J Educ Change (2015) 16:421–450
DOI 10.1007/s10833-015-9257-1

Conceptualizing relations between instructional guidance infrastructure (IGI) and teachers' beliefs about mathematics instruction: Regulative, normative, and cultural-cognitive considerations

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Published online: 30 October 2015

Abstract Scholars have become increasingly interested in what is often referred to as the instructional guidance infrastructure (IGI). Research has identified the characteristics of infrastructures that make them more or less influential in guiding teachers' instruction, such as alignment, authority, and prescriptiveness. Although these are important, a key question is whether and how IGIs work to influence teachers' beliefs and practices. We use new institutional theory to theorize relations between IGIs and teachers' beliefs about how students learn mathematics in two local school systems undergoing instructional reform. Based on new institutional theory, we explore how the three pillars of institutions—regulative, normative, and cultural-cognitive—worked in interaction to shape teachers' beliefs. In doing so, we develop a more comprehensive framework for examining IGIs and how they operate.

Keywords Instructional guidance infrastructure · District reform · Teacher beliefs · New institutional theory

Introduction

Standards-based reform and accountability initiatives over the last quarter century have transformed the US educational sector (Fuhrman et al. 2007; Mehta 2013; Spillane 2012). As federal and state policies increased attention to matters of curriculum and its standardization, local school systems have often been left mostly on their own to figure out how to manage these efforts through the design and

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redesign of instructional guidance infrastructures (IGIs; Cohen and Spillane 1992; Cohen and Moffitt 2009; Elmore 1995; Hightower et al. 2002; Rorrer et al. 2008; Spillane 2004).

We use the term *instructional guidance infrastructure* to denote those structures and resources that are mobilized by local school systems (i.e., school districts in the US) to enable (and at times constrain) school leaders' and teachers' efforts to provide, maintain, and improve instruction (Cohen and Moffitt 2009; Cohen and Spillane 1992; Cohen et al. 2013; Hopkins et al. 2013; Peurach 2011). IGIs include such things as content-based learning standards, curricular materials, student assessments, formal system and organizational positions (e.g., instructional coaches), and organizational routines (e.g., grade level meetings) that, more or less, form a system intended, by design or default, to guide and monitor instruction within local school systems (Cohen et al. 2013; Spillane et al. 2011). Scholars have argued that a well-crafted IGI can provide school leaders and teachers a common framework and vocabulary with which to monitor, explore, and discuss instruction and its improvement (Cohen et al. 2013; Cohen and Moffitt 2009).

Research has highlighted the various characteristics of IGIs that can facilitate teachers' work practice in schools, not just instructional practice but also teachers' work related to teaching and learning more broadly, including through informal exchanges (Coburn and Russell 2008). Scholars have argued that consistency, specificity or prescriptiveness, and authority or power are all IGI features that can shape the relationship between policy and instructional practice (Cohen and Spillane 1992). Additionally, the extent to which IGI components are aligned and coherent around particular ideas about what to teach and how to teach it can affect the resources and learning opportunities that are available to facilitate instructional improvement and maintain standards of instructional practice (Cohen et al. 2013).

Indeed, prior research has identified some of the characteristics and components of IGIs that can facilitate changes in teachers' knowledge, beliefs, and classroom practices (Coburn et al. 2013; Hopkins et al. 2013; Sun et al. 2014). Still, a key question remains: *How do local instructional guidance infrastructures function to influence such changes?* In this paper, we undertake an exploratory, cross-case comparison to uncover how IGIs worked to shape teachers' beliefs about mathematics instruction in two US school districts undertaking reform efforts in mathematics at the elementary level. We focus on teacher beliefs because research has shown that teachers' beliefs shape their instructional decision-making and use of curricular materials in mathematics (Clark and Peterson 1986; Philipp 2007; Thompson 1992; Wilson and Cooney 2002). Moreover, teachers' beliefs about how mathematics should be taught (e.g., teacher- or student-centered) and conceptualizations of mathematics (e.g., procedure- or principled-based) have been associated with their classroom practices (Peterson et al. 1989; Stipek et al. 2001).

We focus on US school districts for two reasons. First, school districts are the primary unit for delivering public educational services in the United States (Kirst and Wirt 2009; Spillane 1996; Tyack 1974), and are most often responsible for providing technical assistance to schools (Mitchell et al. 2011). Second, the state in which our research was conducted has historically been resistant to the standardizing efforts that have characterized US education policy over the last few decades

(Spillane et al. 2011), meaning that school districts in that state had primary responsibility for developing and implementing instructional policy.

To theorize how IGIs shape teachers' beliefs about elementary mathematics instruction within school districts, we draw on new institutional theory (Scott 2007). Institutions refer to a persistent social pattern or social structure typically seen as legitimate and so well-established as to be taken for granted (Jepperson 1991; Scott 2005). Institutions persist because they are continually reproduced and indeed are self-reproducing (Fligstein 2001; Jepperson 1991). We describe three key dimensions of local IGIs as identified by new institutional theory (Scott 2007)—regulative, normative, and cultural-cognitive—and use qualitative and quantitative data to theorize how these three dimensions help us to understand relations between IGIs and teachers' beliefs. In doing so, we develop a framework for analyzing IGIs and examining how they operate.

Our paper is organized like this: We first describe our conceptual model. Then, we outline our research and analytical approach. Turning to findings, we describe the components of the IGI for elementary mathematics education in each district. Then, based on our data analysis, we explore the regulative, normative, and cultural-cognitive dimensions of each district's IGI, and how these dimensions worked in tandem (and in tension) to shape teachers' beliefs about elementary school mathematics. We argue that, in order to understand relations between IGI and practice, we must move beyond singular examinations of the regulative, normative, or cultural-cognitive dimensions and consider how these dimensions work *in interaction*. We conclude with a discussion of the implications of our findings for practice, policy, and research.

Instructional guidance infrastructure: An institutional perspective

Bringing an institutional perspective to the study of instructional guidance infrastructures, we sought to understand, through case studies of two school districts, how the local IGI for elementary mathematics education can support (or not) changes in teachers' beliefs about mathematics instruction. Drawing on prior scholarship (e.g., Cohen et al. 2013; Cohen and Spillane 1992), we explore these three dimensions across five IGI components: (1) instructional frameworks, (2) instructional materials, (3) student assessment, (4) instructional oversight, and (5) teacher professional learning.

Instructional frameworks provide guidelines, more or less specific, on the purpose, content, and sometimes techniques of instruction, and *instructional materials* are the texts and other materials used to implement those frameworks. *Student assessments* examine student performance, which include standardized tests of achievement in US school districts as well as formative and summative assessments developed by district leaders or individual teachers (Little 2012). *Instructional oversight* includes the monitoring of classroom instruction, such as teachers' content coverage and pedagogy, as well as personnel systems for evaluating teachers that are increasingly implemented by US school districts. Such oversight necessitates the de-privatization of instructional practice and can provide

teachers with opportunities to discuss and get feedback on their teaching (Crow et al. 2002; Glickman 1985; Mangin 2007). Finally, we expand prior definitions of *teacher professional learning* (Cohen et al. 2013; Cohen and Spillane 1992) to include formal structures that are created to provide teachers with opportunities to learn and improve their practice on the job, such as organizational routines like professional learning communities (PLCs; Horn and Little 2010; Parise and Spillane 2010; Stoll et al. 2006; Vescio et al. 2008) as well as instructional leadership positions such as coaches and teacher leaders (Coburn and Woulfin 2012; Hopkins et al. 2013; Huguet et al. 2014; Mangin 2014).

Research has shown that articulating these five components in a consistent and well-aligned manner can enable improvement of teaching and learning both within and among schools (Cohen et al. 2013). For example, the most successful Comprehensive School Reform (CSR) models, such as Success for All and America's Choice, were those that developed standards-based curricula, and assessments aligned to those curricula, and that explicitly worked to build school leaders' and teachers' capacity to use them effectively through ongoing professional development (Cohen et al. 2013; Peurach and Neumerski 2015, this issue). Moreover, much current scholarship related to the development of IGIs in the US emphasizes the importance of formal structures (e.g., instructional coaches, organizational routines, professional development) for building capacity to facilitate the implementation of new policies or curricula (Coburn and Russell 2008; Hopkins et al. 2013; Spillane et al. 2011; Stein and Coburn 2008).

