Influence of the School Context and Coach Characteristics on the Extent to Which Coaches are Central in Teachers' Social Networks

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Structured Abstract

Purpose
The findings of a number of studies indicate collegial relationships and access to colleagues with instructional expertise are important supports for teachers' learning and school improvement. Many district instructional improvement initiatives include content-focused coaching as a primary form of job-embedded support for teachers. In this study, we investigated what influences a key dimension of coach effectiveness, coaches' centrality within teachers' social networks.

Research Methods
We analyzed social network and interview data collected in seven middle schools in an urban district to identify coach characteristics and aspects of school context that influenced the extent to which mathematics coaches in these schools were central in mathematics teachers' social networks.

Findings
We found that in schools where coaches were central in teachers' networks, coaches worked with groups of teachers to examine instructional issues during regularly scheduled teacher collaborative meetings. Additionally, we found that the practices of principals influenced the extent to which coaches were central. In the schools where coaches were central, principals regularly attended mathematics teacher collaborative meetings, observed classroom instruction, and met with coaches one-on-one to discuss teachers' instructional practices.

Implications
Findings indicated that many factors influence coach centrality in teachers' networks. Importantly, despite the emergent quality of social networks, some of these factors may be influenced by district policy, including pressing principals to regularly: (a) attend teacher collaborative time, (b) observe classroom instruction and provide feedback, and (c) meet with the coach to support teachers in improving the quality of instruction.

Keywords
social networks, centrality, coaching, leadership

Type of Paper
empirical

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Introduction

There is increasing evidence that teachers' professional communities and access to expertise play an important role in instructional improvement (Coburn & Russell, 2008; Coburn, 2001; Elmore, Peterson, & McCarthey, 1996; Frank, Zhao, & Borman, 2004; Louis, Marks, & Kruse, 1996; Penuel, Riel, Krause & Frank, 2009). Many district reform initiatives include both time for teachers to work together and content-focused coaching as primary forms of job-embedded support (Coburn & Russell, 2008; McLaughlin & Talbert, 2006; Poglinco, Bach, Hovde, Rosenblum, Saunders & Supovitz, 2003; Neufled & Roper, 2003; Darling-Hammond, Wei, Andree, Richardson & Orphanos, 2009). In this study, we investigated a mathematics coaching design in which coaches were intended to play a central role in supporting the improvement of middle-school mathematics teaching in an urban district.

The data for this study comes from the second year of a four-year study in which we investigated how changes in the school and district settings in which mathematics teachers work influence their instructional practices and students' mathematics achievement. The four collaborating districts were attempting to implement ambitious, inquiry-oriented mathematics curricula in the middle grades. Effective implementation required that most mathematics teachers in the four districts reorganize their instructional practices, rather than merely adjust and elaborate their current practices. All four districts provided content-focused coaching to support teachers in reorganizing how they taught mathematics and using adopted instructional materials effectively.

The analysis we report focused on the centrality of school-based middle school mathematics coaches in the schools that they served in one district (District B). We focus on District B because the school-based mathematics coaches were expected to become a central source of expertise for teachers on matters of mathematics instruction. District leaders intended that coaches would support all mathematics teachers in the schools they served. Principals at each middle school had selected a mathematics teacher to become a coach. The coaches received extensive professional development and taught for the first half of each day and coached teachers during the second half of the day.

Based on a review of the relevant literature, we developed conjectures about school and coach characteristics that might influence whether middle-school mathematics coaches become a central source of expertise (i.e., a majority of teachers turn to the coach for advice or information about teaching mathematics). We then analyzed social network and interview data to examine how central the seven coaches were in teachers' social networks and identify what influenced their centrality. We provide evidence that specific aspects of school-level contexts, including time to meet with groups of teachers to collaborate on matters of instruction and support from the principal, influence coaches in becoming a central source of expertise. These findings clarify how district and school leaders can create conditions for coaches to be central sources of expertise for the teachers in their schools.

Content-Focused Coaching

Content-focused coaching is a primary mechanism for providing teachers with access to a colleague who has already developed relatively accomplished instructional practices. (Poglinco, et al., 2003; Neufeld & Roper, 2003). The findings of several studies indicate that teachers' access to instructional expertise is associated with instructional improvement (Author, 2012;

Frank, et al., 2004; Penuel, et al., 2009), and researchers who have examined teacher professional development argue that teachers' co-participation in activities of sufficient depth with an accomplished colleague is critical to their development of ambitious instructional practices (Author, 2008; Borko, 2004; Franke & Kazemi, 2001; Kazemi & Franke, 2004; Wilson & Berne, 1999).

