibilities for induction and where teacher communities are built into the institutional support structures. Investigating the learning that is possible under these conditions and the affordances and constraints of different design choices would paint a much fuller picture of the possibilities and the challenges of supporting the transition into teaching. An alternative approach advocated by several members of Math Crew in their closing interviews is to find ways to provide teachers with more opportunities for choice in their learning. University-district partnerships could be designed in ways that offer beginning teachers choices of different learning communities they could opt to join during their first year of teaching as part of their induction into teaching. Although the organizational details might prove challenging, this approach would provide teachers with agency to pursue the commitments that are closest to their own hearts rather than having the institution impose goals for them. Designing and studying community-based approaches to supporting learning for beginning teachers across different contexts, including communities formed around shared commitments and those formed within existing structures, would paint a richer picture of the kinds of learning that might be possible for beginning teachers and how this learning can best be supported.

Another limitation of this dissertation is that classroom teaching was not a central focus of data collection and analysis, which limited the analyses of teacher learning. This limitation was a result primarily of my multiple roles as designer, facilitator, and researcher. When I visited classrooms, I tended to prioritize my roles as designer and facilitator rather than as researcher. I paid careful attention to supporting teacher learning in the classroom and to gathering information that would inform future community conversations. I did not give as much attention to the data I was collecting. My field notes were not as detailed and complete as they might have been if I had prioritized data collection. I failed to collect useful artifacts such as extensive photographs of classrooms, copies of math tasks, and examples of student work. In addition, I often met with teachers before visiting their classroom, thereby influencing the lessons teachers taught. Future research could build on the findings of learning over time offered here by collecting more robust data on classroom teaching including detailed field notes and/or video recordings of "typical" classroom lessons. This would afford conducting finer grained analyses of shifts in classroom teaching over time.

Finally, a limitation of this dissertation that I find particularly important to draw attention to, given the aim of creating communities that value each member, is the fact that the community was formed without sufficient attention to diversity across context and personal identities. As a result, there were some needs and tensions that were never taken up robustly in the community, and there were limitations in how we were able to fully recognize and support each other. For example, Marie, Kara, Selina, and Tina all taught in classrooms and schools with high populations of emergent bilingual students, whereas Maritza and Lauren did not. Issues of language came up and were discussed, but the complexity and nuances of supporting emergent bilingual students to engage productively with mathematics did not become a central focus in Math Crew, though

such a focus would likely have enriched the learning of the whole community. In addition, there were some differences in identities of the teachers that mattered for their experiences as teachers. For example, Selina and Tina taught in communities where they shared aspects of their identity with their students, with Selina having grown up speaking Spanish and Tina having grown up speaking Cantonese in the same neighborhood as her students. Kara and Marie taught predominately Spanish-speaking emergent bilingual students and are white women who grew up in monolingual households. Sometimes the participants of color brought up aspects of their identity in one-on-one conversations with me, but the ways aspects of teachers' identity (e.g. racial identification, linguistic background, socioeconomic background etc.) mediated their teaching and their learning were never discussed in community conversations. As I elaborate in the positionality section of Chapter 3, I take full responsibility for this limitation as facilitator. By not creating space for us to discuss our own identities and the ways these mediated our experiences in schools, I constrained the allowable ways of being in Math Crew, contradicting the central aim of building a community founded on care, dignity, and connection.

Future research could more fully attend to these issues of diversity in context and identity in the design of Math Crew tools and artifacts and in the data collected and analytic methods used. In terms of the design of tools and artifacts, developing protocols for sharing and discussing classroom stories that include attention to students' history in classrooms, schools, and communities as well as to teachers' personal histories would create space to take up these issues collectively. In addition, including questions in interview protocols about identity and how teachers were making sense of their positions relative to their students would provide useful data to examine an additional aspect of teachers' mediated learning. Attending to these issues in design and in data collection would then provide opportunities to analytically investigate the ways contexts and personal identities mediated teacher learning. In addition, this would enable analyses that could more fully attend to the diversity of teachers' experiences.

In this dissertation, I hope I have offered a story that highlights and elaborates the possibilities of creating robust mathematical learning spaces for children and for teachers that foster new ways of being with each other. As one approach to creating these new possibilities I proposed designing teacher learning communities from the perspective of making a new figured world grounded in care, dignity, and connection. At the same time, the limitations of this project highlight the immensity of the challenge of disrupting systems of schooling that have a deep and enduring history in the United States. I hope that the ideas and analyses offered here will spark future research that builds on these beginnings and goes further to support ambitious and equitable teacher learning that is both transformative and sustainable.

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Appendix A: Interview Protocols

Focus Group Interview
Friday, February 3, 2017; 6:30 - 7:30pm

Framing the interview:

Purposes:

- Learning about how you are experiencing our work together as supportive.
- Learning about the ways in which you do and don't feel supported in your work at school sites.
- Learn about how your experiences with these things are similar to and different from each others'.