The adoption of curricula or formal structures on their own, however, does not necessarily facilitate instructional change or improvement. In our interpretation, existing research indicates that the adoption of new policies and formal structures can support instructional improvement insofar as they attend to three institutional dimensions (Scott 2007), and: (1) require school leaders and teachers to use new materials and/or participate in new routines that support their professional learning (i.e., regulation), (2) shift organizational norms related to how work gets accomplished (e.g., through participation in routines) as well as norms related to standards of teaching practice (i.e., normative), and (3) facilitate changes related to particular beliefs about what to teach and how it should be taught (i.e., cultural-cognitive). Related to the first and third points, there is evidence to suggest that the adoption of instructional coaching and organizational routines that require teachers to interact with a teacher leader and/or with one another can increase teachers' access to instructional expertise (Coburn and Russell 2008), thereby supporting changes in teachers' knowledge, beliefs, and instructional practices in ways that align with curricular reforms (Coburn et al. 2013; Hopkins et al. 2013; Sun et al. 2014) and promote reform sustainability (Coburn et al. 2013). Related to the second point, local norms of practice have been found to be influential in the extent to which teachers' adopt new policies, which can either inhibit of facilitate their implementation (Hopkins 2014). For example, both the practice-oriented norms supported by colleagues and school-level norms have been associated with teachers' reported use of reform-oriented instructional practices (Penuel et al. 2013), and the presence of school-wide norms of shared governance has been correlated with

teachers' instruction as well as student achievement (Bryk et al. 2010; Louis et al. 1996; Newmann and Wehlage 1995; Wahlstrom and Louis 2008).

The existing scholarship thus suggests that regulative, normative, and cultural-cognitive dimensions (Scott 2007) are important considerations in the development of instructional guidance infrastructures and the influence their various components have on practice. While not explicitly stated, prior research that explores these dimensions largely focuses on one dimension in isolation, with few studies exploring how these three dimensions operate in interaction with one another (Hallett and Ventresca 2006). In this article, we consider how these three dimensions work together in order to theorize how IGIs support (or limit) instructional reform in elementary school mathematics. Our goal is to develop a comprehensive framework for understanding the mechanisms through which IGIs enable (and constrain) changes in teachers' beliefs about instruction.

Although several investigations of IGIs attempt to connect particular IGI components directly with instructional practice, we take a step back and explore how IGI components are taken up through the regulative, normative, and cultural-cognitive dimensions embedded in two school districts and further how these dimensions worked in tandem (or in tension). Specifically, we explore the regulative dimension by identifying the formal structures and regulations specific to elementary mathematics instruction that teachers were mandated to participate in or follow, as well as by unpacking how district and school leaders used their regulative authority to support (or not) relevant normative and cultural-cognitive dimensions. The normative dimension includes how teachers' work related to math instruction is accomplished at the district and school levels, and how these norms influence leaders' and teachers' behaviors and promote organizational stability (or instability; Scott 2007).

The cultural-cognitive dimension we explore relates to leaders' and teachers' ideas about how to teach and what should be taught; for example, whether or not student- or teacher-centered pedagogical approaches should be employed in the classroom during mathematics instruction. As we will describe below, we noted significant differences emerging over time between one facet of the cultural-cognitive dimension in the two school districts (i.e., teachers' beliefs about how math should be taught) and found that comparing and contrasting the districts' IGI components was not enough to explain these differences. As such we asked *how* the instructional guidance infrastructure functioned to influence changes in teachers' beliefs and began to unpack each district's IGI along its regulative, normative, and cultural-cognitive dimensions.

Scholars have argued that the instructional guidance infrastructure is less a blueprint that can be taken up by diverse systems, and more of a puzzle that requires fitting different pieces together in ways that enable not only instructional practice, but also instructional maintenance and improvement practice, in particular local contexts (Cohen et al. 2013). We extend this notion and posit that relations between IGI and teachers' beliefs and subsequent practice are developed in a recursive and interactive fashion and can either be enabled or constrained by regulations, norms, and cognitive scripts. However, the sole objective of developing local IGIs should not be to elicit changes in teachers' beliefs or practices by implementing formal

rules and structures or placing normative pressures on teachers to adopt them. Instead, the local IGI must also encompass teachers' practices and beliefs and consider how leaders and teachers produce and reproduce structures, norms, and beliefs as they engage them.

Methods

Data for our analysis were drawn from a longitudinal mixed methods study that took place between the 2009–2010 and 2012–2013 school years in two medium-sized school districts in the Midwestern US, which we refer to as Auburn Park and Twin Rivers. While Auburn Park is a suburban district serving a predominantly white student population, Twin Rivers is a rural district that serves a large Latina/o and English learner (EL) student population. During the last year of our study, 2012–2013, there were approximately 5900 students enrolled in Auburn Park's 14 elementary schools and approximately 4600 students enrolled in Twin Rivers' 14 elementary schools (see Table 1). (These enrollment figures were comparable across the 4 years of our study.) We used interview data collected in both districts from spring 2011 to 2012, survey data collected in spring 2010, 2011, and 2013, as well as publically-available district policy documents. Below, we describe our data sources and comparative case study approach.

Data sources

Qualitative data

In the first phase of our study, we used interviews with district leaders and school staff members as well as publically-available documents to examine the components

Table 1 Elementary school descriptive statistics for the 2012–2013 academic year

Variable	Mean	SD	Min	Max
Auburn Park (n = 14)				
Number of students	418	91	250	601
Free and reduced-price lunch eligible students (%)	25	18	5	59
White students (%)	82	8	67	92
Latino/a students (%)	6	4	2	16
African American students (%)	5	3	2	13
Twin Rivers (n = 14)				
Number of students	325	98	116	457
Free and reduced-price lunch eligible students (%)	68	24	16	95
White students (%)	47	25	7	89
Latino/a students (%)	45	25	7	87
African American students (%)	4	3	0	10

of each district's instructional guidance infrastructure and to uncover the regulative, normative, and cultural-cognitive dimensions of these components. Interviews were conducted with a total of 41 individuals, 33 from Auburn Park and 8 from Twin Rivers. We interviewed two central office administrators per district, one in charge of elementary curriculum and one focused on mathematics instruction, and we interviewed purposively-selected staff members from a subset of elementary schools.

In Auburn Park, five schools were selected for the interview sample to represent the range of organizational structures for elementary math education in the district, including those with math leaders (i.e., instructional coaches and classroom teachers who were also math specialists) and those without. All five principals were interviewed, and teachers were selected for interviews based on their responses to a 2011 social network survey to include those who often sought out others for math instructional advice and information and those who did not.

In Twin Rivers, two schools were selected that were typical for the district in terms of student demographics (i.e., about half Latina/o and half white). Within each school, the principal and instructional coach were interviewed. In one school, three teachers participated in a group interview. Our interviews in Twin Rivers were constrained to those individuals with whom the district arranged meetings; thus, it is important to note that the nature of this sample may lead to some limitations, as we had far fewer interviews to draw upon in Twin Rivers than Auburn Park, and participants in Twin Rivers were selected by the district specifically for the purposes of our interviews. As we will describe in the findings section, our difficulty in collecting data in Twin Rivers may have been related to the district's top-down leadership approach. Given the differences in the district cases that emerged even with this dataset, however, we believe we have sufficient evidence to present our findings; moreover, we supplemented interviews in Twin Rivers with several follow-up conversations with the district math coach.

All interviews ranged from 30 min to 1 h and were audio recorded and transcribed for analysis. Interviewees were asked about the mathematics curriculum in the district and how mathematics instruction was facilitated in their schools. They were also asked how and why they interacted with other staff members related to mathematics instruction and to describe the content of those interactions. In Twin Rivers, interviewees were also asked how the district had responded to the changing demographics of the community, and what types of programmatic accommodations were made for their growing EL population. To complement the interview data, especially in Twin Rivers, we drew upon publically-available district documents, including instructional policies, curriculum maps, and content standards posted on each district's website.

