

Running head: Districts' implementations of CMP

Linking policy, resources, and teachers' use of NSF-funded curriculum materials: Two districts' implementations of CMP

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Abstract

This study focuses on districts' policy actions, the development of social resources, and resulting teacher perceptions and actions around the implementation of a middle school mathematics reform curriculum. In particular, the study builds from prior research that suggests that resources associated with the use of such curricula need to be located in close proximity to teachers, especially those who are novices. The study employs a social capital perspective which considers the structure of teachers' networks, the resources that exist in those networks, and how teachers access those resources. The study applies the policy attribute theory articulated by Desimone et al. (2007) to consider the impact of specific characteristics of policy. The study focuses on two districts chosen because of their long-term use of CMP, the substantial material resources expended in relation to the CMP implementation, and their access to high-quality CMP-specific professional development. There was considerable variation within each district but systematic differences across the districts in terms of authority, explicit consideration of how leadership and expertise was located within grade-level planning teams, and teacher perceptions' of efficacy and teachers' reported adaptations of the curriculum. The results raise questions about aspects of teachers' practices that are within the purview of policy. The first is whether policy can mandate the kind of intellectually challenging practices associated with teaching for understanding. The second is whether scale becomes an impediment to the development of strategically located social resources.

### Introduction

A number of districts have adopted one of the mathematics curricula developed through funding from the National Science Foundation (NSF) as a means to transform their mathematics instruction (Ball & Cohen, 1996; Remillard, 2005). These curricula are designed to be comprehensive and coherent, develop mathematical ideas in depth, promote sense making, and engage students through the use of meaningful contexts and applications (Trafton, Reys, & Wasman, 2001). There is widespread recognition that adopting instructional practices associated with these programs involves a steep learning curve for teachers (Cohen & Barnes, 1993; Heaton, 2000; Remillard, 2000; Schifter, 1998), requiring substantive investments from schools and districts in order to develop the necessary leadership and expertise.

Districts that mandate the use of particular curriculum materials with the goal of transforming instruction face two longstanding challenges related to school reform. First, reforms typically only impact superficial aspects of instruction and rarely reach the core of classroom practices (Elmore, 1996). Second, enacting reforms that reach classroom practice at scale has proven to be a daunting challenge (Coburn, 2003; Elmore). These two challenges are associated with two characteristics of districts' resources and policy actions. First, districts that have successfully transformed their human resources – such as teachers knowledgeable and experienced with an innovation – have developed considerable social resources such as capable and distributed leadership (Gamoran et al., 2003; Spillane, Halverson, & Diamond, 2001) and communities of teachers that inquire into student thinking (Carpenter et al., 2004). Second, districts often impede specific initiatives through policy actions that fragment teachers' attentions and strain the

available resources (Berends et al., 2002). Kennedy (2005), for example, documented on average of twenty intentions teachers attributed to their actions in classroom episodes, intentions that often were directly related to multiple ongoing reform efforts in the teachers' schools or districts.

Therefore, districts' resource allocations, such as providing curriculum materials and access to curriculum-specific professional development, are insufficient by themselves to transform classroom practices (Coburn & Russell, 2007; Confrey et al., 2008; Penuel, Riel, Krause, & Frank, in press). The material allocations must impact the development of social resources in order create generative and sustainable communities of teachers focused on teaching for understanding (Carpenter et al., 2004; Gamoran et al., 2003). Consequently, district policy actions must be carefully analyzed for the ways they facilitate the development of social resources, how they focus teachers' attention, and the extent to which they focus resources on a specific initiative over time.

This study focuses on districts' policy actions, the development of social resources, and resulting teacher perceptions and actions around the implementation of one of the NSF-funded middle school curricula, the Connected Mathematics Project (CMP) (Lappan et al., 1998). In particular, the study builds from prior research that suggests that resources associated with the use of such curricula need to be located in close proximity to teachers, especially those who are novices with respect to the use of the curriculum, in terms of physical location and experienced leadership in whom they trust (Coburn & Russell, 2007; Penuel et al., in press).

The study employs a social capital perspective with the goal of linking district policy actions with teacher practices related to the use of the CMP materials. A focus on

social capital specifically considers the nature of teachers' networks, the resources that exist in those networks, and how teachers access those resources. The study framework further incorporates the specific policy attribute theory articulated by Desimone, Smith and Phillips (2007) to consider the impact of specific characteristics of policy both on the formation of social capital and directly on teachers' practices in relation to the use of CMP.

The study primarily focuses on two districts that are part of a larger study of six districts that have implemented CMP. The six districts were chosen because of their long-term use of CMP, the substantial material resources expended in relation to the CMP implementation, and their access to high-quality CMP-specific professional development. The two districts that serve as the primary focus of this study were chosen because the data collection was the most extensive among the six districts.

### **Conceptual / Theoretical framework**

Schools as organizations have proven to be difficult to study in terms of understanding how policy and resource expenditures impact classroom practice. In part, this is because schools, as organizations, can be characterized as much by their informal networks as they can by their formal organizational structures (Brown & Duguid, 2000), suggesting that top-down decision-making models do not accurately describe schools nor do they function well in terms of designing policy. Non-canonical aspects of school practices, for example, have been described in terms of distributed cognition in which leadership is defined across people, situation, and artifacts, rather than focused on the actions of a principal or other singular leader (Spillane et al., 2001). Social capital theory can provide insights into the ways formal and informal networks in schools access and

share resources that are designed to support an innovation. For districts that are planning to allocate substantive material resources with the goal of transforming their mathematics programs, it is important to understand the nature of teachers' networks and how resources get distributed and shared across those networks.