Question prompts:

- You all must be really busy as first year teachers. **What motivated you** to decide to be part of Math Crew?
- How have the Math Crew meetings been going for you?
    - Do you think these meetings are **supporting you** in the work you are trying to do in your classroom? If so, how?
    - Are there specific things you've been taking with you from these meetings into your classroom? *Can you give an example?*
    - What could make them more useful for you?
    - If necessary: ask if it's similar or different for people who haven't done much talking.
- How have the classroom support visits been going for you? Do you think these visits are **supporting you** in the work you are trying to do in your classroom? If so, how?
- In what ways do you feel supported in the work you are trying to do in your math classroom at your school site?
    - By your colleagues and administrators?
    - By your school or district math policies and structures (curriculum, assessments, pacing guides, etc.)?
    - Maybe: Have you experienced any moments of conflict or tension between how you are thinking about math teaching and learning and how people around you are thinking about it?
    - If necessary: ask if it's similar or different for people who haven't done much talking.

Interview Protocol for Focal Teachers

For the following protocols, the first question in each bullet will be asked of all participants, subsequent questions may be asked as follow up depending on responses.

Math Teaching Practice

- How's math been going for you? How have you felt about teaching math this year relative to the other subjects you teach?
    - What have you enjoyed about teaching math this year?
- How are you feeling about your classroom math community? Looking back at the commitments and indicators we came up with in our very first math crew meeting, what are you feeling good about this year? Is there anything that has been particularly hard for you from these lists?
- If you could envision your perfect math classroom for next year, what would it be like?
- Are there any ways that you think your math teaching might have been different had you not been a part of math crew?

Participation in Math Crew

- What has it been like to be part of math crew for you this year?
    - In what ways do you think our monthly meetings have supported you in the work you are trying to do in your classroom? Can you share an example?
    - Are there specific things you've taken with you from these meetings into your classroom? If so, can you share an example?
    - If you had to name one thing that you got from math crew that made a difference for your teaching this year (if there is anything, its totally fine if there isn't), what would it be?
- How have the classroom visits been going for you?
    - Do you think these visits are supporting you in the work you are trying to do in your classroom? If so, how? Can you share an example?
- So one big point of this project was to learn about what kinds of support first year teachers need to do this kind of work and we were really making it up as we went along so we probably didn't get it just right our first time trying. If a new math crew group was starting up, are there any things we did that you think they should definitely make sure to do? Are there any things you might suggest they do differently than what we did?

School and District Context

- What are some ways you feel supported in the work you are trying to do in your math classroom at your school site?
- Do you think other people you work with understand and/or see value in what you are trying to do in your math teaching? If so, can you share an example?
- What types of support do you get from your site/district for your math teaching? Does that support feel aligned with what you are committed to? With our math crew commitments?

    - By your colleagues and administrators?
    - By your BTSA mentor?
    - By your school or district math policies and structures (curriculum, assessments, pacing guides, etc.)?
        - For Kate, I know early on you were feeling both supported and maybe a little overwhelmed by all the coaching you were getting at your school. How was that been for you?
- Have you experienced any moments of conflict or tension between how you are thinking about math teaching and learning and how people around you are thinking about it?
- If you were in charge of designing support for beginning teachers, what do you think would be most useful for teachers?

Appendix B: Coded Transcript of Selina's Dilemma

Time Stamp	Transcript	Code
[00:59:05.18]	Selina: Largely its about assessing the students. And I bring it up because it's something that was brought up as a first grade team and none of us really knew like how to answer the question. But, I don't know where to start because I have, I do have concerns about the students Angel and is another one of my boys that doesn't talk. And won't engage with a partner even if I pair him up with like the nicest kid in class and most patient kid in class and he will just like won't work with him. And he is always completely disengaged across subjects. He will be like playing with his shoe and he sits right in front of me.	
[01:00:02.16]	Selina: Yeah so him, I don't know, I mean, some strengths that I do see is that he is making an attempt at solving something you know he is using pictures, but then where I am really concerned is that like here (*showing assessment*) he got this right, but I cannot say that with 100% confidence that he didn't copy from somebody else because the same kind of problem I give to him by himself, he just struggles with it.	
[01:00:41.24]	Kara: (*looking at assessment*) seven plus four equals…	
[01:00:43.09]	Selina: (*pointing to problem*) So it is seven plus three plus four	
[01:00:47.20]	Kara: seven plus four equals three..	
[01:00:51.20]	Selina: (*pointing to work*) three plus seven plus four. I don't know. It's just his writing…	
[01:00:59.07]	Kara: Equals?	
[01:00:59.27]	Selina: two	
[01:01:00.23]	Maritza: (*looking at assessment*) Fourteen?	
[01:01:00.23]	Selina: Fourteen.	
[01:01:03.05]	Selina: seven plus four plus three.	
[01:01:05.08]	Mallika: So he had how many circles are drawn there?	
[01:01:08.02]	Selina: Well he also has 10s, he has 40. So it's a lot of writing and often times he doesn't count them all. I don't know (*turning to another problem*) but I mean here he knows, at least his tens is in the right place. 62, it's 68. He has 6 for 60.	Pointing out math
[01:01:40.11]	Kara: But then, its hard to tell what he was counting for the ones place.	
[01:01:43.03]	Selina: He recognized the need for a nine. Like the four and the five. That's 24 + 5. So he saw the nine, somewhere it came from somewhere.	Pointing out math
[01:01:53.07]	Mallika: And he is trying to use the representations that you guys were using, right? He is using number bonds and tens.	Pointing out math
[01:02:01.01]	Selina: Yeah he is really trying. But his thinking is like all	