Quantitative data

In the study's second phase, we used survey data to compare and contrast the two districts and to confirm (or disconfirm) our qualitative findings. This process allowed us to triangulate data sources and ensure that our assertions were appropriate. In Auburn Park, 331 school staff members responded to the survey in

2010, 393 in 2011, and 384 in 2013, for response rates of 81, 95, and 94 %, respectively. In Twin Rivers, 243 staff members responded in 2010, 276 in 2011, and 316 in 2013, with response rates of 68, 71, and 83 %, respectively. The majority of respondents in both districts (69 % in Auburn Park and 63 % in Twin Rivers in 2013) were full-time teachers assigned to single grade levels, and about a quarter of respondents reported teaching multiple grades (24 % in Auburn Park and 28 % in Twin Rivers in 2013).

Although the survey focused on a variety of aspects of the school organization,[1] our analysis focused on those items pertaining to components of the IGI as well as regulative, normative, and cultural-cognitive dimensions that emerged as important in our qualitative analysis. With respect to teacher professional learning (one of the five IGI components) and regulation (i.e., what is required of teachers), we examined the number of professional development hours teachers reported receiving related to mathematics from 2009 to 2010, the year before the districts implemented new math curricula, and 2012–2013, the third year of curriculum implementation. Looking longitudinally at this item allowed us to understand how each district supported teachers' professional learning at a time of math instructional reform. The survey asked teachers to indicate the number of math-focused professional development hours they participated in over the past summer and current school year, with response options of less than 4, 4–8, 9–16, 17–32 h, and 33 or more hours. Given the low number of respondents who participated in more than 9–16 h, we collapsed the last three categories.

With respect to normative dimensions, we examined the extent to which teachers felt they had influence over policy and curricular decisions in their districts and schools, as teacher involvement in decision-making emerged as important in our qualitative analysis. Teachers were asked to rate their level of influence on a scale of 1 (none) to 4 (a great deal) with respect to the following areas: determining which books and instructional materials are used in classrooms, establishing the curriculum and instructional program, determining the content of in-service programs, setting standards for student behavior, and determining goals for improving the school. Because these items were internally consistent (Cronbach's alpha = 0.92 on average for all 3 years of data), we created a factor to examine teachers' reported level of overall influence.

We also examined the de-privatization of teachers' instruction by exploring how often they reported observing, being observed by, engaging in in-depth discussions with, and reviewing student work with other teachers, teacher leaders or specialists, and the school principal, on a scale of 1 (never) to 6 (daily). We focused our analysis on weekly and daily interactions (i.e., scores of 5 or 6) to explore those interactions that were regular and consistent and thus more likely integral to school norms.

Related to cultural-cognitive dimensions, we previously examined teachers' beliefs related to how students learn mathematics, and our findings were an important impetus for the present study, as we explain below. Our survey contained 18 items related to math teaching and learning adapted from the Fennema-Sherman

[1] See http://www.distributedleadership.org/DLS/Instruments.html for a copy of the survey instrument.

Short Form (Mulhern and Rae 1998). Based on a factor analysis of these items, we identified two factors, one related to teachers' beliefs about student learning (Cronbach's alpha = 0.86 on average), and another related to how best to teach math (Cronbach's alpha = 0.82 on average). We present the former here, as we saw significant changes in that variable over time in both districts. That factor included six items, such as "Recall of number facts should precede the development of an understanding of the related operation," and "Students should master computational procedures before they are expected to understand how those procedures work," which teachers rated on a 1–5 Likert scale from strongly disagree to strongly agree. A higher score indicates that teachers reported beliefs aligned with direct instructional approaches (i.e., teacher-centered), while a lower score indicates more student-centered beliefs.

Data analysis

We employed a descriptive case study methodology (Yin 2008) to compare and contrast the two district's IGIs for elementary math education. The district was our unit of analysis, given the importance of the district in developing instructional policy in the US and the differences we observed between our case districts. We acknowledge that by looking at the district level, we may have obscured some between-school differences.

We began by analyzing our qualitative data, including interviews and district policy documents. We conducted two rounds of coding in NVivo 10, the first of which focused on the five IGI components (frameworks, materials, assessments, oversight, and teacher professional learning). After this round of coding, we created a series of content-analytic summary matrices (Miles et al. 2014) to identify similarities and differences between the districts across the five IGI components. At this point, we realized that this comparison did not give us enough information to generate hypotheses about why we observed distinct differences in teachers' beliefs between the districts. Thus, after developing our conceptual framework, we conducted a second round of coding to explore the regulative, normative, and cultural-cognitive dimensions of each district's IGI. At first, we created another series of content-analytic summary matrices to examine these three dimensions within each IGI component. For example, we examined regulation, norms, and cognitive scripts within each IGI component. Through this process, we discovered that these matrices artificially isolated regulative, normative, and cultural-cognitive dimensions, and instead they were often related and influenced one another. Thus, we conducted a series of queries in NVivo to examine the intersections of the three dimensions and identified two key examples of those intersections, which we present below.

Because our interview data were not representative of each district as a whole, we incorporated analysis of the districtwide survey where possible to triangulate our findings. Depending on the item, and whether or not the variable was categorical or continuous, we tabulated percentages across item responses or averages for teachers in each district, respectively, using Stata 13. For example, we examined the percentage of teachers who reported different levels of professional development

and compared these percentages between districts and across time using tests of proportions. In contrast, we examined teachers' reported level of influence, a continuous variable, by calculating means and standard deviations and comparing between districts and across time using cross-group mean-comparison tests. Overall, the survey data were used to supplement our findings from the qualitative data and to either confirm or disconfirm our primary assertions, which we describe in the next section.

Findings

We embarked on this study to solve something of a puzzle with respect to changes in teachers' beliefs about how students learn math from the year before a new mathematics curriculum was adopted (2009–2010) to the third year of curriculum implementation (2012–2013). Specifically, although teachers in both districts reported roughly equivalent beliefs before the implementation of the new curricula, teachers in Auburn Park shifted away from teacher-centered beliefs and toward more student-centered beliefs over time, while teachers in Twin Rivers shifted in the opposite direction (see Table 2; Hopkins et al. 2013).

To understand what might be happening, we compared the various components of each district's IGI for elementary mathematics education, which, as we will show below, were relatively similar. We then unpacked each district's IGI further, and we found new institutional theory to be useful in helping us to peel back the layers of curricular reform in each school system. As such, we report our findings in two steps. First, we describe the five components of each district's IGI for elementary math education as it implemented a new curriculum. Then, we explore how the regulative, normative, and cultural-cognitive dimensions of each local IGI worked in interaction.

Instructional guidance infrastructures

Building on prior scholarship (Cohen and Spillane 1992), we consider five components of IGIs (i.e., instructional frameworks, materials, student assessments,

Table 2 Teachers' reported beliefs about how students learn mathematics

	Auburn Park		Twin Rivers	
	n	Mean (SD)	n	Mean (SD)
2009–2010	162	2.67 (0.73)	173	2.60 (0.72)
2010–2011	161	2.54 (0.78)	191	2.78** (0.75)
2012–2013	171	2.43 (0.78)	235	2.81** (0.75)

A higher score indicates more teacher-centered beliefs (i.e., less inquiry-oriented)

** $p < .01$, indicating significant differences between districts in 2010–2011 and 2012–2013

Within-district differences over time were also significant at $p < .05$ or lower

instructional oversight, and teacher professional learning) in each school district, considering their relative similarities.

Frameworks, materials, and assessments

The adoption of statewide K-12 mathematics standards in 2009 prompted both Auburn Park and Twin Rivers to redesign their IGIs for elementary school mathematics (grades K-6 in Auburn Park and grades K-5 in Twin Rivers). Whereas Auburn Park engaged in a standards-alignment process before adopting new elementary math standards, Twin Rivers adopted the new state standards district-wide without modifications. This difference in standards adoption meant that Auburn Park had somewhat different math standards than Twin Rivers, as district leaders in Auburn Park discovered that state and national (i.e., the Common Core) standards were not well-aligned. Georgia, the district's director of elementary curriculum, described the challenge of aligning standards across district, state, and national levels:

> We did the alignment crosswalk, and we were not aligned, let's say between a state standard or a Common Core or a district one … The state is gonna find out very shortly because they have gone to the state board and said that the standards are in perfect alignment with the Common Core, and they are so far apart it's not even funny. So in math we started … that realignment and really delving into these are the indicators that we're teaching. Our district has always taken great pride in the fact that we have our own district standards, but do we align with the state? Do we align with the Common Core?