Social capital theory suggests that resources and expertise are embedded in social networks and it is through social networks that one gains access to resources (Portes, 1998). Nahapiet & Ghoshal (1998), for example, define social capital as "the sum of actual and potential resources embedded in, available through, and derived from a network of relationships possessed by an individual or social unit" (p. 243). They state that the "central premise of social capital theory is that networks of relationships constitute a valuable resource for the conduct of social affairs" (p. 243). Social capital can thus facilitate access to or the development of other forms of capital, such as human capital and material resources.

Bourdieu (1986) introduced the contemporary analysis of social capital in part to distinguish it from other forms of capital discussed by classical economists and to provide critical social analyses about the nature of resources that are not so visible or measurable but have consequences for individuals' economic opportunities. Bourdieu decomposed capital into two elements, the social relations by which individuals accessed resources possessed by their associates and the resources themselves (Portes, 1998). Sociologists have applied Bourdieu's notion of social capital to collective entities.

Social capital theory as applied to collectives has been used to study the dissemination of innovations and the flow of information in businesses, though recently it has been applied to the study of STEM reform efforts (Coburn & Russell, 2007; Penuel et

al., in press). Social capital theorists have postulated the impact of dense networks characterized by frequent interactions and social cohesion (strong ties) and sparse networks that reduce redundancy and allow information to flow more efficiently (weak ties) (Burt, 1992; Granovetter, 1973). Hansen (1999), for example, found that strong ties allowed for the transfer of tacit and complex knowledge while weak ties impeded the transfer of complex knowledge and were more efficient for the transfer of simple knowledge. Hansen noted, however, that creating strong inter-unit ties is an expensive proposition requiring ongoing commitments of time and resources to maintain. Hansen's work alludes to the material costs of building expertise at scale within organizations. Furthermore, his work is consistent with research on professional development in mathematics education, in which small-scale, sustained, and intensive professional development models are more effective than brief workshops in terms of helping teachers adopt complex practices (Garet et al., 1999), and thus points to the need for ongoing resource commitments to generate and sustain expertise necessary to transform mathematics instruction (Gamoran et al., 2003).

Researchers caution that social capital does not always function as a resource in terms of adopting an innovation or transferring complex knowledge. Not all groups that share job responsibilities form cohesive communities, and in fact may be characterized more in terms of sub-groups and 'micro-politics' (Achinstein, 2002). Furthermore, members within groups often share histories that lead to complex interpersonal dynamics that may include tension and conflict (Grossman & Wineburg, 2000). Other research focused on the norms of academic departments or grade-level teams suggests that organizational cultures aligned with disciplinary characteristics facilitate particular views

of teaching and learning that may prove as impediments to reform (Bidwell & Yasumoto, 1999). Thus, social capital can facilitate or impede efforts to enact a particular reform.

Research in mathematics education demonstrates that generative and sustainable reform of instructional practices toward teaching for understanding is associated with participation in professional communities that inquire into student thinking in relation to particular content (Carpenter et al., 2004). Research further shows that such 'communities of inquiry' benefit from leadership situated within the communities as well as access to expertise, either in the form of teacher leaders or from external consultants (Carpenter et al., Gamoran et al., 2003). Gamoran et al. articulate a model in which the expenditure of material resources (anything that money can buy in terms of release time, professional development, outside consultants, common planning time) results in the development of human resources, in the form of knowledgeable teachers who can teach for understanding, and social resources, such as communities of inquiry and distributed leadership. Gamoran et al. note that social resources are a critical form of support for the development of human resources.

In relation to the social capital and mathematics education literatures, a number of issues emerge. The first relates to how 'communities of inquiry' develop in the first place. That is, how do teachers begin to develop an interest in student thinking and how do they find colleagues with which to collaborate? Coburn and Russell (2007) note that research provides "evidence that social networks develop as individuals form network ties based on their *perceptions of others*," including those who share similar beliefs, job responsibilities, or who have expertise (p. xx, author's italics). Typically, teachers are organized into informal subgroups (Frank & Zhao, 2005) and interact with only a few

colleagues who share common beliefs (Bidwell & Yasumoto, 1999). Trust is an important component of the informal subgroups, but does not by itself facilitate meaningful interactions. Coburn and Russell, for example, found that teachers trust those with whom they interact most frequently, though those interactions often tend to be superficial or logistical in relation to an innovation.

Coburn and Russell (2007) noted that teachers have a propensity to reach out to colleagues that are physically proximate rather than those with expertise. Furthermore, when teachers reach out to colleagues who had already been implementing an innovation, they were significantly more likely to change their practice (Penuel, Franke, & Krause, 2006). These findings suggest that teachers on their own are unlikely to engage in substantive inquiry into student thinking or to seek relations with those more expert, indicating that the presence of material resources and social capital alone are not sufficient.

Leadership plays an important role in establishing trust and authority, which are both related to teacher participation in high-quality professional development (Desimone et al., 2007). In particular, leadership needs to be situated within teachers' social networks, in the form of coaches and mentors, so that teachers have access to the leaders' expertise and vision (Penuel, Fishman, Yamaguchi, & Gallagher, in press). The term *teacher leaders* is broadly defined by Gamoran et al. (2003) to encompass instructional personnel who do not serve in an evaluative capacity and who participate in some of the forms of school leadership identified by Spillane, Halverson & Diamond (2001), particularly advocating for teaching for understanding, building norms of trust and collaboration, and monitoring the growth of teachers as they attempt to transform their

practices. Teacher-leaders include mentors or coaches. In general, having access to leaders who possess expertise can be a statistically significant predictor of innovation use (Frank et al., 2002; Penuel et al., accepted), but it is important to note that the presence of teacher leaders does not ensure access to the appropriate expertise. In some cases, these roles have not filled their intended purpose, either because of how administrators assign non-mentoring responsibilities to personnel with those titles or because the personnel lack the necessary expertise (Coburn & Russell, 2007; Penuel et al., in press).