	over the place. And even with basic math facts he struggles, like five plus two. So I don't know.	
[01:02:19.22]	Selina: My concern with him is just like his own work, he never shares, I really don't think he feels confident in math, but then I can't say for sure because he just doesn't express that, anything. He is just like sitting there playing with something or he won't like talk with a partner, he would just sit.	
[01:02:47.22]	Selina: But there was that one time where he was, they were doing comparisons, he was saying something about the 30 and 40, and trying to compare those so there were pockets here and there.	
[01:03:01.25]	Mallika: Do you have that sense of like when those pockets are there or like anything?	
[01:03:08.02]	Selina: It's just very hard for me. To zone in, like if you weren't there to document that, I wouldn't have known. So it is really hard for me to really figure out like okay what does he know really really well that I can like build upon and reference.	
[01:03:32.25]	Mallika: I mean I think there is also that like, and so much, sometimes I really feel like just it's so hard to get kids to show what they know like I don't, I don't necessarily, like I feel like he is trying a lot of stuff there so there is a lot that is going on. But, yeah like, even if you, like it's really hard to know in that situation where kids don't feel	Sensible reasons for behavior
[01:04:01.16]	Selina: And to him that makes sense.	
[01:04:03.09]	Mallika: Like if he, does, will he explain?	
[01:04:06.25]	Selina: He will just be like [shrug shoulders]. Kind of like, Alexis but more like, 'I don't know.'	
[01:04:16.17]	Mallika: But sometimes.	
[01:04:17.24]	Selina: I have had them like double check, triple check, because alot my kids mess up, because they are just not paying attention to what they are doing. So I need to tell them, 'okay, check it again.' And that's when they will be like 'oh yeah no.' So thats when I am like, 'check your work and your answer, make sure it says what you want it to say.' And he didn't make any changes, so to him that made sense. But then if I ask him, 'okay what did you do? or what happened here.'	
[01:04:47.09]	Kara: I feel like I have kids who I tell to like double check, when I think they are missing something that I think they could figure out and they say like yeah it's fine, but, don't, it doesn't actually make sense to them.	
[01:05:04.12]	Kara: They are kinda like taking a stab in the dark and trying things, but not really feeling confident with there first try. So looking over again is kind of like staring from scratch. Just like 'well I thought I understood this, but maybe that's wrong,	Sensible reasons

	but I don't want to try again because it's hard and stressful.' And I think especially with this where you are not allowed to help them, like I can't go through one problem at a time because there are so many.	
[01:05:30.07]	Selina: Well I mean these I gave in small groups. So he was like in a group of 4 or 5, because, yeah no, it would be a lot worse if I just give it everyone and say, 'here go.' Because a lot of the things with it is reading, my kids aren't reading fluently yet.	Unpack task
[01:05:49.01]	Kara: That's crazy that's first grade. That's such a long test. Ours are yeah, like five pages long and both sides. My goodness like yeah fat word problems like it's a chunk of four lines of text for each problem. You can't do out without being a fluent reader.	Unpack task
[01:06:13.23]	Kara: 'Show your work showing picture, diagrams or words.' and then a space. Because we took all the space of the page with our writing.	
[01:06:23.17]	Mallika: So yeah I am guessing that the issue of like, I guess maybe I am hearing two issues, you brought up, there is the assessments and the fact that they have to take this thing that really doesn't, maybe feel appropriate for them sometimes. Then there is also this just not sure Selina: how to support him	
[01:06:45.09]	Selina: He is one of my kids, with everyone else I can kind of pinpoint what their needs are and where I can support, here I don't know what it is that he needs from me.	
[01:07:04.19]	Mallika: Do other people have students like that? Or suggest ideas about what to do?	
[01:07:19.09]	Kara: I think its hard with first grade, because like the big math concepts seem so large. Like by third grade, they umm, I guess when some of the refinement of skills isn't there, it's like 'oh they are missing this basic thing and that's what I need to go back to,' but with this it's like all the basics are like swirling around.	Unpack task
[01:07:41.27]	Kara: I can, I mean, maybe just with some of the place value stuff it seems like they just, the one that stood out to me '24+9', I mean '24 + 5' and he had 90 and just you know like going back to, '4+5 and what's that?' and then/or like '20+5' just like breaking it up so there's not so much going on in one. Making sure he has some concept of 1's versus 10's, and doing that with like place value blocks.	
[01:08:19.12]	Selina: Yeah he doesn't have concepts of ones and tens. I showed him a two digit number and I asked, 'what is this digit mean.' For example, I gave him 16, 'what does the one mean?' He says, 'one.'	
[01:08:36.09]	Mallika: It's really hard.	