As a result of this "alignment crosswalk," Auburn Park leaders developed district math standards that they felt were in line with both the state and the Common Core.

The new math standards developed and/or adopted in each district served as guides as district leaders considered the curriculum and materials they would use to teach them. In both districts, a curriculum committee comprised of teachers from across the district worked on curriculum selection and development. In Auburn Park, the team was called the district math "toolbox"; the toolbox was an organizational routine (Feldman and Pentland 2003) that required members to meet regularly and discuss curricular issues. In Twin Rivers, however, teachers volunteered to participate on the committee only during times of curricular adoption.

The districts' processes for selecting instructional materials also differed slightly. While the Twin Rivers committee focused on selecting instructional materials without explicit discussions of their theoretical or conceptual underpinnings, Auburn Park's toolbox first conceptualized the approaches they wanted to emphasize in the curriculum and then undertook materials selection with those approaches in mind. Georgia explained Auburn Park's process: "It's not about, 'Oh, we're gonna adopt these materials and we're gonna teach it just exactly the way it is.' It's because we've identified how we want it taught and what we wanted to teach and then what resources will support that. So we first write our curriculum, and then we decide what [materials] we're going to use." Toolbox members in Auburn Park

first decided "what they wanted to teach" through the adoption of standards, "how they wanted to teach it" with the development of concepts and skills to be addressed at each grade level, and then selected materials to meet these criteria.

As a result of these processes, both districts selected reform-oriented programs (Slavin and Lake 2008), with each taking a different pedagogical approach. Auburn Park adopted *Investigations in Number, Data, and Space*, an inquiry-based program that provides open-ended activities to explore "big mathematical ideas" through an emphasis on problem solving (Stein and Coburn 2008, n.p.). The program's guiding principles are that: "Students have mathematical ideas," "Teachers are engaged in ongoing learning about mathematics content and how students learn mathematics," and "Teachers collaborate with the students and curriculum materials to create the curriculum as enacted in the classroom" (TERC 2013). In contrast, Twin Rivers adopted *Math Expressions*, which "combin[es] a reform math program focus on understanding with a more traditional program focus on skill" (Houghton Mifflin Harcourt 2012, p. 6). Teachers using *Expressions* are asked to begin each lesson by demonstrating and explaining a concept, then encouraging students to practice the concept with teacher and peer support. *Expressions* thus supports more teacher-centered approaches to teaching math than *Investigations*, which heavily emphasizes student-centered approaches.

After selecting materials, each district committee developed unit plans as well as district-level student assessments for each grade level. In Auburn Park, the toolbox matched standards and curricular concepts and indicators to the nine instructional units in *Investigations* and created pacing plans for every grade level, outlining when different concepts should be taught within each unit. To gauge student learning, the toolbox developed nine problem-solving assessments for each grade to be administered at the end of every instructional unit. Similarly, the curriculum committee in Twin Rivers used the new *Math Expressions* materials to develop curriculum maps, which indicated the mathematical concepts that should be taught each quarter, as well as the standards that should be addressed, at every grade level. Additionally, the committee used state math standards to write district quarterly benchmark assessments. In summary, while the processes of adopting standards and developing curriculum maps and assessments were relatively similar in both districts, Auburn Park's curriculum development process was more elaborated than Twin Rivers, and the materials adopted by each district differed in their instructional approaches (i.e., student-centered versus teacher-centered).

Oversight and teacher professional learning

Formal leaders in both districts, including school principals and math coaches, were primarily responsible for the oversight of elementary mathematics instruction. Elementary school principals in both districts completed formal observations in most teachers' classrooms twice per year, though this frequency varied depending on teachers' years of experience. In contrast, coaches in both districts, while at times completing formal observations, engaged in co-teaching and modeling to support teachers' use of the new mathematics curricula. Whereas Twin Rivers had one math coach assigned to all eight of its Title I elementary schools, Auburn Park's coaching

model changed over time, with three full-time coaches assigned to individual schools during the 2010–2011 school year and then to multiple schools by the 2012–2013 school year. Kathy, the Twin Rivers math coach, talked about her work: "The most valuable way to make a difference in implementation [of *Math Expressions*] is through co-teaching and planning with teachers. So I have been really busy this year either teaching or pulling small groups or going in and station teaching." This sentiment was echoed by all three coaches in Auburn Park.

With respect to teacher professional learning, both districts engaged in an ongoing professional development initiative to prepare select teachers as math specialists. A local university partner offered the program, and participants took courses over an 18-month period that focused on deepening their knowledge of the core math topics necessary to support an inquiry-based approach. While Auburn Park had 13 participating teachers between 2009–2010 and 2012–2013, Twin Rivers had nine participating teachers in the same period. The program's premise was that participants would return to their schools as math specialists, either as regular classroom teachers or math coaches, and serve as sources of advice and information related to mathematics instruction. The program thus provided both formal and informal learning opportunities in that it intended to support participants in the program as well as teachers with whom program participants interacted. Our prior work (Hopkins et al. 2013; Spillane and Hopkins 2013) shows that this initiative did indeed shift teachers' interaction patterns related to math instruction. In addition, monthly professional development workshops at each school provided formal teacher learning opportunities related to the new math curricula. In Auburn Park, toolbox members were in charge of delivering professional development. They developed workshops with district leaders, and then went back to their school sites to provide the training.

Teachers in Twin Rivers were also offered full-day professional development, which occurred twice per semester at their school sites. Principals organized each workshop, but teacher leaders, including the math coach and math specialists, were the primary facilitators of the meeting. Overall, teachers in Auburn Park reported participating in more professional development hours related to mathematics over

Table 3 Teachers' reported hours of mathematics professional development

	Auburn Park			Twin Rivers		
	Fewer than 4 h	4–8 h	9 or more hours	Fewer than 4 h	4–8 h	9 or more hours
2009–2010	65 % (201)	19 % (59)	16 % (50)	60 % (133)	21 % (46)	19 % (42)
2010–2011	48 (176)	31 (113)	22 (81)	48 (124)	30 (78)	23 (59)
2012–2013	43 (156)	30 (108)	28 (100)	63*** (185)	21 (61)	18 (49)

Each cell includes the percentage and the number (n) of teachers who reported that level of professional development

*** $p < .001$, indicating the proportion of teachers receiving fewer than 4 h of professional development in 2012–2013 was significantly higher in Twin Rivers than Auburn Park

time than teachers in Twin Rivers. In 2009–2010, the year before the new math curricula were implemented in each district, teachers in both districts reported receiving about the same amount of professional development, with 60–65 % of teachers reporting fewer than 4 h, and 16–19 % of teachers reporting 9 h or more (see Table 3). These figures shifted in both districts by 2010–2011, the first year of curriculum implementation, with teachers reporting more math professional development hours. Whereas Auburn Park sustained this increase in professional development hours in 2012–2013, the number of hours teachers reported in Twin Rivers shifted back to pre-implementation levels. Specifically, 63 % of Twin Rivers teachers reported receiving fewer than 4 h of math professional development, compared to just 43 % in Auburn Park, a difference in proportion that is statistically significant. Thus, while the districts followed similar structures to support teacher professional learning, Auburn Park teachers had more exposure to formal professional development in math over the first few years of curriculum implementation.