Penuel, Franke & Krause (2006) note that interactions with colleagues function as continually evolving resources that help individuals interpret initiatives in terms of their own practice. However, research on STEM reform from a social capital perspective has not fully taken into account the evolving nature of such resources. In particular, districts tend to focus heavily on professional development at the beginning of an initiative and less so after the initial implementation. Furthermore, leaders change and new teachers are hired, affecting the need for and distribution of expertise within a network. Given the expensive nature of developing and maintaining expertise and sustained interactions in relation to an innovation, these demographic changes are likely to impact the nature of teachers' social networks. Furthermore, as will be discussed in more detail below, policy initiatives that outline new curriculum and instructional priorities create demands on existing resources. Blumenfeld et al. (2000), for example, note that divergent or contradictory policies and practices influence how teacher engage with an innovation. These findings indicate that though networks evolve, districts' attention to the resource distribution within the networks may not.

Summary of social capital perspective. A social capital perspective considers the formation and nature of teachers' social networks and how resources are distributed and accessed in these networks. Teachers, especially those new to a reform, are likely to interact with colleagues located nearby and with whom they have frequent interactions. Thus, there is a need to develop and distribute leadership and expertise at the nodes of networks in which novices reside.

Policy characteristics that impact social capital

Teachers are impacted by the policy context in which they work (Desimone et al., 2007), though some aspects of teacher practices are beyond the reach of policy (Coburn & Russell, 2007). Desimone et al. applied policy attributes theory to identify four policy characteristics that are prevalent in the literature on school reform: authority, power, coherence and stability. They analyzed these attributes with respect to teacher participation in professional development and found that authority and stability were most prevalently associated with participation in high quality types of professional development.

Desimone et al. (2007) state that authority "is the extent to which a policy is accepted and persuasive to those who have to implement it – usually principals and teachers" (Desimone et al., p. 1089). The presence of authority implies that teachers have 'bought into' a reform because, for example, they have helped design it, have been convinced of its efficacy by a trusted colleague, or have observed evidence of its efficacy. Power, on the other hand, "is achieved through rewards and sanctions" (Desimone et al., p. 1089). Desimone et al. state that power has been associated with shallow and short-term implementations, while authority is associated with more profound and sustained

implementations. These two attributes are in tension with each other in that it is unlikely that teachers will implement a reform because they think it's a good idea *and* because they will suffer consequences if they do not.

The other two attributes are more interrelated than in tension with each other. The third attribute, consistency, "is the extent to which a policy is aligned with other policies in the same school, district, and state, and with the perceptions and beliefs of its implementers" (Desimone et al., p. 1089). Consistency is synonymous with coherence or alignment, which researchers have identified as important characteristics of effective reform efforts (Blumenfeld et al., 2000; Clune, 1998; Smith & O'Day, 1993). The last attribute is stability, which characterizes the longevity of personnel and policies and is a "significant influence on the level and quality of implementation" (Desimone et al., p. 1090). Together, consistency and stability characterize the extent to which policy actions create divergent demands on the scarce attention and resources available to teachers. Typically, teachers face a fragmented policy environment in which they attempt to fulfill multiple intentions in any given teaching episode (Kennedy, 2005). Tyack and Cuban (1995) state that the pace of policy action, defined as the adoption of reforms, is faster than the pace at which reforms can be effectively implemented. This typically means that before the implementation of a reform reaches the level of classroom practice, a new policy action is put into place that suggests a new direction, with corresponding shifts in instructional priorities and resource allocations. These policy actions stem from emerging local priorities and from broader national educational 'crises', making it difficult to reach a stable consensus on local educational policy. Consequently, most educational reform efforts fail to impact core teaching and learning practices (Elmore, 1996).

Stability and consistency can be linked to authority in that teachers are more likely to participate in high-quality professional development if they deem their environment to be stable (Desimone et al., 2007). Stability and consistency can contribute to authority by demonstrating that districts are paying more than lip service to a reform and that the reform is likely to endure and will be worth the challenges associated with developing expertise in relation to the reform goals.

#### Research questions

The research questions articulate the connections illustrated by the arrows in figure 1. The assumption upon which the questions are based is that the districts have committed substantial material resources to the reform over a span of years. This context provides insight into what happens when districts expend considerable resources and whether the expenditure of those resources results in the development of human and social capital.

The research questions are:

1. How does district policy context, in terms of the four attributes described above, impact the formation of social capital in teacher's social networks and teachers' use of curriculum materials?
2. What is the nature of teachers' social networks, and how does that impact teachers' sense of efficacy with the curriculum and their reported use of the curriculum?
3. How have policy and networks evolved over time, and how has this evolution impacted available resources and use of curriculum?

#### Context

The data analyzed in this article come from a larger study focused on six school districts' implementations of the Connected Mathematics Project (CMP) middle school mathematics curriculum (Lappan et al., 1998), one of the NSF-funded curricula. The six districts were geographically proximate but demographically diverse and included a large urban district, a small rural district, and three inner ring suburban districts, all located in the Northeast US. Each of the districts had committed substantial resources to implementing CMP, including buying the textbook materials and associated teacher resources, mandating CMP as the primary curriculum resource for the middle school grades, and offering ongoing CMP-specific professional development, much of it directed through the local research university. The five non-rural districts had been using CMP for over five years at the time of the study, offering an insight into the long-term impact of the districts' efforts to implement CMP.

The study is specifically situated in two districts that are long-term implementers of the Connected Mathematics Project (CMP) curriculum (Lappan et al., 1998), described below. The two districts have participated in several multi-million dollar grants at the local research university aimed at middle school mathematics reform and have further expended substantial material resources to implement CMP. The districts are located in the same county in western New York, providing some constancy in terms of the accountability system, but are diverse in terms of demographics and scores on the statewide test. The districts were selected because they had used CMP for more than five years, had committed substantial resources to supporting the implementation, and had consistent access to outside expertise related to the use of the curriculum. Furthermore,

these districts were the ones in which the research team was able to interview the greatest percentage of teachers.