	Selina: It’s really hard.	
[01:08:41.07]	Maritza: How does he do with like manipulatives?	
[01:08:50.29]	Selina: He will gravitate towards the cubes, sometimes it helps him, sometimes he has a hard time keeping track of what he has in front of him. Like if it's like counting on or just sometimes he'll like count way more than he needs.	
[01:09:23.01]	Mallika: Yeah, I mean I wonder, sometimes I think, and I had a student like this in sixth grade, which in some cases felt like a lot, and umm, where like the kids just think that math is like some random stuff you write on a page, and totally [unintelligible], like he is writing some stuff down, and it's like the same kind of stuff he is seeing, but it doesn't actually connect to like	Sensible reasons
[01:09:45.14]	Mallika: You know sometimes I think kids learn in school that like you just write some stuff down, but not actually related to anything, it's just like scratches and circles, and symbols. So I wonder, but I think that, those kids do have ways of making sense of the world. Like math is a thing that people use and do stuff with, and kids do count in life you know, outside of math class, but like I wonder, this experience that I am thinking about, they really just like that is not suppose to make sense, it's just some random stuff, put down on a paper.	Sensible reasons
[01:10:23.18]	Mallika: So I wonder about like, patterns, have you tried doing silent math or some kind of thing with him? And like doing, I don't know, I wonder if like, or maybe, like things where focuses not even on like writing stuff down, but like making sense of like the situation. Modeling or acting it out, or like I wonder umm, like is there some sense for him somewhere that is maybe not yet connected to like what goes on the paper, and how to find like the place of sense for him.	
[01:11:03.04]	Mallika: I don't know, or maybe, that there is some sense that we just don't know what it is, that we can't figure it out, but maybe he just doesn't have the language to explain it. But, yeah, have you, do you have a sense of if he gravitates towards patterns, or like [crosstalk].	
[01:11:20.07]	Selina: I feel like he has come up during silent math because he is like figured something out, even then he still not 100% certain. But, I am trying to think, I think there might have been one time where he figured out the pattern, and he wanted to keep coming back. Or the first time like got it wrong but he came back and tried it again.	
[01:11:45.21]	Mallika: The kid that I am thinking about in sixth grade, like silent math, became, he would just do the same kind of patterns a lot. You know bigger numbers, but that became, like that's the way, is how he felt number sense. Because, I think it was like a moment where he was finally like 'oh like	

	things are suppose to be predictable? Like there's supposed, there some sort of order to this, it not just like this random thing.' So you know.	
[01:12:10.18]	Mallika: I am wondering, what's the way in for him, of like something that is stable and makes sense and it's not just random crap that's floating around. Because it feels like a legitimate position, like you know in first grade there's so much stuff going on.	Sensible reasons
[01:12:23.12]	Selina: He's like looking for something predictable like 24+5 [Mallika: right, right] he gravitated to that 4 and the 5 and that's 9. 'And I am like I am just going to put a 9 somewhere. Because there is suppose to be a 9 here.'	Point out math
[01:12:39.04]	Kara: Yeah I mean I just feel like on his page he is doing so much. Mallika: right, right Kara: Like this is a lot of work. I don't know if this equals 40. But just like with this one (*pointing to work*) Like I don't know how he got it or what he was trying to do. This has 26 circles, and his answer here is 26. This is umm unrelated.	Point out math
[01:13:03.13]	Selina: The tens are, there are nine tens. I am guessing pertains to that nine.	Point out math
[01:13:09.12]	Mallika: I mean I am wondering if he was adding 9 to 26, I mean 9 and 16 and just was just off one, you know Kara: right, right. Mallika: It feels kinda like a sensible.	Point out math
[01:13:18.17]	Kara: 9 circles [unintelligible] It's really hard though, like I feel like this math is really conceptual. [Mallika: it is]. Like 9+ blank equals 16. That is not like super automatic for me. You know it's not like ' oh of course.'	Unpack task
[01:13:45.12]	Selina: One you have to know if you are adding or subtracting, and two you got to cross the ten. And a lot of my kids are still adding, so a lot of them added 9 tens.	Unpack task
[01:13:55.14]	Mallika: And just even knowing that question, we are still like 'what is that problem about.'	Unpack task
[01:13:59.10]	Kara: Yeah, we had one of those where it was like, k+200 = 392. And like yeah, I mean my kids got it, but like I remember first looking at it and being like, 'huh. That is like tricky to explain.' [crosstalk] Like just the conceptual it, like they could get there, but it was still like 'what is k.' Like those variables are just so random. It's just a random letter that means question mark. That means you figure out what needs to go there.	Unpack task
[01:14:33.14]	Selina: That means box. [Kara: yeah that means box]. Yeah it just gets worst because I mean this question is uhh what's his name had six cars, his mom gave him some more, on his	Unpack task

	birthday, and you know he has 16 cars. How many cars did his mom give him. And there is a bunch of information that you don't need in there. You could just say like, ' Aaron had six cars. his mom gave him fours. How many cars does he have now?' It's like no, 'he likes to collect cars. and he had six'	
[01:15:04.25]	Kara: It's his birthday so his mom gave him more	
[01:15:07.15]	Selina: And it's like why are you doing this, and a lot of my kids see text and they are focused on reading it and a lot of them are still decoding. So even though I read it to them, they will go back and read it themselves. And use up all that energy to like read that small piece. And it's like who is making these tests.	
[01:15:35.23]	Kara: Of course, cus that doesn't stay in your head. They are so evil.	Sensible reasons
[01:15:39.03]	Mallika: I think he is doing alot though. Like that feels really clear. He is not, not, he is like not checking out and the stuff he is doing is connected to what you've been doing in class.	
[01:15:48.09]	Tina: You can tell he was trying to count them [pointing to paper and dots on circles]	Point out math
[01:15:51.05]	Kara: oh yeah the pencil marks too, he is counting them off after. And then draw them.	Point out math
[01:15:58.14]	Selina: Yeah and on paper when you see them, and when he is on his white board. He is doing a lot, but then throughout the rest of the lesson [body language] 'what are you doing!?Look up here'	
[01:16:10.08]	Mallika: Yeah I mean, I can also like relate to that. Like if it feels like random marks, it's hard to pay attention to that. I would be like, I would way rather be pretending to tie my shoe, because she's writing random things.	Sensible reasons
[01:16:28.18]	Selina: There is no way your shoe can be untied for the fifth time. In the last ten minutes.	
[01:16:35.02]	Mallika: Even at the beginning of the course, like some people were like choosing to move there car during math time, every time and I found something, like I told the whole class, ' can you just not, math time that I want to hold. I literally said it that way because, I feel like, some people are like, they wanna be checked out, like what is it that they don't want to be present for this? Like 'I actually don't want to do the math because I don't feel like I know what is going on.' So I feel like there are alot of things and, I don't know, in first grade it's like looking at your shoelace.	Sensible reasons
[01:17:05.28]	Selina: or going to the bathroom	
[01:17:07.14]	Mallika: Right, right, but yeah, there are those kids who are like, you know this doesn't feel good, so like, how can I	Sensible reasons