Although an increasing number of districts are expending significant resources to implement coaching designs, the empirical and theoretical literature on content-focused coaching is very limited. Only a few studies have assessed the direct impact of content-focused coaching on instruction and learning, and the results from such studies have yielded mixed results (Garet, Porter, Desimone, Birman, & Yoon, 2008; Neufeld & Roper, 2003; Ross, 1992). While some studies indicate that content-focused coaching can have a positive effect on the development of teacher efficacy, implementation of new instructional techniques, and student achievement (Campbell & Malkus, 2011; Cantrell & Hughes, 2008; Marsh, McComb, Lockwood, Martorell, Gershwin, & Naftel, 2008; Matsumura, Garnier, & Resnick, 2010; Ross, 1992; Sailors & Price, 2010), other studies showed no effect on instructional improvement (Gamse, Jacob, Horst, Boulay, & Unlu, 2008; VanKeer & Verhaeghe, 2005). The research evidence might be mixed at least in part because of variation in the implementation coaching designs. For example, the amount and type of coaching that teachers receive has been shown to be substantively different across schools within a district (Matsumura, Sartoris, Bickel, Garnier, 2009; Coburn & Russell, 2008). As a consequence, the forms and quality of support that teachers in different schools receive from mathematics coaches can vary widely. In this regard, coaching policies and programs appear to be susceptible to the same range of influences as other educational reforms (Coburn, 2001, 2006; Coburn & Stein, 2006; Matsumura, et al., 2009). An important first step in

understanding the variation in the effectiveness of coaching designs is to examine what influences the extent to which coaches become a central source of expertise in schools.

Coach Characteristics and School Context

The current research literature indicates that several coach characteristics and aspects of school context influence the implementation and success of content-focused coaching designs. These potential influences include: the coach's expertise in matters of mathematics instruction, the teachers' perceptions of the coach as someone who is capable of assisting them, time for coaches to meet with groups of teachers, and the amount and type of support that coaches receive from principals.

Coach Characteristics

Coach expertise in matters of mathematics instruction. There is evidence that teachers' access to instructional expertise is critical in improving the quality of instruction (Coburn & Russell, 2008; Penuel, et al., 2009). We therefore examined whether coaches who have developed the types of instructional practices that are the focus of a district's instructional improvement effort are more central in teachers' social networks than are coaches whose instructional practices are less accomplished.

Teachers' Perceptions of the Coach. We also investigated the possibility that teachers' *perceptions* of coach expertise are influential but that teachers use criteria other than the alignment of coaches' instructional practices with the goals of the instructional improvement effort to assess their instructional expertise. There is evidence that teachers turn to others who they perceive as having instructional expertise for advice (Burkhardt & Brass, 1990; Spillane, Hallett, & Diamond, 2003). Prior research also indicates that teachers' perceptions about others'

role competence, in this case whether a coach is skilled at sharing his or her expertise, may influence whether a teacher turns to a coach (Borgatti & Cross, 2003). In addition, there is evidence that people's prior relationships influence the formation of network ties (Bryk et al., 2010; Coburn & Russell, 2008). We therefore examined the following aspects of teachers' perceptions of the coach: (a) teachers' perceptions of the coach's instructional expertise, (b) their perceptions of the coach's coaching ability, and (c) their prior history with a coach.

Time to Meet with Groups of Teachers

Trust is conjectured to be an important characteristic of teachers' social networks because it prompts the sharing of information in social interaction (Adler & Kwon, 2002). Trust between teachers and coaches is a necessary condition for them to discuss the changes in practice demanded by ambitious instructional reform efforts (Coburn & Russell, 2008; Tschannen-Moran & Hoy, 2000). The findings of several studies indicate that professional learning communities can support the development of trust necessary for risk taking (Bryk & Schneider, 2002; Louis, et al.,1996; Newmann, King, & Youngs, 2000). An increasing number of districts, including the district examined in this study, are attempting to foster school-based professional learning communities (Horn & Little, 2010; Hargreaves, 2007). We conjectured that regularly scheduled time during the school day for teachers to collaborate regularly with a coach might support the establishment of relational trust and thus influence teachers' decisions to seek instructional advice from the coach. We therefore examined whether teacher collaborative meetings influenced the centrality of coaches within teachers' social networks.