Both districts also had organizational routines in place to support teacher collaboration and professional learning. In Auburn Park, teachers were required to participate in professional learning communities (PLCs) with their grade-level team members once per week for 45 min, where they had discussions related specifically to instruction and its improvement. The general topics for PLCs were set by the district and relayed through the school principal, with one meeting per month focused on language arts, one on mathematics, one on student concerns, and one on any instructional issue the PLC wanted to discuss. These meetings were required in addition to any meetings each grade-level team held related to instructional planning or pacing. In Twin Rivers, school schedules were shortened 1 day per week to give teachers 1 h to meet in grade level teams. Unlike Auburn Park, the district did not regulate topics for these meetings, and it was left up to teachers to decide what to discuss.

In general, both districts' IGIs for elementary math education were relatively similar. Each district adopted new math standards and selected reform-oriented materials, and they developed unit plans and student assessments to gauge student's progress. Moreover, teachers in both districts were monitored by their principals, provided support from coaches and math specialists, and offered professional development. They also had opportunities to collaborate and learn from their colleagues in grade-level teams.

Still, there were a few key differences. First, IGI components were more aligned in Auburn Park than in Twin Rivers. In Auburn Park, the math toolbox was responsible for standards adoption, curriculum development, materials selection, and professional development related to math, which supported alignment between frameworks, materials, assessments, and teacher professional learning. Second, Auburn Park offered both increased and sustained professional development related to math, which is important for supporting teacher learning and capacity building (Darling-Hammond and McLaughlin 1996; Lytle and Cochran-Smith 1994). Third, the materials adopted by each district differed, with Auburn Park selecting materials that supported a more student-centered pedagogical approach than Twin Rivers.

These differences help to explain, at least in part, why teachers' beliefs about student math learning moved in opposite directions in the districts. That is, it could be that Auburn Park teachers shifted toward more student-centered beliefs, and Twin Rivers teachers toward more teacher-centered beliefs (see Table 2), because of the materials they were asked to teach, the level of supports they were provided in using them, and the extent to which the materials aligned with other IGI features. Still, after examining the IGI components in each district, it was not entirely clear *how* these components worked together (or not) to support changes in teachers' beliefs, and we were not yet convinced we had solved the puzzle related to why teachers' beliefs moved in opposite directions. We thus extended our analysis by turning to an exploration of the regulative, normative, and cultural-cognitive dimensions of each district's IGI.

Regulative, normative, and cultural-cognitive dimensions

In this section, we consider the regulative, normative, and cultural-cognitive dimensions of each district's IGI for math education, and examine how these dimensions worked in tandem (or tension) to support (or constrain) the development of teachers' beliefs. We first explore how these dimensions interacted at the district level, and then within schools.

Bureaucratic control, shared governance, and beliefs about mathematics at the district level

Auburn Park

Norms at the district level in Auburn Park supported shared governance and teachers' involvement in decision-making as their IGI for elementary math education was designed and redesigned. District leadership supported teachers' direct involvement in decisions related to curriculum implementation, as Georgia described: "Our assistant superintendent for curriculum and instruction and the one prior to him had a good, clear vision of how curriculum, instruction, and assessment really had to work together and the power of teachers and that teacher leadership." The primary method used to engage teachers in leadership was through the curriculum toolboxes that met monthly to make decisions related to standards adoption and materials selection, to develop the district's mathematics curriculum. William, the toolbox leader, described their work:

> They [toolbox members] took those *Investigations* resources and developed our UBDs Understanding by Design) for each of the units at each grade level. The UBDs include learning targets, which … are our standards, and then the concepts and indicators associated with that unit are developed, like your guiding questions, your big understandings, all of your resources, and a suggested pacing.

William described toolbox members' responsibilities with respect to curriculum implementation, responsibilities that were regulated by district leaders. In this way,

a norm of shared governance was supported through district regulations, suggesting that normative and regulative IGI dimensions worked in tandem.

The emphasis placed on teacher decision-making in Auburn Park sometimes meant that district leaders' ideas about the math curriculum were overruled. Georgia described how sixth grade representatives of the math toolbox selected materials that she did not believe aligned as well with the student-centered curriculum, but that she supported because of the district's norm of shared governance:

> [In grades] K-5 our teachers went with a total inquiry-based model. Sixth grade went with a very traditional model, and philosophically I don't agree with the program that they selected. But, we had made some decisions as a team. We knew what the research said and we knew the kids had to be actively engaged, they had to be in an inquiry model. We had those parameters, and they knew going in that was the expectation. So they selected the resources to teach the curriculum, and they are spending an amazing amount of time making inquiry-based lessons. And so I could let them make that decision because I knew philosophically the work would be done to get to where we needed to be.

Because the *Investigations* program focused on grades K-5, the sixth grade team had to select other resources, and they were given the freedom to select the materials they felt best supported the district math curriculum. Even though the sixth grade materials were not as student-centered as *Investigations*, the sixth grade toolbox spent an "amazing amount to time" designing inquiry-oriented lessons. In this case, the norm of shared governance interacted with the cultural-cognitive dimension, and the toolbox acted within those norms to support the district's philosophy related to how math should be taught.

Relatedly, we found evidence that district leaders attended to the cultural-cognitive dimension to ensure that toolbox members supported student-centered beliefs about mathematics teaching and learning. As the district began its curricular reform process in 2009, Georgia undertook an extensive vetting process to select new toolbox participants. Prior to that time, principals nominated teachers who they viewed as strong teachers and instructional leaders in math, and district leaders selected among those nominees to include at least two teachers from every grade level and one teacher from all 14 elementary schools. The rationale behind this process, according to Georgia, was that it "allowed for vertical alignment of the curriculum, and it ensured that similar content was taught across schools."

As the district began to engage in curricular reform, however, principals and district leaders expressed concern that some of their schools did not have any teachers with both the necessary content knowledge and leadership capacity to engage effectively on the mathematics toolbox. As such, Georgia "revamped" the toolbox, administering a survey that asked principals to rate teachers' mathematics instruction and using these data to select the highest scoring teachers. The result of this process was that some teachers were asked to leave the toolbox, and others asked to join, resulting in only 10 of the 14 elementary schools being represented. By selecting teachers to serve on the toolbox who supported the district's emerging

student-centered philosophy, district and school leaders used their regulative authority to augment the cultural-cognitive dimension of the IGI.

Even though these changes resulted in a toolbox whose members were perceived to be well-aligned with "best practices" in mathematics, as William put it, district leaders provided professional development to so that the toolbox could develop a common vision of elementary math education. As a result of that training, district leaders trusted the toolbox to make decisions that were aligned with the cognitive scripts they supported, as Georgia described: "You have to be willing to sit back. When you let teachers make decisions you have to do the background and build that capacity so they make the best choice." Georgia acknowledged the need to "build that capacity," which they did prior to asking the toolbox to make any decisions. Of note is that Auburn Park leaders also made explicit efforts to select participants for the university professional development program who were on the toolbox, thereby selecting individuals for the program who already aligned with the district's approach. Again, district leaders used their regulative authority to support a norm of shared governance as well as cognitive scripts related to student-centered and inquiry-oriented mathematics instruction.

Although the toolbox was officially in charge of curricular decisions, district leaders used regulative authority when there were too many viewpoints expressed. At one point when the toolbox struggled to reach consensus around the new standards, curricular units, and assessments, William described how district leaders scaled back to just a few members who were assigned to the work:

> One thing I found out with working with these toolboxes is you have the best of the best teachers in that room; that's who we pick to be on those toolboxes, but they don't always all share the same philosophy. And when you get together in that group and give 'em a task and here's what we're gonna do, when I go back the next day and look at the product of what they did I could have seven grade levels and seven totally different looking outcomes. So the magnitude of the task that was looking at us this year with getting everything aligned, trying to do that with the entire toolbox just seemed way too overwhelming and we had to narrow it down a little bit. So that's kinda why we handpicked certain individuals.

While Auburn Park leaders included teachers in the IGI design process, they also exerted control to ensure the curriculum was developed in a manner that aligned with the district's focus on student-centered math instruction.