	escape it. But I do feel like so much goes by so quickly in elementary school math and you know for first graders, there is alot going on, for every grade, but umm so like ways to umm, something like the silent math or number talk or some sort of way to hold something that is stable for them that they can you know, like even if that looked really similar for a while, you know, it would be interesting to see if participation change at all, or like, umm yeah, because I think it can feel like everyday is like a new, right? new things.	
[01:17:51.20]	Selina: I feel like I can imagine just seeing a bunch of words, which he is not one of my strongest readers, and at first like we figured, part of the problem, 'you need to wear your glasses.' So he has them now, but it's still lots of [unintelligible] squiggly lines that he suppose to makes sense of he is like 'I da know' [Selina shrugs shoulders]. So I'll try see silent math and do more things with patterns.	
[01:18:17.29]	Mallika: Yeah to see maybe and like the same kind of things, you know patterns like multiple chances to see and like those kinds of patterns I think can really help kids who, if that is, I mean I don't know, that's the thing if he's, the thing is like math is some random, that it doesn't make sense. I think patterns can relate to kids a bit more. I don't know, does anyone have any other ideas?	
[01:18:40.20]	Kara: I mean it just like with his, figuring out with him, do you understand like correspondence between like the number and it's numerical and whatever symbols that you were doing, it seems like that is not quite matching, so it's like 6, the number 6, and then 6 circles and it's just like he is getting confused with what symbols to use and lines for ten and maybe just like some chart for him where it's like one, and circle and two and two circles, and going up like tens, the line, however, you would like to put it and show it just so it's like consistent because it seems like he doesn't have a system, to fall back on that makes sense for him, and it's actually rounded, and like the numbers.	
[01:19:32.25]	Selina: And that makes me think of like he was drawing on his white board and I could see that he didn't understand something,] like that ten, and he would like go and draw all those as circles, and of course [unintelligible]	
[01:19:53.20]	Mallika: Yeah it's really abstract. A line being worth ten, I mean when we were doing planet pent this year like people had there five little tiles and then pushed them together and they were like so it that still a pent? And if we move it apart, and they were like is that pent? And I am like yeah it's still a pent, and like you know it's like the line is more abstract. it's really abstract.	Unpack task

[01:20:19.02]	Kara: Just standing in for that rod, it's like it's a place value cubes. But I think like having that chart or like just some graphic thing for him to like refer to, it's like this is this. And this is what I would put on in my page, and whatever it is that makes it feel like reason, to what he is drawing.	Unpack task
[01:20:39.01]	Mallika: And I feel like every [unintelligible] like of your first graders students can benefit with the same kind of things.	
[01:20:45.28]	Kara: Right.	
[01:20:47.12]	As it is, they **just** learned that those symbols mean numbers. Now they're having to learn that they also mean dots and lines. and that line, that's I. which also can be L…and also one and sometimes, it's 10	Unpack task
[01:21:10.00]	Mallika: When you think enough about it, it's like a miracle that anyone ever figures anything out. What?!?" Maritza: Totally	
[01:21:14.09]	Selina: (*draws a vertical line in the air)* What does **this** mean? "**1**", "**L**", "**A 10**?"	
[01:21:18.23]	Kara: Yeah that is so true. This totally means 1 or ten (*points to assessment*)	Unpack task
[01:21:23.26]	Selina: Yeah or an L.	
[01:21:26.23]	Kara: Or L or I. But really a one or ten. Like that's so messed up, Like sometimes, **this** totally mean ones."	Unpack task
[01:21:33.17]	Selina: If your doing tally marks.	
[01:21:39.20]	Kara: Yeah that's table points. This is five this is a fifty	
[01:21:52.12]	Maritza: No I think it is very confusing that like they literally, I like multiple methods, I think that's great, but I find it frustrating when you are forced to teach like a whole lesson is about a method, and if that method isn't making sense to them you're totally confusing them on something that maybe they thought they understood, and for that whole lesson they are like, 'I thought I understood but clearly I don't understand.'	
[01:22:19.17]	Kara: I started to do that today with like fractions in a number line, because we have just been doing like the fraction kits and they are like loving it. The fraction cubes, and it's like super visual, and you can do it on a number line. And they were just like 'what!? what is this? This makes zero sense. ' And I just, yeah I tried to do it for like ten minutes and I was like, 'let's go back to the fun stuff.'	
[01:22:43.18]	Selina: Part of the, one of the days, [unintelligible] add one to one with tens, and some kids were like it clicked for them and other were like shaking there head. I was like you know forget it. No we are not going to do this, because you could see its just torture for them. Yeah sometimes I really don't know what's harder, teaching first grade or being in first grade. I really don't know. Literally they ask so much of like these tiny humans	