Support Provided by the Principal

Several prior investigations of content-focused coaching indicate that coaches require the support of school principals to effectively perform their responsibilities (Grant & Davenport,

2009; Mangin, 2005; Smylie, Conley & Marks, 2002; Youngs & King, 2002; Marks & Printy, 2003). Mangin (2007) found evidence of a link between principals' knowledge of the role of the coach, their communication with the coach, and their support for coaching. In her study, principals who were highly supportive repeatedly communicated an expectation of instructional improvement to teachers and emphasized that teachers should work with their coach to meet these expectations. Matsumura and colleagues (2009) found that principals' beliefs regarding the coach's role and responsibilities were associated with the frequency with which teachers opened their classrooms to a coach. They also found that principal leadership (defined as actively participating in the content-focused coaching program and publicly endorsing the coach's instructional expertise) was significantly associated with the frequency with which teachers conferred with the coach and were observed by the coach as they taught reading comprehension lessons.

In addition to attending professional development about the coaching program (Matsumura et al., 2009) and publicly endorsing the coach (Mangin, 2007; Matsumura et al., 2009), we conjecture that three further principal practices might influence the extent to which a coach is central in teachers' social networks. These additional practices are: observing teachers' instruction, attending teacher collaborative meetings, and meeting regularly with the coach to discuss the needs of individual teachers. We therefore documented each of these aspects of the participating principals' practices as instructional leaders.

Teacher Social Networks

In many coaching designs across the US, the coach is expected be a central source of instructional expertise for all teachers in a particular content area. Penuel et al. (2009) suggested that social network analysis of teachers in a school offers a method for understanding how

teachers' interactions relate to instructional improvement. In particular, they argue that a network perspective can be used to "analyze the efficacy of reform coaches for improving teachers' access to expertise and resources and for facilitating the change process" (p.126). The extent to which teachers seek advice or information from the coach relates to how effective the coach is in supporting teachers' instructional improvement. Within the field of social network analysis, measures of network centrality quantify the existence and density of ties to particular individuals. Network centrality is often related to power or influence, but can be defined and interpreted in many different ways (Hanneman & Riddle, 2005). In this case, our examination of coach centrality is more closely related to measuring a coach's influence than power (our choice of a measure is explained in the subsequent section).

District and school leaders can create conditions for the development of particular types of social interactions (e.g., teachers co-planning together in common planning time), but the social relations and networks are emergent phenomena that continually regenerate in the course of ongoing interactions (Coburn & Russell, 2008; Smylie & Evans, 2006; Spillane, Reiser & Gomez, 2006). By analyzing social network data, we were able to examine the interactions between individuals within the school as they related to supporting teachers' instructional improvement. Supplementing these measures with interview data allowed us to investigate how coach characteristics and aspects of school context directly influence coach centrality at the school level and, more indirectly, at the level of individual teachers' decisions about seeking advice from the coach.

District B

District B is a large urban school district that served nearly 80,000 students, of whom approximately 70% were identified as economically disadvantaged, 30% as English Language

Learners, and 10% as students with disabilities[1]. District B students consistently scored lower on state achievement tests in mathematics than other urban districts in the same state. District B had prioritized middle-grades mathematics and had implemented the inquiry-oriented curriculum *Connected Mathematics Project* 2 (CMP2) in the 2007-2008 school year. District leaders had created the position of school-based mathematics coaches to support teachers' in using CMP2 effectively. At the time of the study, the district was in its second year of implementing this curriculum.

Description of District B's Design for Mathematics Coaching

In the fall of 2008, we interviewed key district leaders from the offices of Leadership and Curriculum and Instruction (including the mathematics department) and asked them to describe the intended role of the coach and how coaches were supported to fulfill these responsibilities. The district was in its fourth year of using the half-time, school-based mathematics coaches in each school. District leaders described four goals for the coaches: (1) provide one-on-one instructional support to their colleagues in the classroom (e.g., model instruction, provide feedback), (2) act as a resource for the principal in matters of mathematics content (e.g., observe instruction with the principal and discuss their observations), (3) provide professional development to all middle school mathematics teachers on district professional development days (e.g., workshops on examining student work), and (4) provide professional development support to their colleagues at their school (e.g., follow-up work on how to use student work to inform instruction). In addition, district leaders specifically mentioned that the coach was to be a supporter rather than an evaluator of teachers.