Table 4 Teachers' reported level of influence in policy and curricular decisions

	Auburn Park		Twin Rivers	
	n	Mean (SD)	n	Mean (SD)
2009–2010	254	2.60 (0.65)	171	2.39** (0.51)
2010–2011	298	2.49 (0.65)	191	2.26** (0.52)
2012–2013	292	2.59 (0.55)	235	2.33** (0.56)

** $p < .01$

Twin Rivers

In contrast with Auburn Park's emphasis on shared governance, Twin Rivers supported more hierarchical decision-making. These differences were evident in our analysis of the survey data, which indicated that teachers in Auburn Park reported higher levels of influence in policy and curricular decisions than teachers in Twin Rivers (see Table 4). While there were no significant changes in teachers' reported level of influence in either district, differences in teachers' average level of influence were significant between districts in every year of our study.

Like Auburn Park's toolbox, Twin Rivers had a mathematics curriculum committee comprised of 12 volunteer teachers, two from each grade level. Although this committee was in charge of selecting instructional resources and developing curriculum maps and quarterly assessments based on state standards, it was not responsible for standards adoption or professional development. Standards adoption was decided by district leaders, and professional development was left up to principals, who worked with the math coach and math specialists to develop workshops. Moreover, teachers on the Twin Rivers committee only met during times of curricular adoption, which occurred about every 5 years. According to Kathy, the math coach, the superintendent asked the committee to choose a curriculum that supported the newly-adopted math standards through student-centered approaches and was demonstrated to increase student achievement. The committee then outlined a set of criteria for the math curriculum and applied them in their review and selection process:

> We ordered several sample resource kits from different companies. The secondary math coach and I looked through the resources and narrowed the choices down. We met several times as a team to look through materials and discuss our thinking. The choice was then narrowed down to *Trailblazers* (Hunt, 2014) and *Math Expressions* (Houghton Mifflin Harcourt, 2012), the two we felt were the most student-centered programs. We had reps from both companies come and talk to us and voted again.

Once the committee selected materials, district policy required the committee to present them to the superintendent for approval. Upon approval, the committee worked together to develop curriculum maps for each grade level K-5 that served as guides to teaching the materials and the standards, and they wrote quarterly student assessments that aligned with the state standards.

The ad hoc committee structure in Twin Rivers differed from Auburn Park, where the toolbox was established as an organizational routine to support ongoing curricular development, even when there was no active curricular adoption. Also, Auburn Park leaders supported the development of the toolbox's knowledge of research related to mathematics instruction and then turned over decision-making to the group. In contrast, the superintendent in Twin Rivers had the final say in curricular decisions, and he did not support professional development for the committee related to his vision for math instruction. The absence of professional learning opportunities likely limited the extent to which Twin Rivers committee members developed shared understandings about math instruction before beginning

the curriculum review process. Additionally, the university professional development program was implemented in Twin Rivers as a disconnected add-on to other initiatives. Whereas Auburn Park ensured that participants were also on the toolbox, district leaders in Twin Rivers did not take part in selecting teachers to participate in the program. Instead, teachers applied directly to the university, and university faculty selected participants among the applicant pool.

Overall, district leaders in Twin Rivers used regulative authority to mandate math standards adoption and to select materials, then they allowed teachers to "implement state standards any way they choose" in their classrooms, as the district math coach indicated. This norm of teacher autonomy, as opposed to shared governance, likely worked in tension with the implementation of a districtwide math curriculum. Given that teachers were not actively engaged in making curricular decisions, nor was teachers' professional learning attended to, teachers in Twin Rivers may have rejected the new curriculum or taken it up in the classroom in ways that were not originally intended. For example, as an overall approach, the *Math Expressions* materials state that teachers should begin lessons by introducing and demonstrating a mathematical concept, then have students work collaboratively on a task related to that concept. If teachers had no training or prior experience related to the latter, they may have focused primarily on the teacher-centered aspects of the lesson and become discouraged from taking up or believing in the student-centered components (Whitney et al. 2008). In other words, the regulative, normative, and cultural-cognitive dimensions may have worked in tension at the district level in Twin Rivers in ways that shifted teachers' beliefs toward more teacher-centered approaches.

Regulation and the de-privatization of instruction within schools

At the school level, norms in Auburn Park fostered teachers' collective work with one another and with teacher leaders around the implementation of the new math curriculum, which facilitated the de-privatization of classroom instruction. In Twin Rivers, teachers tended to work in isolation and had fewer opportunities to collaborate with other teachers or teacher leaders. Our analysis of survey data from 2012 to 2013, when the curriculum had been implemented for 2 years and teachers had time to adjust their practices to new IGI components, suggested that teachers in Auburn Park engaged more frequently in activities that de-privatized their practice than teachers in Twin Rivers. Of note is that Auburn Park teachers reported higher rates of observation from other teachers and specialists than teachers in Twin Rivers (see Table 5). Moreover, while 36 % of Auburn Park teachers reported reviewing student work with other teachers on a daily or weekly basis, only 18 % of Twin Rivers teachers reported this level of engagement. Additionally, 38 % of teachers in Auburn Park reported daily or weekly in-depth discussions of their teaching with coaches, compared to 20 % of teachers in Twin Rivers. Finally, Twin Rivers teachers reported more principal observations than did teachers in Auburn Park, although this may be indicative of the greater number of new teachers in Twin Rivers who required formal teaching observations.

Table 5 Percent of teachers (n) who reported *daily or weekly interactions* with other school staff members, 2012–2013

	Other teacher		Teacher leader or specialist		Principal	
	Auburn Park	Twin Rivers	Auburn Park	Twin Rivers	Auburn Park	Twin Rivers
Observe others	19 % (68)	14 % (42)	8 % (29)	4 % (13)	1 % (4)	4 % (10)
Observe you	18 (65)	12 (36)	10 (37)	4 (11)	3 (10)	13 (39)
In-depth discussions of your teaching	69 (249)	65 (195)	38 (138)	20* (58)	12 (45)	10 (30)
Review student work	36 (133)	18* (55)	15 (53)	7 (21)	5 (18)	4 (12)

Each cell includes the percentage and number (n) of teachers

* $p < .05$, indicating the proportion of teachers reporting this level of interaction was significantly different between the two districts. We include data from 2012 to 2013 only for parsimony, as these figures were relatively similar across all years of the study

Auburn Park

Our qualitative analysis revealed that Auburn Park's PLC organizational routine supported teachers' collaborative work around mathematics instruction in ways that fostered collective decision-making and de-privatization. All of the teachers we interviewed stated that their PLC interactions emphasized curriculum and teaching practice, as opposed to the day-to-day planning that was the focus of other grade-level meetings. Becky, a fourth grade teacher at Chamberlin Elementary, described her focus on curriculum implementation during a PLC: "I had a question about why, why are we doing this [in the new curriculum]? Why does this fit in and can you explain this? It's a method for adding … usually in *Investigations* they give you lots of different methods to add up a problem and it was one of them that I was not exactly sure on." Becky described how the PLC provided a space to receive support and to make sense of the new math curriculum with her colleagues. Similarly, Andrea, a third grade teacher at Ashton Elementary, captured the collaborative and consensus-like nature of PLC exchanges: "We work really well together. We're all open to suggestions and … when you're sinking and you're thinking, 'What else can I do?' somebody comes up with, try this." For Andrea, norms of collaboration and openness dominated the PLC, with colleagues being "open to suggestions" and working "well together." These accounts capture how norms of de-privatized practice and collaboration pervaded the PLC routine in Auburn Park.

The normative dimension of the PLC routine also worked in interaction with the regulative dimension. District and school leaders required, and school principals insisted, that teachers participate weekly in PLCs, and teachers were well aware of these regulations. Katie, a sixth grade teacher at Chavez Elementary, noted: "We get a weekly plan from our principal, and she tells us whether we're talking about assessments that week, or whether we're talking about curriculum." Evelyn, a special education teacher at Kingsley Elementary, was more direct: "It's been in a way mandated. It's kinda like, 'You will work as a team whether you want to or not.

This is your team so figure it out.'" Further, district regulation dictated the topics that PLCs were to work on each week, as described above.