[01:23:20.13]	Kara: I feel that too with my kids like it's, like everything they have to do is hard, and every single one of them is an English language learner. Like that's a huge cognitive burden to come to school and listen to instructions, sit and listen, sit and listen, and produce.	Unpack task
[01:23:37.00]	Selina : I am just glad. We talked about this, wants our final reading assessment to be like a written thing and I am like 'no first graders have so much trouble in coding . Whatever they try to do flies out the window.' This why when I was giving this and I saw, him using the number chart to count on and then they wrote the answer, and I was like 'okay, but you need to show something to support what you did.' And they all immediately gravitated towards drawings because that is a lot easier, to then, but like, 'I know you didn't solve it with a drawing, you counted on and I could see you.' But they are not going to write, 'I counted off like blah blah blah blah blah	
[01:24:20.09]	Kara: Writing in math is super hard for them.	

*Note: The conversation continued for 5 more minutes but switched topics away from Antonio's assessment and to the topic of assessment more generally. For this reason I did not code the last part of the conversation.

Appendix C: Barriers to Equity-oriented Learning

The learning described so far in this dissertation was typical of the learning of five of the six Math Crew participants. Marie's experience differed substantively from the experiences of other participants and provides a window into some of the barriers faced by beginning teachers hoping to take up ambitious and equitable mathematics teaching. Marie chose to be part of the Math Crew learning community, indicating that she shared the same commitments as the other participants. She participated actively in the conversations and activities when she attended community meetings. However, over the course of the school year her attendance in Math Crew meetings and participation in classroom visits declined, and her classroom teaching took a different direction from the other five participants. In this appendix I look more closely at Marie's participation in Math Crew and at the ways her context differed from that of other participants' to analyze the barriers she experienced and to consider what conditions might be necessary to support robust equity-oriented learning for beginning teachers. In future research and writing, I intend to analyze Marie's case in greater depth as her experiences raise interesting questions about supporting teacher learning.

Participation in Community Meetings

Marie attended six of the nine Math Crew community meetings over the course of the school year. She attended regularly through February, missing only the meeting in December, which had been rescheduled for a Sunday morning instead of the usual Friday evening and was attended by only three participants. She missed two of the final three meetings, texting an hour before the last meeting of the year to say she was overbooked and couldn't make it. She was the only participant who did not attend the Math Crew reunion meeting held during the 2017-2018 school year. She emailed the group an hour before the reunion to say she would not be able to be there. When Marie attended community meetings she shared her ideas and actively engaged with other's ideas. At our first meeting in September, she suggested starting a routine of one person sharing a positive story about their classroom community each month. This was a routine we began at the next meeting and kept throughout the school year. Marie shared a positive story from her classroom at the January Math Crew meeting. She was invited to share a dilemma from her classroom for the March community meeting but declined my invitation, responding, "I don't have anything specific in mind right now." Marie was the only participant to miss the final Math Crew meeting and she was the only participant to miss three meetings over the course of the school year. Her inconsistent attendance, especially during phase 2 of the Math Crew meetings, meant that she had fewer opportunities to engage in the deeper relational investigations of teaching and learning that became typical during community meetings.

Participation in Classroom Visits

I visited Marie's classroom four times over the course of the school year, in September, October, January, and April. She met with me before the October visit to talk about the lesson she would be teaching. When I emailed her to schedule the next visit, she asked to reschedule a couple of times and then sent me an email requesting to opt out of the classroom visits, writing,

> I still want to participate in Math Crew, but I'm hoping to take a break from classroom visits. It has nothing to do with you (you must believe this!!), and everything to do with me feeling overburdened with so many meetings, observations, and PD's already, that fitting more into my schedule feels like too far a personal stretch. This is not to say that I will not be ready for coordinating visits at a later date, but right now I feel the need to let go of some things to open up some "breathing" space for my practice and my classroom. I hope that makes sense.
>
> I would still like to attend Math Crew, if it's okay with you. Would this be okay, for now? I don't want to negatively impact your dissertation research, but I need to make some personal choices to keep my sanity and energy focused in a positive way as we start the new year. Let me know what you think.
>
> Marie, Email communication, 12/29/16

I wrote back to her, acknowledging her overwhelm, appreciating her honesty, and suggesting some different ways we could do classroom visits that might feel less overwhelming to her. I let her know that we didn't need to meet beforehand and reminded her that the purpose of Math Crew was to be supportive for her and not an added burden. I told her that I would like to still stay connected to her students and to what was going on in her classroom and wondered if it would work for her if I just visited and noted student and teacher strengths. She responded by writing, "Okay, that feels much better to me! Let's do a student/teacher strengths visit first, maybe Thursday, 1/12? Thanks for your flexibility, Mallika. It means so much to me." (email communication, 12/29/16). For the January visit and the April visit, we did not meet beforehand or discuss the lesson afterwards. I emailed her after my observation using the same format I used for my follow up emails to all participants, writing some specific student mathematical strengths I had noticed, naming some actions she had taken to make space for those strengths, and suggesting some ideas for how she might build on those strengths.