[1] Demographic information for the district and each participating school was gathered from schooldatadirect.org.

District leaders supported the mathematics coaches by providing sustained professional development that focused on the CMP2 curriculum and on the ways in which teachers would need to reorganize their instructional practices in order to use the curriculum effectively. In addition, district leaders provided training in cognitive coaching (asking teachers specific questions to help them reflect on their practice) and district mathematics specialists worked with coaches one-on-one at their schools. Finally, district leaders indicated that prior to the beginning of the school year, they had worked closely with principals and coaches to support a shared understanding of coaches' responsibilities.

Participants

As part of the larger four-year study, we worked with district leaders to select a sample seven middle schools that was representative of the range of capacities for instructional improvement in middle schools across the district. In each school, we recruited approximately 5 randomly selected mathematics teachers, their principals, and their mathematics coaches to participate in the study. We also recruited assistant principals who were responsible for mathematics instruction. Across our sample of seven schools, 32 teachers, 7 coaches, and 9 school leaders participated in the study. In order to examine teacher networks, we collected additional data by requesting that all of the mathematics teachers in the seven schools provide information about who they go to for advice or information about teaching mathematics (as will be explained further in the data section).

Methods

Data Collection

The data we collected include: 1) an online network survey sent to all mathematics teachers in the seven schools, asking them to indicate who they turn to for advice or information

about teaching mathematics, 2) audio-recorded interviews conducted with school-level full participants—mathematics teachers, coaches, and school leaders—to understand both their work and the school contexts, and 3) video-recordings of coaches' classroom instruction.

Network survey. We drew on information from the online network survey sent in March 2009 to every mathematics teacher in the seven schools (n=70) to determine how many teachers in each school turn to their coach for advice or information about teaching mathematics. We attempted to survey all mathematics teachers in the school, rather than just full study participants, to have a complete understanding of the mathematics teacher social networks in each school. On the survey, teachers typed in the name and formal role (e.g., math coach) of the person from whom they seek advice, and provided additional information about the frequency, influence, and content of those interactions. For this study, we limited our analysis of the social network data to the existence of interactions.

Interviews. We asked all participants (teachers, coaches, and school leaders) to describe what they understand to be the role of the coach. We documented the types of support that principals provided coaches by 1) asking principals to describe whether they meet with the coach, what they discuss, and what are additional ways in which they support the coach, and 2) asking coaches to describe their work with the principal and their views of how the principal supports their work. To understand whether the teachers perceived the coach as someone who was capable of assisting them, we asked them to describe if they work with the coach and in what ways, as well as why they choose to work with the coach. In order to assess structural supports for coaches' work, we asked all participants whether time is scheduled during the school day for mathematics teachers to work together, who attends these meetings, and the content of the meetings.

Video-recordings of coaches' classroom instruction. We assessed the seven coaches' capabilities as mathematics teachers by coding video-recordings of two consecutive mathematics lessons conducted by each coach using the *Instructional Quality Assessment* (IQA) (Matsumura, Slater, Junker, Peterson, Boston, Steele, & Resnick, 2006). This instrument is consistent with District B's vision of high-quality mathematics instruction. Because the protocol closely examines the type of tasks used and the discussion that takes place around the tasks, we explicitly asked participants to include a problem-solving activity and to engage students in a whole-class discussion during the lesson. The IQA has been deemed reliable and valid (Boston & Wolf, 2006; Matsumura, Garnier, Slater, & Boston, 2008).

Data Analysis

Network survey. We first examined the response rate on the network survey and decided that in order to have an adequate representation of the math teacher network in a school that it was important to have responses from over 60% of the teachers. Six schools met this criterion (see response rates in Table 1). To assess whether the coaches were central in these six schools, we first created sociograms for the six schools using UCINET social analysis software (Borgatti, Everett & Freeman, 2002) (see Appendix A). Because our focus was on the influence of individuals within teacher networks, we defined the centrality of an individual as the in-degree centrality, or the ratio of the number of ties directed toward that individual to the total ties that could be directed toward that individual (Hanneman & Riddle, 2005). For example, if a school has 6 mathematics teachers who completed a network survey and a coach, and 4 of those teachers report that they seek advice from the coach then the in-degree centrality of the coach is 4/6 or .6667. Based on each coach's in-degree centrality, we then grouped coaches into three categories of centrality: central, somewhat central, and not central.