### The curriculum

CMP is an NSF-funded middle school curriculum. NSF-funded curricula are comprehensive and coherent, develop mathematical ideas in depth, promote sense-making, and engage students through the use of meaningful contexts and applications (Trafton, Reys, and Wasman, 2001); as such, they represent a substantive departure from commercially-developed curricula. CMP is the most widely adopted middle school NSF-funded curriculum and was rated as “exemplary” in terms of its content (US Department of Education, 1999). CMP is a 3-year curriculum for grades 6-8, designed to provide students with multiple opportunities to explore and formalize their understanding of key mathematical ideas within five major “strands” (numbers and operations, geometry, measurement, data analysis and probability, and algebra). The curriculum is organized into units, each comprising of 3-5 “investigations” where students explore a key mathematical concept or process. Each investigation begins with the presentation of a meaningful real-life problem/situation that embodies the mathematical concept/process under study (“launch”), followed by a combination of whole class and small group guided explorations, and concluding with a discussion in which the mathematical concept/process at the core of the investigation is explicitly identified and its understanding reinforced.

CMP promotes the use of diverse approaches to problems and suggests that students “should pose conjectures, question each other, offer alternatives, provide reasons, refine their strategies and conjectures, and make connections” (Lappan et al., 2004, p. 17).

Furthermore, the expectation is that students will not achieve mastery of a skill or concept at the end of each investigation, but instead students will gain formal and abstract understanding after a progression of activities that allow time for exploration and incremental development of concepts, usually 4 to 6 weeks for each unit.

The CMP teacher resource materials include what Davis and Krajcik (2005) describe as the *design rationale* of the curriculum, such as descriptions and analyses of a variety of student responses to a particular problem, mappings of student learning over time, and consideration of various representations of and connections between mathematical concepts. The teacher resource materials provide a detailed description of the mathematical goals for each investigation and include suggested questions and anticipated student responses for many questions.

#### Methods

The study was a qualitative case study of two districts, with data from four other districts occasionally drawn on to supplement the findings. The primary source of data consisted of interviews of teachers, principals, and district-level administrators. In one of the districts, every teacher, principal, and district administrator with responsibilities related to mathematics instruction was interviewed. In the second district, twelve teachers (over half of the total number), both principals, and the district-wide mathematics supervisor were interviewed. In both districts, curriculum documents such as pacing charts were also collected. In both districts, three teachers were videotaped for a minimum of five classes in relation to another ongoing study, and these data were drawn on as well. The data will be analyzed using qualitative techniques involving both typological and inductive coding (LeCompte & Preissle, 2003).

The interviews consisted of questions about: (1) the interviewee's perceptions of the philosophy and design of CMP; (2) the interviewee's participation in CMP-related professional development; (3) the interviewee's perceptions about the effectiveness of the curriculum; (4) the interviewee's perceptions of the district's efforts to adopt and implementation, including the history of those processes; (5) the colleagues with whom the interviewee collaborates and the content and frequency of interactions with those colleagues; (6) the nature of districts' curriculum guidelines and pacing charts; (7) other concurrent reforms that impact the CMP implementation; (8) leaders to whom teachers turn if they need resources; (9) the impact of the state high-stakes assessment; and (10) district demographics, including students and parents.

The videotape data were used to interview teachers about specific instances of curriculum use. The six teachers were asked about: (1) the purposes and processes of how they designed that instance of instruction, including adaptations and revisions from the base curriculum and from how they designed the task in previous years, (2) their reflections on how the task design engaged students, (3) the experiences and resources they drew on to design instruction, and (4) how they might revise the instructional design in the future based on how they perceived student engagement.

The logic of the study design for the typological coding is illustrated in Figure 1. The logic suggests that policy, in the form of resource allocation as well as policy actions related to the articulation of curriculum and instructional priorities, have a direct impact on how teachers interpret and use curriculum materials and an indirect impact through the formation of social capital. As described above, the four policy attributes analyzed by Desimone et al. (2007) are authority, power, stability, and consistency. Social capital was

deemed to influence how teachers interpret and use curriculum materials by providing resources and structuring interactions around the use of the materials. Following Coburn and Russell (2007), social capital was analyzed in terms of the (1) structure of networks; (2) access to expertise; (3) content of interaction; and (4) trust.

Finally, teachers' interpretations and uses of the curriculum materials are characterized in terms of teachers' characterizing of the qualities of CMP, their perceptions in terms of whether the materials are a good fit for their district context, whether they feel sufficiently supporting in using the materials, and who they adapt the materials. Certain interpretations of the curriculum were privileged in terms of characterizing teachers' interpretations. In particular, the understanding of the developmental nature of CMP was considered to be a characterization that displayed deeper understanding of the curriculum than describing CMP as promoting active student engagement, engaging students in discussions, or appealing to students' sense of relevance by setting problems in context. Though these latter features accurately characterize practices advocated by the CMP designers, they can also be applied to redesign tasks from conventional curricula. The most prominent characteristics of the CMP materials that distinguishes it from conventional curricula is the emphasis on developing understanding of concepts over investigations and units that span weeks rather than developing skill or procedural fluency over a span of one or two lessons. Furthermore, a well-supported implementation should preserve the features of CMP, particularly the developmental characteristics of the curriculum.

For each district, I constructed a history of the adoption and implementation, in order to establish the ways authority, power, alignment, and consistency were established

from the start, to document the substantive material expenditures, the implicit models for distributed leadership and development of social capital.

### Results

There was considerable variation within each district but systematic differences across districts in terms of authority, explicit consideration of how leadership and expertise was located within grade-level planning teams, and teacher perceptions' of efficacy and teachers' reported adaptations of the curriculum. Though some of the systematic variation across districts can be attributed to differences in student demographics, the policy context also accounted for some variation, indicating potential lessons for other districts planning to implement an NSF-funded curriculum.