Given Marie's limited participation in classroom visits, she did not have the same opportunities to engage in relational investigations of teaching and learning in her classroom as did other participants. Lauren, Maritza, Selina, and Tina all opted to continue meeting with me before classroom visits even when I told them that it was up to them and they could choose whether or not that would be helpful for them. Kara opted not to meet beforehand and instead chose to spend time debriefing informally with me after each observation. These one-on-one conversations created many opportunities for us to think together about the problems of practice that were most pressing for them, to discuss individual students' mathematical experiences, and to brainstorm how teachers might work on the issues they cared about in their classroom communities. With Marie, I did not have these same opportunities, and I was much less clear about what problems of practice she wanted to work on in her classroom, what she was learning about her students' mathematical experiences, and what kind of support she might need. Marie's declining participation and her reduced opportunities for learning in Math Crew were not a function of Marie's lack of dedication, but instead were deeply intertwined with the specifics of her setting, described in the next section.

Marie's Classroom and School Contexts

Marie's school context was quite different from the other participants in several ways that seem consequential for her participation in Math Crew. She was the only participant teaching at a charter school (Rise Up Charter School). At Rise Up, teachers had weekly professional development time and, according to Marie, they spent most of this time looking at student achievement data (as measured by assessments administered by teachers on a regular basis) and discussing how to improve the data. Marie frequently used the word "urgency" in talking about how her colleagues talked about data and student achievement. For example, in the focus group interview in February she commented, "I feel this incredible sense of urgency from admin, and I feel it too. I mean I know my kids are well below grade level, most of them. And so having that pressure to get your kids up to grade level, improve your data, does make it difficult." Marie brought up this issue multiple times during the school year and she seemed to experience a sense of pressure from administrators and colleagues much more consistently than other Math Crew teachers.

Rise Up had recently received some grant money to work on "personalized learning" for students. The way the school chose to take up personalized learning was to place students in small groups with the intention of "meeting students' individual needs." This took different forms depending on the content area. In mathematics, Marie was strongly encouraged to break her class of 24 first graders into smaller groups so that she could work more intensively with students. In addition, the school used an online individual mathematics program where students would move through different levels of skills and concepts. Teachers were expected to include this program as part of their math instruction. Teachers at Rise Up had recently chosen to switch their math curriculum to TERC Investigations because they thought it offered a strong conceptual foundation and included engaging activities. TERC includes a "math workshop" model where students often have some choice about what they work on, and may return to games or other activities that had been previously introduced. Marie mentioned often in Math Crew how much she liked this curriculum.

Rise Up provided beginning teachers with substantial amounts of classroom coaching. Marie had a literacy coach, an induction mentor, and an involved principal who all visited her classroom regularly and met with her to debrief observations. She reported that she found her induction mentor to be very supportive and helpful. She also reported that she found visits from the literacy coach and her principal to be more stressful as they tended to focus on what was not working and what she was not doing well. Marie was the only Math Crew participant to have so many people regularly observing her instruction. All Math Crew participants had induction mentors who observed them occasionally as this is part of the standard beginning teacher induction program in California (BTSA), but no other participants had additional coaches visiting their classrooms and most received very few visits from administrators. In her closing interview Marie talked about how hard and overwhelming it was for her to have so many people in her classroom, and connected this to her limited participation in Math Crew, saying,

> "I am an intense introvert and this year has been really hard for me, particularly because…I've had to do a lot of different types of interactions with coaches, and principals, and other teachers, and I tend to do a lot of reflection anyway. And for

> me, I guess, having to do a lot of shared reflections and talking with so many different people about what I was thinking about before the lesson, what happened during the lesson, what happened after, what I want to work on, um, I don't know, I don't want to sound ungrateful, but its been a lot for me. And it's been overstimulation. And I think that's where, for me, I wanted to be more involved with Math Crew and with you, but I was just like at this point where I just needed me time and I just needed to set some boundaries because it was overtaking my life. And it was making me miserable…So I feel like I needed to make changes to my life and to say no where I needed to."
>
> Marie, Closing Interview, 5/31/17

Marie's Learning Over Time

In my observations in her classroom over the course of the year, it was evident that Marie learned to implement many new teaching practices. Most of these practices were not well aligned with the Math Crew shared vision of building a math community where every student meaningfully contributes to the mathematical work of the classroom. In particular, Marie worked hard to figure out how to implement a small group model of instruction in her classroom and much of the change in teaching I observed was related to how to manage this structure. In my first observation in Marie's classroom, in September, she started the lesson with a routine on the carpet where students shared different ways to make the number 13. Students then worked on a word problem from the Investigations curriculum. They could choose who to work with and where in the room to work. When students finished they could choose a game from the curriculum to play with a partner. By my next observation in October, Marie had begun splitting her class of 24 students into two groups of twelve. One group worked on the online math program on computers while the other group worked with her on the carpet on the math lesson for the day. After 25 minutes, the two groups switched. At the end of class, she facilitated a short math discussion on the carpet. In January, Marie split her class into 3 groups of eight students, a structure she kept for the rest of the year. For each math period, the three small groups would move through three different 12-minute rotations; meeting with Marie on the carpet for a lesson, working independently on the online math program, and playing math games with a partner. During my observations, the remainder of class time was spent giving instructions for how to rotate through the stations and facilitating a short whole class math activity such as locating numbers on a hundreds chart. This type of small group structure is not easy to implement with first-graders as it requires students to be relatively independent. When I observed in January and in April, Marie spent quite a bit of time reminding students about how to do the rotations and then giving them feedback on their behavior at the end of the lesson. This structure did not provide Marie with much time to observe and listen to students as they worked on mathematics. She was responsible for introducing and monitoring the math activity for the day with each small group in only 12 minutes. In practice, this meant that most of that time was spent giving directions and then making sure students followed them.