Interviews. We coded transcripts of the interview conducted with the 32 teachers and their coaches and school leaders using a coding scheme developed from a review of the literature on coaching and supporting teacher learning. This scheme was designed to examine: 1) the expected role of the coach from all participants' perspectives, 2) the ways in which principals provide support to coaches, 3) activities in which the coach and principal co-participate, 4) why teachers indicate they go to the coach, and 5) whether there is regularly scheduled time for groups of mathematics teachers to work together. Once we had completed the coding, we looked for patterns regarding our conjectures about coach characteristics and aspects of the school setting that might influence whether the coaches were central in teacher networks. For each school, we created analytic memos in which we described teachers' perceptions of the coach and aspects of the school context relevant to our conjectures. In doing so, we triangulated coaches', teachers', and instructional leaders' accounts of the coaches' work to ensure that we did not privilege any one person's account.

Video-recordings of coaches' classroom instruction. We coded the video-recordings of the coaches' classroom instruction using eight IQA rubrics[2] that focus on the cognitive demand of the instructional tasks used in lessons and the nature of classroom discussion (Stein, et al., 2000). These rubrics assess student learning opportunities and thus the effectiveness of instruction. Scores for each rubric range from 0 to 4, with a 0 representing a lack of the desired practice and a 4 representing high quality instruction. Each video was scored by trained coders who were required to reach 80% reliability before beginning to code. We assessed ongoing reliability by double-coding 20% of the classroom sessions, with each rater being checked

[2] Potential of the Task, Task Implementation, Academic Rigor of the Discussion, Participation, Teacher Linking, Student Linking, Teacher Asking, and Student Providing. See (Boston & Wolf, 2006) for more information.

approximately every other week. The overall percent agreement on those double-coded sessions was 73.5%. The percent of scores within one was 97.4%.

Cross-case analysis

Once we had coded the interview data, we conducted a cross-case analysis (Yin, 2003) by comparing our categorization of the coaches as central, somewhat central, or not central in the teachers' networks with our analysis of the interviews and video-recordings of the coaches' classroom instruction. A cross-case analysis is appropriate given that our goal was to investigate whether and how coach characteristics and aspects of the school setting influence coach centrality.

Findings

Case Selection

Our primary criterion for case selection was our categorization of the coaches as central, somewhat central, and not central based on in-degree centrality. In-degree centrality and other information about the seven schools are shown in Table 1. We had responses from less than 60% of the mathematics teachers in one school and therefore excluded this school from the analysis as we did not have an adequate representation of the mathematics teacher network. Our interviews indicated that the coaches in two of the remaining six schools (Schools 3 and 4) were not central in teacher networks because they were unable to fulfill their coaching responsibilities. In School 4, the coach had significant health problems and was not able to work with teachers as intended. The coach in School 3 was asked by her principal to teach full time and was therefore unable to work with teachers during the school day. We excluded both schools from the analysis and conducted a cross-case comparative analysis to account for variation in the centrality of the

coaches in the remaining four schools (central: School 5 and School 6, somewhat central: School 7, and not central: School 2).

----------INSERT TABLE 1 ABOUT HERE----------

Expertise of the Coach

We investigated whether coaches whose instructional practices were aligned with district goals for mathematics instruction were more central in teachers' social networks. We created one measure of instructional expertise by calculating the mean score for each coach across the 8 IQA coding rubrics. Recall that scores on the IQA range from 0 to 4, with a 0 representing a lack of a desired practice and a 4 representing high quality instruction. The mean IQA scores of four coaches in our reduced sample ranged from 2.125 to 2.75. The central coaches at School 6 and School 5 had mean scores of 2.125 and 2.25, respectively. The coach at School 7, who was somewhat central, scored 2.75, and the coach at School 2, who was not central, scored 2.25. While there is some variation in the coach scores on this measure, there are not large enough differences to justify characterizing one coach as more expert than the others. As a consequence, we were unable to examine the influence of our measure of instructional expertise on coach centrality in teachers' social networks. However, we can conclude that instructional expertise is not the only factor that influences coach centrality because there was variation in centrality even though the coaches' expertise as measured by the IQA was similar.