Below, I present each of the three districts. I then synthesize the findings from the districts in terms of the logic model presented in figure 1. For each district, I begin with a brief history of the adoption and implementation processes, in order to establish the extent to which the districts committed material resources and tried to establish teacher support for the use of the CMP materials.

#### Denton<sup>1</sup>

Denton has about 3600 students, with one middle school and one high school, and is one of the highest performing districts in the county. It was described by one its administrators in the following way:

The majority of people live here because of the school district. That used to be because of the school district or the temples being close by. And although we still do have um a significant Jewish population, it is not as large as it once was. We also have a large Islamic population now, and that leads us to another

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<sup>1</sup> The names of each school district and teachers in the paper are pseudonyms.

characteristic, which is the ethnic and religious diversity in the community. ...our kids ... speak over 46 different languages.

Denton participated in three NSF-funded grants at the middle school level in the 1990's. The grants focused on reforming middle school mathematics instruction, on building from student errors, and on expanding instructional strategies with students who had been labeled as having learning disabilities. In 1994-1995, the teachers in Denton, with the assistance of a local university-based researcher, began creating their own instructional units, which led them to explore NSF-funded curricula, in part because they found that creating their own units was too time-intensive. They were able to study pre-publication materials for various curricula, which helped them develop an understanding of what was available and what comprehensive materials looked like. In the mid-1990's, some of the middle school teachers began to implement innovative units, which led to discussions among about half of the mathematics teachers about the impact of these units on students' thinking. In February 1998, several teachers were sent to Michigan for training on units from each grade level, after which Denton implemented 2-3 units at the 7<sup>th</sup> and 8<sup>th</sup> grades. At that point, there were no 6<sup>th</sup> grade teachers willing to use the CMP materials. The first few years after 1998, teachers taught CMP materials and other teacher-created or traditional materials. During this time there was additional training conducted under the auspices of one of the NSF grants as well as presentations from CMP personnel from Michigan. During this time, the Michigan personnel communicated that it was best to use CMP as comprehensively as possible and to trust the way the materials developed concepts. The teachers using the CMP materials initially reported

supplementing the materials, as had been their prior practice with other curricula, but came to the conclusion that they could trust the materials and stopped supplementing.

The three 8<sup>th</sup> grade teachers wrote a proposal to get the books funded, and the superintendent gave them some money. Although initially the program was only adopted by the 7<sup>th</sup> and 8<sup>th</sup> grade teachers, the decision to purchase the books began the process of articulating a coherent 6 – 8 curriculum. Up to that point, each teacher had autonomy about what textbook materials they could use and there was no attempt to articulate a curriculum across the grades. Two of the 7<sup>th</sup> grade teachers agreed to use CMP units. In 2003, one of the 8<sup>th</sup> grade teachers, Cummings, moved to 6<sup>th</sup> grade, and the process of moving CMP to the 6<sup>th</sup> grade proceeded. The small group of 8<sup>th</sup> grade teachers became leaders, though two of them moved to other roles in the district and Cummings moved to 6<sup>th</sup> grade, as noted. In 2004, the district hired another 6<sup>th</sup> grade teacher, Pless, who was able to anchor the 6<sup>th</sup> grade team. The 7<sup>th</sup> and 8<sup>th</sup> grade implementations were well established at this point, though the most experienced users and recognized leaders had moved on to other positions. It is important to note that Denton did not begin implementing the materials at a grade level until they were able to 'anchor' the grade level with a recognized leader who supported CMP.

Denton policy context. Denton has provided their middle school teachers with almost unlimited access to CMP-based professional development, including sending several teachers to Michigan for unit training from the curriculum developers. All of the eight current teachers reported having sufficient opportunities for training and that they felt well-supported by the district in terms of using the CMP materials.

Denton has a history of being one of the top three highest scoring districts in the county on the state assessment, and this has insulated them from the impact of the changing nature of the high-stakes state assessment. New York has changed the middle school curriculum and state assessment over the last several years, and the feeling expressed across all three districts is that the new standards and assessments do not match well with CMP in terms of content or philosophy. Administrators in Denton, however, have adopted the attitude that they are better served following the curriculum, though some minor modifications have been implemented to cover *performance indicators* (New York's term for the classification of mathematical skills and content) not in the CMP materials. Therefore, the curriculum in Denton has remained relatively stable. Furthermore, their program to accelerate some of their students was established several years ago, and teachers did not report any curricular changes related to that program.

Social capital analysis. The most cited collegial interactions in Denton occurred in the context of the grade-level planning teams. Each of the teams had their own culture and focus of interactions. Two of the three 8<sup>th</sup> grade teachers interacted almost daily, in part because their classrooms were located nearby. All three of the 8<sup>th</sup> grade teachers would meet at least once before the beginning of a new unit to plan the pacing of the unit, to divide the production and revision of worksheets and common assessments, and to reflect on what worked and did not work from the previous year. The two teachers who frequently interacted would discuss surprising developments or difficulties they encountered in teaching particular lessons.

The 7<sup>th</sup> grade team, by contrast, barely interacted the year in which the study took place. All three teachers indicated that this was in part due to the fact that no new units

had been introduced that year. They stated that in years past the interactions were more frequent and geared toward generating a common understanding of the content of the unit. One of the members of the 7<sup>th</sup> grade team, Dougall, though he stated his full support of CMP in the interview, was cited by several other teachers as not being very supportive of CMP, and one of other 7<sup>th</sup> grade teachers cited this as a factor in the team's lack of interactions.

The 6<sup>th</sup> grade team had an established leader, Pless, who had been hired because of her experience with and support of CMP and her strong content knowledge (for example, she has taught Calculus at a local IHE). The other two members of the team cited her as the person to whom they turned when they had a question about the mathematics in CMP. The group met at least once a week to discuss pacing, common assessments, lesson features, and to explore the mathematics in the investigations. Pless stated that she turned to Cummings for collaboration and support and not the members of her team.