Though school leaders mandated PLC participation and discussion topics, they were not the sources of authority or power in the actual performance of the PLC routine. Brenda, a kindergarten teacher at Ashton Elementary, captured this dynamic:

> Leading the [PLC] meeting kind of depends on what the theme for it is. When I'm talking about my kids I lead the meeting and then everybody kind of pipes in, and we work on things that could help with them. We all put in our two cents worth, so whether it is double scoring or talking about other kids, we all put in our ideas and then kind of come together; it's a collaborative effort

Brenda characterized PLC deliberations through norms of collaboration and consensus, with authority dependent on whoever had expertise. Although principals frequently attended PLCs, they reported putting aside their regulatory authority and not leading PLCs, and instead contributing based on their expertise. Jillian, principal at Bryant Elementary, noted: "My goal is to be at every PLC. I'm a team member, hopefully I'm another resource, another opinion for when we're looking at curriculum, to help guide them, and am definitely not the leader."

Interactions among the regulative and normative dimensions of Auburn Park's IGI, as captured in the PLC routine, were not static; our analysis suggests they shifted depending on time and place. With respect to time, principals reported using regulation differently depending on how the particular PLC functioned. For example, Georgia, the former principal at Bryant Elementary (and later a district leader) explained:

> In the beginning we were very tightly managed, that 'I want you to talk about kids at this time', 'I want double scoring,' and all of that, and so it was more tightly managed in the beginning when we first started to more loosely as teachers started … taking control of their own groups. I attended as frequently as I could, trying to get the groups to be more data driven, be more diagnostic.

Georgia's account captures how, when the PLC routine was introduced at Bryant, the regulatory dimension dominated as she worked to get PLC members to discuss instruction and share their ideas. Georgia went on to say that teachers studied their PLCs in practice using "surveys" and "observations" as well as an outside consultant to "observe our teams and give us feedback." According to Georgia, "in the beginning it was embarrassing" for teachers who did not "want to brag … when you ask them to start sharing ideas, but over time it opened up, people were much more willing." In other words, school norms at the beginning did not support de-privatized practice. Georgia explained that the school's leadership team used this research and their regulative authority "to guide … [and] tighten" the PLCs so that over time new norms took hold. Other Auburn Park principals we interviewed shared similar accounts.

With respect to place, Auburn Park principals openly acknowledged that some PLCs were more effectively than others and reported using their regulatory authority as needed. Evelyn, the principal at Kingsley Elementary, explained:

> Math came out [as a focus of PLCs], especially after the … district kind of said, 'We really think that teams need to work on math.' So we work on communication, problem solving, not just math skills…. I decided to pick a grade level [to participate in their PLC]. The reason why I picked that grade level was because using the [state achievement] testing from last year there weren't very many kids excelling. And so I decided knowing those kids that we could push 'em a little harder and so I joined that team for classroom goals.

Evelyn described how this PLC did not operate in ways that she was satisfied with from either an achievement standpoint or a cultural-cognitive perspective ("not just math skills"). She went on to point out how she used her regulatory authority to treat this PLC differently by making an effort to be present so as to get the PLC performing differently.

Other principals, such as Kelly at Chamberlain Elementary, spoke about using their regulatory authority to hire staff who subscribed to particular beliefs about mathematics teaching and instructional improvement (e.g., "willing to try things"): "A very strong teacher; strong practices across the board. Not just math practices but just strong teaching instruction … somebody who really gets curriculum and is willing to grow with changes and willing to try things." Kelly also explained how using her authority as principal allowed her to "handpick a solid person at each grade level and then work people around them" to grow her PLCs. In short, to understand how the PLC routine, a key component of Auburn Park's IGI for mathematics, supported changes in teachers' beliefs about math instruction, we had to attend to regulative, normative, and cultural-cognitive dimensions and how they interacted over time.

Twin Rivers

In contrast with Auburn Park, the Twin Rivers superintendent believed that individual teachers should make instructional decisions, even though a common curriculum was adopted at the district level. Jen, a teacher at Ash Elementary, noted that teachers rarely engaged with one another around math instructional issues: "Well what I think is our teachers are pretty comfortable with it now. You know, it's not like, 'I don't know what to do.'" Because teachers already "know what to do," they did not feel the need to collaborate or work collectively around the implementation of the new math curriculum. This norm of teacher autonomy meant that grade-level meetings, while scheduled to occur once per week for an hour, only occurred if necessary, as indicated by the learning facilitator at Pine Elementary: "Grade-level meetings are scheduled kind of as needed. If there's not a topic to discuss, we're not gonna meet, there's nothing to meet about. People have plenty of meetings in the first place."

When grade-level meetings did occur, teachers most often focused on developing strategies to meet particular students' needs in mathematics, rather than discussing their approaches to mathematics instruction more generally. Hallie, the principal at Pine Elementary, shared: "I would say that they share overall improvement strategies like, 'Oh if you can get him on the computer … he loved it,' or 'This was

the topic he liked.' They do a lot of that type of thing. There's a lot of willingness to address the needs and to share that." Similarly, a teacher at Ash Elementary explained that student goal setting was a common topic during team meetings: "We talk about, 'So what are your goals? What have you been working on? Can you show me an example of that?' Like if we're student goal setting, 'Hey, show me what you're doing in student goal setting.' And then a lot of questions to see like, 'So what are you gonna do next?'" Thus, the norm in Twin Rivers was to let teachers make their own decisions related to curriculum implementation, and the focus of their joint work, when it occurred, was to improve math instruction for individual students.

Teachers' focus on individual students likely stemmed from the need for school leaders and teachers to respond to a changing student population, as the district shifted to a "majority minority" district serving a large population of Latina/o students and English learners. Rather than focusing on math instructional improvement and maintenance at a time of curricular change, school leaders were focused on developing school cultures that adequately addressed the needs of their culturally and linguistically diverse learners. Hallie, the principal at Pine Elementary, shared her goal to develop cohesiveness and an overall openness to other perspectives among her teachers:

> I would say my struggle is, right now, or my goal would be to be getting staff more cohesive and more on board with seeing things from different perspectives. I have to look at it from the kids' perspective, I have to look at it from the teachers' perspective, I have to look at it from the parent perspective, I have to look at it from district perspective. Now after looking at all of that what is best for the child and how do I make that happen? So getting teachers to see it when they put all their hard work and sweat and tears into something and not understanding why they're not getting the response that they would like, it's easy to blame, or it's easy to say 'Oh, it's because they don't speak English' or 'It's because they aren't involved.' Well, it could be lots of other things. So seeing that as a whole I think would be my goal.

Hallie went on to say that, before she could focus on content-specific instructional issues, she needed to attend to teachers' perspectives about their students and ensure that they were all on the same page with respect to supporting their needs. Hallie also noted that her school's culture was the result of "a lack of participation" from teachers as "times changed and things got harder and looked different." Thus, a positive, participatory culture needed to be cultivated among teachers before instructional improvement efforts could ensue.

Whereas Auburn Park principals described hiring new teachers who would support a student-centered approach to teaching math, the principal at Ash Elementary in Twin Rivers, John, shared that his focus was on hiring teachers who had positive attitudes about students and could take on the "challenge" of working with them:

> When I ask certain questions about their character, and if they teach children also from the heart. We think about what it is, their experience of working with kids, do they want the challenge of working with kids? Knowing that you are

> going to always have the pressure more than a lot of places getting the kids to proficiency and what's mandatory with AYP and such. But you can pretty much figure that to be at Ash School to be hired here that you would not only have the strengths, the background knowledge from student teaching experience if you're a brand new teacher or whatever but, you have to have compassion and be able to express that compassion for wanting to be the best for kids.

John's first priority was finding compassionate teachers who could both care for students and work under the pressure of federal and state policies that mandated test score improvement.

Overall, the norm of teacher autonomy and the cognitive scripts that revolved around individual student needs in Twin Rivers did not support teachers' collective engagement with the math curriculum, limiting the extent to which teachers had opportunities to learn about and improve their instruction. Moreover, as demographics shifted and principals saw a lack of teacher engagement, their focus was on developing positive perspectives about the new student population among teachers, rather than on facilitating mathematics curriculum implementation. These foci meant that normative and cultural-cognitive IGI dimensions were in tension with the regulatory dimension of Twin River's IGI for math education, which prescribed teacher implementation of new math standards and materials.