Teachers' Perceptions of the Coach

We investigate possible relations between the teachers' perceptions of their coaches and the extent to which the coaches were central in teachers' networks by analyzing the interviews conducted with 32 mathematics teachers in the larger sample of seven schools. We focused in

particular on whether their decisions to turn to a coach for advice were influenced by (a) their perceptions of the coach's instructional expertise, (b) their perceptions of the coach's coaching ability, and (c) their prior history with a coach.

Teachers' perceptions of the coach's instructional expertise. We distinguished between coaches' expertise as assessed in terms of the alignment of their practices with district goals, and teachers' perceptions of their coach's instructional expertise. Approximately one-fourth of teachers indicated that the coach's familiarity with the mathematics curriculum contributed to their decision to seek advice from the coach. For example, one teacher explained that she sought the coach's advice because, "she has taught all three grade levels of math in middle school, so she knows what is taught at each grade level… so I often will ask her questions referring to what's expected at other grade levels of the students." In this and other cases, a coach's familiarity with and knowledge of the curriculum was important for some teachers.

Coach's years of teaching experience. The responses of approximately one-fourth of teachers indicated that they took their coach's years of experience teaching mathematics as an indictor of instructional expertise and sought advice from the coach. For example, a teacher described his coach in the following terms: "She's kind of the master leader and because of her experience, twenty plus years, she has a lot of experience for us to draw on." Although years of experience are not necessarily a proxy for accomplishment as a teacher, some teachers viewed it as important that the coach could draw on extensive classroom experience when assisting them. This could be because years of experience is relatively easy to determine, whereas characteristics that are more directly related to instructional expertise (e.g., mathematical knowledge for teaching) might be more difficult for a teacher to assess.

Teachers' perceptions of coaching ability. Approximately one-fifth of teachers indicated that their decision to turn to a coach was influenced by their perceptions of their coach's ability to communicate with them effectively and support them in improving their instructional practice. For example, a teacher indicated that he valued the manner in which the coach critiqued of his work: "Her constructive criticism is never taken, you know, with any animosity or anything. She's got a very easy way of working with people and she's not pushy." A few teachers (about one-tenth) cited a lack of communication skills as a reason why they did not seek advice from the coach at their school. For example, one teacher told us that she did not seek advice from her coach because, "she thinks she is every single one of our bosses and that when she says jump, we must jump. And she's not easy to talk to."

Prior history with the coach. Approximately one-fourth of teachers interviewed stated that their decision to turn to the coach was influenced by their prior history of working with the coach. For example, a teacher said, "I've been here [at this school] for about fourteen years, and [the coach] was right across the hall from me when we, when I first started and she was my lifeline, you know. [When] I ran into a problem, which was daily, you know, helping me or just, you know, keeping me going along the right path." Several other teachers also indicated that the assistance they received from the coach in their first year of teaching was influential.

Summary. Our findings indicate that the teachers assessed their coaches' capabilities in terms of (a) familiarity with the curriculum, (b) years of experience, (c) coaching ability and (d) prior history with the coach. The perceptions of their coach's capabilities were consequential for their decisions about whether or not to turn to the coach for advice about teaching mathematics. Significantly, none of the teachers we interviewed from the seven schools assessed their coach's expertise in terms of whether their instructional practices were aligned the district's goals for

mathematics teaching. Instead, they based their assessments on years of experience or familiarity with the curriculum. This finding suggests that the teachers' perceptions of coach instructional expertise might be specific to the problems of practice on which they were currently working.

Scheduled Time for the Coach to Work with Groups of Teachers

We conjectured that coaches would be more central to teachers' social networks in schools where there was regularly scheduled time for the coach to work with groups of mathematics teachers on instructional issues. Time was scheduled during the school day for mathematics teachers to meet in all four schools. The mathematics teachers at two schools (Schools 6 and 7) met together once a week whereas the mathematics teachers at School 2 met together every morning. The teachers at these three schools also had separate time each week to work with same-grade colleagues. At School 5, teachers did not meet together as a mathematics department but instead, worked with teachers who taught the same grade level every other day. There are no discernable relationships between the frequency, length of time, and organization of teacher meetings (i.e., all mathematics teachers or by grade level) and the centrality of the coach in the four schools. In contrast, the purpose and content of the meetings, and who led the meetings do appear to be influential.