Teachers' perceptions and actions. In general, the culture of the department was supportive of CMP, and, with the exception of the 7<sup>th</sup> grade team, supplementing was only done to cover content from the state exam not in the CMP materials, such as scientific notation, which the state had heavily (and inexplicably) emphasized the prior year. The teachers generally felt competent and well-supported in using the CMP materials, did not mention the amount of instructional time as an obstacle, and felt that the administrators continued to support the comprehensive use of CMP in spite of changes in the state standards and high-stakes assessment.

There was some variation across the grade levels in the reported and observed adaptations of the curriculum. The 6<sup>th</sup> grade teachers, led by Pless, tended to reorganize content to help students focus on particular task features and to highlight the progression of ideas across units. Their revisions did little to alter the content of the student text or the emphasis of particular investigations, which they followed quite closely. The 7<sup>th</sup> grade team, on the other hand, tended to supplement the curriculum in ways that did not necessarily connect to the content in the student texts. Dougall, for example, jettisoned an entire unit because he did not feel the representations were flexible enough and created his own unit using a different representation for computing with integers. Another 7<sup>th</sup> grade teacher mentioned that she 'extended' the material in CMP to include other contexts to make it more broadly applicable. Two members of the 8<sup>th</sup> grade team interviewed for a related study described revisions in two units that emphasized formal representations and procedures earlier than appeared in the CMP unit. Though the team generally followed the student text quite closely, their revisions indicated a lack of recognition of the developmental nature of the tasks in the two CMP units.

Four of the teachers explicitly mentioned learning mathematics more deeply as a result of using the CMP materials, though that topic was not a focus of the interview. The eight teachers generally felt that CMP helped their students learn better and that the materials were more effective than traditional materials.

#### Belleview-Burney

Belleview-Burney is a larger district than Denton (two middle schools), is more diverse socioeconomically, and generally scores in the middle of the districts in the county in which all three districts in this study reside.

The adoption process began in the late 1990's when several experienced teachers expressed unhappiness with the conventional middle school curriculum textbooks they were using and in having to create materials that engaged their students. The three teachers were involved with a team that investigated a number of curricula, which included attending a number of presentations in which teachers and university educators familiar with CMP described the materials and presented student work. The team decided in the summer of 2000 to go with CMP, beginning with training in 2001 and initial adoption occurred in the fall of 2001. Besides being dissatisfied with the conventional textbooks, the team felt that CMP was a good fit with the current state test and standards. Their goal was initially to do the recommended phase-in, but the phase-in ultimately proceeded quite rapidly, over a span of 2 to 3 years. In the first year, three units were implemented, with two or three units added each year so that by the end of the third year CMP constituted the entire 6 – 8 curriculum.

After the adoption, Belleview-Burney bought into an NSF-funded grant at the local research university so that their teachers could go to the UR trainings. They participated in that grant for 3 years, until 2003, when a new assistant superintendent got hired who restricted teachers' access to CMP-related professional development by not allowing teachers to go to trainings during the day.

Belleview-Burney policy context. Although all of the twelve teachers interviewed in Belleview-Burney stated that they had sufficient access to CMP-related professional development, the teachers also stated they had typically attended only a couple of unit-level trainings. None of the teachers reported attending training for all of the units they were expected to teach before they taught the unit, and a number of them indicated that

they felt that timing of the trainings was inconvenient in that they occurred during the school day. Furthermore, the break in opportunities created when the former superintendent eliminated opportunities for training made the initial years after implementation difficult, as CMP was still being rolled out and many teachers still had not received adequate training. Thus, while Belleview-Burney ultimately expended considerable resources to train their teachers on CMP, the training actually received by teachers was sporadic, though deemed very helpful and available by most of the teachers. The only teacher complaint about lack of resources concerned attending unit training as groups. Several teachers reported that the model had been to send only one teacher per grade level to a training, who would then report back to the other teachers. Three teachers indicated that they benefited from and would prefer to attend as an entire grade level team.

Belleview-Burney, due to its precarious ranking in the county in relation to test scores, was impacted considerably by changes in the state standards and assessments. The teachers reported supplementing the CMP materials to cover some of the performance indicators. Furthermore, many of the teachers felt that the range of material to cover for the state test exceeded the instructional time allotted, especially considering that CMP was designed to be more developmental and student-centered, both of which were deemed to be time-intensive.

The district had recently increased the number of students who were accelerated, and this had two repercussions. First, it increased the range of ability levels in the accelerated class, making it difficult to maintain the pace for all of the students. Second, it pushed instructional units down a grade level for the accelerated classes. Third, the

eighth grade accelerated students were switched to conventional algebra texts instead of CMP units. Several teachers attributed this push to expand the number of students who would be able to take AP Calculus in high school. Consequently, teachers at the 6<sup>th</sup> and 7<sup>th</sup> grades were teaching new units, for which they had received little or no training, and the number of units at each grade level had also expanded, further increasing the time pressures.

The amount of minutes for mathematics instruction was a constant tension over the years leading up to and including the year the study took place. The previous year the teachers would see each class 5 out of every 6 days for 52 minutes, and in the year of the study that had been reduced to 3 out of 4 days for 57 minutes. One of the teachers said she had done an analysis of the number of instructional minutes and found that Belleview-Burney at one point in the last several years had the lowest in the county.

The overall impact of these features of the policy context was to strain teachers' capacity to understand and teach CMP in ways they viewed as consistent with the designers' intentions. The teachers described the curriculum and instructional context, in terms of time and student composition of classes, as moving targets.

Social capital analysis. Unlike in Denton, we are not able to interview every teacher in Belleview-Burney. Consequently, we are unable to describe as comprehensively as possible the teachers' social networks. However, in both schools we have data on planning groups in two grade levels.