Marie learned a lot about how to implement and monitor small group rotations with first-graders. She got better at this practice over time, spending less time on directions, and using her time more efficiently with her small group. Students learned how to follow these rotations independently. They knew where to go at what time and

they knew what they were supposed to do during each rotation. In terms of the Rise Up push toward "personalized learning" as they defined it, this structure was sensible in that it allowed time each day for students to work on the online program and it gave Marie time to work with a smaller group of students for math lessons. However, this structure allowed very little time for Marie to listen to students' mathematical thinking, to support students to talk to each other about mathematics, and to more deeply investigate students' mathematical experiences.

Marie was aware that she had participated less in Math Crew and gotten less out of it than other participants, and we discussed this in her closing interview. I asked all participants to share an example of how being part of Math Crew had impacted their classroom teaching. Kara, Maritza, Selina, Tina, and Lauren all answered this question quickly and with multiple examples. Marie paused for a long time and then said, "Hmm, I'm having a hard time thinking of one. Can I keep thinking and come back to it?" Later in the interview, she eventually thought of a writing prompt she had given her students after hearing Tina share about a writing prompt during the discussion of her dilemma about Albert. Toward the end of the interview, I asked her if she had anything more to add and she said, "I appreciated being part of Math Crew this year. I just wish I could have had more time to give to it. I feel like I could have engaged a lot more and used a lot more. And I just couldn't. I just wasn't in the space to do it and that's a bummer but it is what it is."

Barriers to Marie's Learning

In my closing interview with Marie, in response to her comments such as the one above about her experience of feeling overwhelmed and not being able to participate in the ways she wanted in Math Crew, I asked her if she had any thoughts about what might have supported her to stay more connected. She responded,

> "I'm not sure. I don't know, it's tricky. I feel like I respond well when I have the opportunity to opt in to something. And I wanted to, like in my heart, opt in to Math Crew. But it felt like, all of my other obligations related to school were mandatory, even if they weren't… even if I really wasn't getting that much out of it. And even if it was like one of those 'grin and bear it' for the next two hours. So, I guess I just would like to see a little more flexibility for teachers and more opportunities, like we talk about giving our students, for choice around teacher development that can align with our interests and our pedagogy too. So I feel like if I had had a little more flexibility and choice I would have redistributed my energy."
>
> Marie, Closing Interview, 5/31/17

Marie's experience and reflections are particularly interesting given the fact that she had the most "support" of the beginning teachers in Math Crew. She received regular visits from multiple veteran teachers who were all tasked with supporting her to improve her instruction. Yet one result of the support Marie received was that she spent a lot of her energy trying to preform appropriately for these different observers. She did not seem to feel nearly as much freedom to take risks in her classroom as other participants, to try practices that might differ from what was typical in her school community. Her

reflections on the support she received suggest that she experienced much of it as surveillance of her teaching rather than as support for her learning.

The constant presence of observers was also complicated by the fact that in many ways Marie's school activity system differed from the Math Crew activity system most dramatically of all participants. The heavy focus on assessment data and personalized learning at Rise Up contradicted the shared commitment in Math Crew of creating more equitable classroom communities by placing an emphasis on individual performance rather than on the classroom learning ecology. Marie brought up the tensions she felt with respect to her school context in Math Crew but the tensions she experienced were often different from other participants and did not get taken up robustly in community conversations. Marie's case raises questions about how we might support beginning teachers to improve their practice while also allowing them the space to try new practices that align with their commitments. In addition, Marie's story reinforces the importance of considering what it might look like to support equity-oriented teacher learning across different contexts where teachers and administrators might be operating from different assumptions about equity, mathematics, and learning.

Summary

The purpose of this appendix was to add some complexity to the picture of teacher learning offered in the body of the dissertation. Though all Math Crew participants learned to collectively engage in relational investigations of teaching in community conversations, Marie did not take up relational investigation in her classroom teaching in the same ways as other participants. Marie's experiences in Math Crew and in her classroom and school shed light on some of the conditions that may be necessary to support robust equity-oriented learning for beginning teachers and on the possible barriers they may face to engaging deeply in this work. Her story suggests that making space to take risks in one's teaching may be an important aspect of supporting learning for beginning teachers. While it seems sensible that the more support we offer beginning teachers, the better, we may also need to consider whether that support leaves teachers space to try and to sometimes fail. As anyone who has ever taught children can attest, failing (and sometimes failing spectacularly) is a necessary part of improving teaching practice, especially when working toward a vision of teaching that is not yet widely held. In addition, Marie's case highlights the potential intellectual and emotional toll of constant evaluation. Marie was not able to opt into Math Crew in the ways she wanted to "in [her] heart" because she was so overwhelmed by all she was being asked to do at her school setting. I recently learned that Marie is the only participant who is no longer working as a classroom teacher. She chose to leave the classroom after her second year and the emotional demands and pressures of her job were a central factor in her decision. Marie's experience troubles and deepens the stories of learning offered in this dissertation, raising important questions for future research about supporting equity-oriented teacher learning across settings.