In the schools where the coaches were central in teachers' social networks, the teacher collaborative meetings focused on aspects of classroom instruction. A majority of the teachers and the coaches in the two schools where the coach was central reported that they engaged in the following activities together: planning for upcoming instruction, doing mathematics tasks from the curriculum together, considering possible solution strategies to mathematics tasks, discussing strategies for supporting different groups of students (e.g., ELL students), and discussing how

prior lessons had played out with students. The coaches in these two schools shaped the meeting agendas and led the meetings, which focused on key aspects of classroom instructional practice.

In contrast, the teachers and coaches at the two schools where the coaches were less central reported engaging in the following activities together: discussing pacing (e.g., whether they were on pace with the district's curriculum frameworks), coordinating testing dates, and coordinating interventions or tutoring for individual students. In School 7, where the coach was somewhat central, the coach led the meetings but the meetings rarely focused on classroom instruction. In School 2, where the coach was not central, the department chair created administratively focused agendas and led meetings; the coach participated in the meetings but did not take a leadership role.

These findings suggest that leading teacher meetings that focus directly on aspects of classroom instruction influences the extent to which the coach is central in teachers' networks. Routines in which teachers work with a coach on instructional practice might become established in such meetings, thereby influencing the teachers' decisions to turn to the coach for instructional guidance outside formal teacher meetings.

Teaching at the Same Grade Level as the Coach

There were also indications that teaching the same grade level as the coach might be related to whether teachers sought advice from their coach. In all four schools, a majority (over 75%) of the teachers who taught the same grade as the coach indicated that they went to the coach for advice about mathematics instruction. In contrast, less than half the teachers who taught a different grade level than the coach (approximately 40%) identified the coach as someone they went to for advice about mathematics instruction. Many of this latter group of teachers indicated that they first consulted a same grade-level colleague rather than the coach

when they had a question about teaching mathematics. Teachers who teach the same grade level as the coach might view the coach as a colleague who is addressing similar curricular issues, thereby increasing the likelihood that they will turn to the coach for instructional guidance. This influence on coach centrality is probably specific to coaching designs in which coaches teach for part of the day and support their colleagues for part of the day.

Principal Support for the Mathematics Coach

We investigated whether principals' practices as instructional leaders and their interactions with coaches influence whether the coach is central in teachers' social networks by analyzing the interviews conducted with participants in the four case comparison schools. This analysis suggests that three principal instructional leadership practices might support the coaches' work with teachers. These practices are: (1) attending teacher collaborative meetings; (2) observing teachers' classroom instruction; and (3) meeting regularly with the coach one-on-one to discuss teachers' classroom practices and the coach's work in supporting them to improve those practices. In addition, the principals in the two schools where the coach was more central were able to articulate concrete expectations for how coaches should work with teachers that were compatible with district leaders' expectations.

Attending teacher collaborative meetings. The first finding is that principals at the two schools where the coaches were central attended the teacher collaborative meetings regularly. In the schools where the coaches were somewhat central and not central, the attendance of the principals was much more infrequent. In particular, at these schools (2 and 7) teachers reported that the principal "occasionally attends" or "pops in" to the meetings. The principals at the other schools (5 and 6), where the coaches were more central, attended department meetings on a

regular basis and stayed for the entire meeting. Further, our data suggests that the principals' purposes for attending the meetings also differ, and therefore might influence centrality.

At the school where the coach was not central (School 2), the principal described the purpose for his visits as primarily administrative (e.g., discuss upcoming testing dates). At the school where the coach was somewhat central (School 7), the principal indicated that during the meetings he "occasionally interjects with administrative information." This differs from the purposes described by the principals in the two schools where the coach was central. The principals at those two schools both indicated that they attend teacher collaborative meetings for reasons broadly related to setting expectations about teachers' instructional practices. For example, at School 5, the principal described attending the collaborative meetings in order to assess teachers' current understandings of instruction by "listening to how teachers are discussing instruction." The principal at School 6 described how she used the department meetings to tell teachers what she is looking for when she observes a lesson and, after conducting observations, shares her assessments of what took place when she observed a classroom. The frequency with which principals' attend teacher collaborative meetings in order to set expectations and/or assessing teachers' understandings about current instructional practices appears to influence coach centrality.