The 6<sup>th</sup> grade teams in each of the two schools interacted the most consistently. At Lewis Middle School, the 6<sup>th</sup> grade team had been together for years, though at the time of the interviews, one of the team had been assigned to the role of coach and another had

gone out on maternity leave. In the previous three years, however, the two team members who were interviewed reported that they had slowly built up trusting relationships. They now felt comfortable admitting that they needed help to understand the development of mathematics in a particular unit. They met at least once a week to discuss pacing, to develop worksheets based on the investigations, to create guided notes for the students, to reflect on what had gone well or not in past implementations, and to discuss mathematics they found confusing. The 6<sup>th</sup> grade team at Clark Middle School also met regularly for similar functions, though the composition of the team was newer.

At Lewis, there appeared to be two seventh-grade groups and at least one 8<sup>th</sup> grade group that planned separately. Each group had a veteran teacher whom the junior members cited as a resource who helped them to understand the CMP units and who helped them create modifications or to otherwise navigate the demands of using CMP in the policy context described above. At Clark Middle School, I interviewed four teachers, and the three who did not teach 6<sup>th</sup> grade indicated that they did not regularly plan together or formally discuss the materials on a regular basis. They reported less frequent, more informal interactions, and all felt they could get questions answered if they needed to. All of the teachers interviewed felt that resources, in the form of professional development, more experienced colleagues, or district-level leadership, were always available if they needed them. Only one of the twelve teachers felt unprepared to teach the curriculum, as will be described in more detail below. None of the grade level teams indicated formal attempts to inquire into student thinking in relation to particular unit or explicit discussions of student strategies.

Once a month, the teachers would meet as a department. Most of the time, these meetings were devoted to discussing issues around the state assessment, though more recently grade-level teachers from both schools met to discuss upcoming units.

Teachers' perceptions and actions. There were several trends in the reported and observed adaptations of CMP. First, the teachers created mini-units or worksheets focused on the performance indicators that were not on the state test. Second, four of the teachers reported breaking investigations into smaller tasks to make it more structured for students. Third, four teachers mentioned creating guided notes for students to follow after an investigation, in part to alleviate parent concerns that students did not have ample guidance when working on their homework.

Most of the adaptations reported or observed were intended to reinforce a skill or concept soon after it was taught, in part because of the reported emphasis on the state test on those skills and concepts. The implication was that students needed 'reinforcing' of a skill or concept the day or very soon after it was introduced in order for students to master it. Only two teachers indicated that one of the important features of CMP was its spiraling or developmental nature, which meant that students developed understanding of a concept over a span of lessons. Furthermore, several teachers characterized the important features of CMP in terms of students' active exploration of concepts, student presentation and comparison of multiple explanations, the use of manipulatives, and the use of context to make mathematics seem relevant. Although these features are important, they do not fully distinguish the CMP materials from conventional texts, which may be altered to include those features but which would still emphasize mastery at the end of a lesson or activity.

The teachers generally stated a philosophical alignment with features of CMP such as active exploration of concepts, student presentation and comparison of multiple explanations, the use of manipulatives, and the use of context to make mathematics seem relevant, but felt unable to use the materials effectively given the time and curriculum pressures. Furthermore, most of the teachers felt the strain of constantly learning new units and of the constantly changing nature of the curriculum and of the student composition in their classes as a result of the effort to accelerate most of the students (over 50% of the students in both schools were accelerated). As a result, most of the teacher felt they were adapting the materials or instruction in ways that violated the intent of the curriculum.

#### Synthesis of districts

The characteristics of the districts' policy contexts differed considerably, with Denton maintaining a stable and consistent policy context over time, while Belleview-Burney experienced considerable changes from their emphasis on acceleration, changes in New York's standards and high-stakes assessments, and from decisions about instructional time.

The differences had a substantive impact in how teachers reported satisfaction or dissatisfaction with the effectiveness of the CMP materials, with their ability to use them appropriately, and with the constant learning associated with their use. Teachers in both districts expressed the challenges of teaching units for the first time, especially without prior unit-level training, so the constant flux of units in Belleview-Burney is important.

The stability and alignment policy characteristics impacted the authority, or persuasiveness, of the implementations. The more stable and aligned the policy, the more

the teachers feel supported in their use of CMP. Teachers in Belleview-Burney in particular cited the tension between the allocated instructional time and the content they were required to cover as severe challenges in implementing CMP in the way they felt the designers intended.

The adoption and implementation histories and strategies also differed across the two districts. Denton's adoption and implementation resulted from a long history of involvement in grants and curriculum-writing activities. The core group of teachers in Denton initiated the adoption process at their grade level first and only implemented it at grade levels in which they established support beforehand and in which they were able to provide 'anchored' leadership. Thus, authority was a prerequisite to adoption in Denton. Ultimately, CMP became the primary curriculum resource in all three grades and received unwavering support from school and district administrators. New teachers in Denton are encouraged to get trained in CMP and are expected to embrace the materials.

Belleview-Burney, on the other hand, experienced a more typical implementation. Although the initial stimulus for adopting CMP came from a group that included several teachers seeking more engaging materials, the adoption and implementation was controlled at the district level. Furthermore, the district faced an unexpected challenge early in the implementation when the assistant superintendent reduced access to professional development. The implementation was both mandated and unevenly supported at first, though the current teachers report adequate opportunities to attend CMP-specific professional development. Unlike Denton, however, the teachers in Belleview-Burney have on average attended less professional development, citing logistical reasons (such as not wanting to leave classes to a substitute) for not attending.

Though this is a valid reason for not attending professional development, it was never mentioned in Denton, suggesting that their teachers are more committed to CMP.