In Auburn Park, although the district served a predominantly white population, their EL population was increasing slowly, and district leaders were concerned about meeting ELs' needs. In contrast with Twin Rivers' response, however, which focused squarely on individual students, Georgia described how Auburn Park leaders integrated EL experts into their curriculum development work:

> Where we've had the gap [between ELs and other students] is in math. We did not serve our ELs in the area of math. I'm sure this was not surprising to anybody … we did not meet AYP and we were identified as not meeting standards in the area of math for our ELs. So we had to write a plan. So what we've done is bring in our EL folks and have them work within that curriculum, integrating EL within the math toolbox. So really everybody is involved. And again we decided to have our EL folks at the table from the beginning rather than a secondary group.

In response to "not meeting AYP" for ELs, district leaders integrated EL experts onto the math toolbox instead of having them meet as a separate group. District leaders thus kept the math curriculum at the core of their work and integrated students' needs within it, further bolstering interactions between regulative, normative, and cultural-cognitive dimensions.

Discussion and conclusion

Our paper sketches an analytic framework for understanding how IGIs components can support (or constrain) changes in teachers' beliefs about mathematics instruction, which prior research has associated with changes in teachers'

instructional practice in math (e.g., Peterson et al. 1989; Stipek et al. 2001). While IGIs can look similar in terms of their component parts and even in terms of the alignment among these various components, the ways in which they function on the ground can look rather different. We argue that attending to how regulative, normative, and cultural-cognitive dimensions of IGIs work in interaction can help us theorize reasons for these differences.

Our findings suggest that IGI components can influence teachers' beliefs about instruction to the extent that they enable (or constrain) leaders' and teachers' work practices, and that these practices are shaped by regulative, normative, and cultural-cognitive dimensions. We use the term practice here not to refer to instructional practice inside classrooms, though that is clearly important, but instead to refer to those interactions that occur among school leaders and teachers as they engage in the work of providing instruction as well as maintaining and improving its quality. Examples of work practice include interactions between district administrators and teachers as new curricular materials are reviewed and selected, or interactions within grade-level teams as they work collaboratively to incorporate new materials into their instruction. Our analysis showed that instances of practice must be understood within an institutional context that is shaped by formal structures and regulations—as well as by norms about how work is to be accomplished and beliefs about what should be taught and how—as these factors facilitate practice just as they are taken up and transformed through practice (Hallett and Ventresca 2006; Scott 2007).

Such is the "duality of social structure" (Giddens 1984, p. 25), with the IGI serving as both a framework that guides practice, to the extent that people use it in their interactions with one another, as well as a product of practice. In this interactive view, organizational members are regarded as experienced and capable of effecting change on the social order (i.e., structures and rules) while at the same time their interactions are shaped by the very same social structures (Scott 2007). This perspective allows us to see how IGIs, through their various components and as enacted through institutional dimensions (i.e., regulations, norms, cognitive scripts), can enable (or constrain) sense-making (Coburn 2001, 2005; Spillane et al. 2002, 2006) among local actors. For example, the toolbox and subsequent activity structures at the district level in Auburn Park, as well as the PLC routine at the school level, enabled teachers and leaders to engage in robust collective sense-making around curricular reform in mathematics. These regulated activities, that took place within district-wide norms of shared governance, offered an interactive space for school leaders and teachers to make sense of the teacher-centered curriculum and to incorporate it into their cognitive scripts. While these activities allowed leaders and teachers to participate in developing IGI components, they also promoted deep understanding and alignment across actors that facilitated a new vision for math teaching and learning. Leaders' and teachers' work practices and interactions related to elementary math instruction were shaped by the institutional structures and regulations, while at the same time these practices shifted normative and cultural-cognitive dimensions as leaders and teachers engaged in collective sense-making.

In our two school districts, the IGIs influenced teachers' beliefs about how mathematics are taught *through their use in everyday practice*. Our findings reveal

that IGIs can be influential to the extent they are taken up and used, or produced and reproduced, in practice. Particular IGI components (e.g., curriculum materials, organizational routines, etc.), the characteristics of these components (e.g., coherence, prescriptiveness, etc.), and the functions they address or serve (e.g., teacher learning, instructional reform, etc.) are important. Still, the extent to which IGIs shape teachers' beliefs depends on more than these components, characteristics, and functions. They ultimately depend on how the normative, regulative, and cultural-cognitive dimensions of IGIs influence practice on the ground inside schools and school systems.

While most prior work has focused on making direct connections between various IGI components and instructional practice, or on just one dimension of the district or school at a time (regulation, norms, cognitive scripts), our findings show the critical importance of examining these dimensions in interaction rather than in isolation, though which dimension comes to the fore varies over time and place. Further, our account reveals how IGI components (e.g., curriculum materials, standards, assessments, organizational routines) work in interaction, and that focusing on any one component (e.g., curricular materials, professional learning) and its association with instructional change is inadequate. Ultimately, any examination of IGI implementation should consider not just how the IGI supports changes in classroom practice, but also changes in district- and school-level practices as observed in the interactions among district and school leaders and teachers. This is essential if we want to understand the mechanisms at play in relations between IGI components and classroom practice.

To illustrate, consider how regulative, normative, and cultural-cognitive dimensions of the PLC routine in Auburn Park influenced the practices that school leaders and teachers engaged in around the new math curriculum. Our analysis of the PLC routine revealed norms of collegiality and collective sense-making, but it also implicated several other components of Auburn Park's IGI including (but not limited to) the mathematics curriculum that the district mandated for all teachers, the student assessments developed by the district toolbox that all teachers were required to give and use, the positional authority of the school principal, and so on. These components worked in tandem to facilitate teachers' work practice around student-centered mathematics instruction as outlined in the new curriculum, which in turn influenced teachers' cognitive scripts around how students should learn mathematics.

In contrast, our analysis in Twin Rivers showed how regulative, normative, and cultural-cognitive dimensions can work in tension. While the district used regulation to enforce the adoption of math standards and the implementation of a new math curriculum, district norms of teacher autonomy meant that teachers were not involved on an ongoing basis in curriculum development. The tension between the regulative and normative dimensions of the IGI contributed to the limited influence that various IGI components had on leaders' and teachers' interactions. Moreover, while the district increased support for teacher learning about math instruction initially, they did not sustain that support, which likely influenced the extent to which teachers interacted with one another and limited opportunities for collective sense-making. Overall, district and school norms and cognitive scripts in Twin Rivers were not adequately supported during the curricular change. Indeed, our evidence suggests

that the tensions inherent in Twin Rivers' IGI may have pushed teachers to use the new math materials in such a way that emphasized teacher-centered approaches, as they had few opportunities to engage in collaborative work practices that might have shifted their cognitive scripts in another direction.

It is also important to remember that Auburn Park and Twin Rivers served very different student populations, which likely shaped how the regulative, normative, and cultural-cognitive dimensions of the IGI interacted. Specifically, given that Twin Rivers was a district struggling to serve a changing student population, school leaders and teachers focused on addressing individual students' needs, which seemed to take away from content-centered instructional improvement. While most districts are like Twin Rivers and employ an add-on approach to serving ELs, Auburn Park integrated their EL curriculum into the content areas at the district level, which likely allowed district leaders to continue to take up regulative, normative, and cultural-cognitive dimensions in interactive ways. Still, given that Twin Rivers is similar to many school districts across the US, more research is needed to understand how to undertake instructional improvement efforts that take all three dimensions into account, while also responding to changing student demographics.

Overall, our analysis shows the need for educational reformers to take a step back when designing or developing instructional guidance infrastructures to consider not just how various IGI components will facilitate change or improvement in instruction, but also how these components will influence district- and school-level practice among leaders and teachers. Such considerations must be made with regulative, normative, and cultural-cognitive dimensions in mind in order to identify possible interactions and/or tensions that could support or limit IGI implementation and its influence. These interactions and tensions must be addressed if improvement efforts are to be taken up and maintained. In this way, our study reveals the ways in which new institutional theory can provide a diagnostic frame for school reform efforts. It also shows how new institutional theory and sense-making theory can be collectively drawn upon to more fully understand how IGIs influence teachers' beliefs about instruction.

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