In both districts, there was considerable variation across planning groups in terms of frequency of interactions and content of interactions. There were some similarities in that teachers tended to form their strongest ties with those who shared teaching responsibilities, beliefs about teaching and learning, and who were physically proximate, which mirrors findings elsewhere.

Denton had an explicit strategy to provide 'anchored leadership' at each grade level before they would implement at that grade level, whereas Belleview-Burney (as well as the other four districts that were part of the larger study) did not. Leadership in Belleview-Burney within the grade-level planning teams usually came from the teacher most experienced in the use of the CMP materials. The leadership functioned less to implement a particular vision of CMP than it was to navigate the use of the materials within the policy context (e.g. how to cover material, adapt it for mastery of skills and procedures, and adapt if for particular groups of students). The Denton grade level groups shared similar logistical concerns but were more likely to reference and adhere to recommendations in the teacher resource materials and suggestions from CMP unit trainings. Denton also had more access to external expertise through the teacher on special assignment, Cummings, who shared a joint appointment with the local research university, and through Michigan-based CMP trainings.

A number of teachers in both districts collaborated only on issues of pacing and common assessments and were otherwise rather individualistic in terms of their planning habits, relying on their past experiences as the primary guide, a finding which echoes

Coburn and Russell's (2007) sentiment that some things are out of the reach of policy, a point to be discussed in more detail below.

In terms of the respective implementations, the Denton teachers were more likely to maintain the comprehensiveness of the materials, in terms of number of units, the number of investigations within units, the use of supplemental materials, and the presentation of entire investigations rather than dividing up investigations so that students would only focus on one question at a time. The instruction in Denton was thus more likely to preserve the developmental nature of the CMP materials.

### Discussion and Implications

The results suggest that policy context matters, especially in relation to the differences between Denton and Belleview-Burney. For example, the resulting time and curricular pressures in Belleview-Burney discouraged teachers from implementing CMP in a way they deemed as consistent with the designers' intentions and focused them on the mastery of skills and procedures rather than the developmental nature of CMP. In terms of the development of social resources that have been shown to facilitate generative and sustainable reform, the impact of policy is less apparent, as will be discussed below.

In either district, it is important to consider which teachers drew most on the resources in their networks. In both districts, it was evident that new teachers turned to more experienced teachers in their immediate proximity to help interpret the mathematics and activities in the units and to adapt the curriculum according to the perceived needs of the students and to the perceived intentions of district policy. Another smaller group of teachers included those teachers who wanted to explore the complexities of student thinking, notably Pless and Cummings. Teachers' networks in both districts functioned

mostly to share logistical information such as pacing of lessons and to share labor such as worksheets and common assessments.

The ideal vision of presence and function of social resources, to inquire deeply into student thinking, anticipate strategies, and reflect on observations in order to adapt approaches to more effectively engage students with mathematical ideas, was limited in both districts, and involved teachers (mostly Pless and Cummings) who had deep and flexible content knowledge, a disposition of inquiry, and the willingness to revise their implementations from one year to the next.

The results raise questions about aspects of teachers' practices that are within the purview of policy. Districts can provide common planning time and opportunities to collaborate and provide opportunities for curriculum-specific professional development, but policy cannot ultimately dictate how teachers use the time or, in the case of all six districts that were part of the larger study, even if they attend professional development. Policy can at best provide conditions for teachers to develop dispositions toward inquiring into student thinking, in particular by creating a stable and consistent policy context. In Denton, the teachers understood policy as being supportive of using CMP as comprehensively as possible, while in Belleview-Burney the perception was that district policy impeded the comprehensive use of CMP materials in ways that matched the designers' intentions. The policy perception was associated with the Denton teachers' greater participation in CMP-specific professional development and adaptations that preserved to a greater degree the developmental nature of the curriculum compared to teachers in the other five districts.

Policy can also influence the identification and roles of leaders that impact the implementation, particularly teacher leaders. In Denton there were specific intentions to insert leaders into grade level teams before the team was asked to implement the materials. The Denton leaders were and continue to be highly knowledgeable of CMP, philosophically aligned with the curriculum design, and aware of its developmental nature. In Belleview-Burney the leadership in teacher networks has been mostly informally established and has gravitated toward those with experience teaching CMP but not necessarily those who have consistently attended training or who understand the developmental nature of the curriculum. The other four districts from the larger study ranged between Denton and Belleview-Burney in identifying teacher leaders, but none had the same vision of 'anchored leadership' within each grade level planning team; furthermore, the policy contexts and the adaptations of the CMP materials were more like Belleview-Burney's than Denton's. It would appear then that formal policy mechanisms can provide limited influence in establishing the 'communities of inquiry' associated with generative and sustainable efforts to teach for understanding.

There are two other salient points to which the results speak. The first is whether policy can mandate the kind of intellectually challenging practices associated with teaching for understanding. The characteristics of 'communities of inquiry' require that teachers think beyond the daily constraints and competing intentions to inquire into how student thinking develops over time as a result of particular learning experiences. No policy can force teachers to engage in practices that are intellectually challenging and risky. Policy can at best create conditions that facilitate the formation of such practices,

but that policy would need to provide substantial autonomy to teachers, a trend antithetical to NCLB-related policy.

Second, scale is an issue. With the exception of the rural district, the size of the districts was directly associated with challenges in establishing effective leadership within teachers' networks. In the two smaller districts the process of selecting CMP was more organic and led by multiple teachers who constituted a significant percentage of the total teaching staff. In order to implement CMP district-wide, the larger districts were forced to mandate CMP in buildings in which authority for the implementation was not well established. In these districts, power, defined as teacher's implementing CMP in the threat of sanctions for not doing so, was a more prevalent policy characteristic. This study does not address how to expand effective implementations at scale and in fact suggests that working primarily on a small scale is most effective, a finding reinforced by larger analyses of effective professional development (Garet et al., 1999).

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Figure 1: Research design – logic and identification of variables