Observation of classroom instruction. We drew on the teacher and principal interviews to determine the frequency with which principals in the four case schools observed mathematics instruction. We found that principals in the three schools in which the coach was either central or somewhat central (Schools 5, 6, and 7) visited classrooms at least weekly to observe teachers' instruction and provide teachers feedback. In contrast, the principal of the school where the coach was not central (School 2) did not regularly observe teachers' instruction. The three

principals who visited mathematics classrooms regularly might have developed a stronger understanding of individual teachers' instructional practices and thus been better positioned to work with the coach during one-on-one planning meetings.

Principal and coach meetings. Analysis of the principal and coach interviews indicated that principals in the three schools where the coach was either central or somewhat central (Schools 5, 6, and 7) met with their mathematics coaches one-on-one each week. For example, the principal at School 7 (somewhat central) indicated that he met with each content-focused coach that served his school individually, "I'll have my coaches come back in and that's when we have a real focused, where are you at? You know, those things we can't talk about in front of everybody. They give me concerns…they're in here all the time and so we're constantly communicating." In contrast, the principal and coach at the school where the coach was not central (School 2) both indicated that they did not meet on a regular basis to discuss the coach's work.

The three principals who met with their mathematics coach regularly also observed classroom instruction regularly. These principals contributed to their coaches' work during the one-on-one meetings by discussing individual teachers' instruction and by suggesting teachers with whom the coach should work based on their classroom observations. For example, the coach at School 7 (somewhat central) reported, "[The principal] kind of says, you know, I really need you to work with this teacher." Similarly, the principal at School 6 (central) described how she discussed individual teachers' development with her coach, "So I don't really ask her to evaluate them, but I do ask her for feedback on, is anybody going to need any extra help? Or do we need to get [district mathematics specialists] involved? Or do we need to have them go watch

somebody at a different school?" In working together in this way, the principal and coach assume joint responsibility for improving the quality of mathematics instruction in the school.

Expectations of the coach. In the interviews we conducted with them, all four principals described the coach's role as supporting teachers. However, the principals in the two schools where the coach was central articulated detailed expectations for how the coach should assist teachers that were generally consistent with district leaders' vision for coaching. These expectations included giving teachers methods and tools to help them be successful in their classrooms, providing assistance through one-on-one coaching (e.g., modeling lessons with the teachers who might need assistance), and working on instructional issues with groups of teachers. In contrast, the two principals at the schools where the coach was either somewhat central or not central were less explicit when describing the coach's role, saying that coaches should "go into classrooms and help teachers head in the right direction" (Principal, School 7) and "monitor and address teacher issues" (Assistant Principal in charge of mathematics instruction, School 2). These principals described the role more generically as orienting and supporting the weak teachers but said little about how coaches should work with teachers.

We hypothesize that the principals at the schools where the coaches were central might have been able to describe the coach's role in greater detail because they were more involved in the mathematics program at their school and worked more closely with their coaches. Specifically, they attended mathematics teacher meetings, observed classroom instruction regularly, and met with the coach individually to discuss instruction at least weekly.

Summary. At the schools where coaches are central to teachers' social networks (Schools 5 and 6), the principals regularly attended teacher collaborative meetings for the purposes of assessing teachers' current understandings or setting expectations about teachers'

instructional practices. The principals at these schools may have set the expectation that these meetings are for teachers to work on issues of instruction with their colleagues and with the coach. Additionally, as we reported previously, the teacher collaborative meetings at the two schools where the coach was central were led by a coach and focused on key aspects of classroom instruction. It is therefore possible that the principals at these two schools might have had opportunities to improve their understanding of the mathematics underlying instructional tasks and key instructional practices, thereby improving their understanding both of the complexity of teaching mathematics effectively and of the amount of support that teachers need from coaches.

Discussion

In this study, we investigated whether certain coach and school characteristics influence the extent to which mathematics coaches are central within teachers' social networks. We were not able to determine whether the alignment of coaches' instructional practices with district goals for mathematics instruction influenced their centrality due to lack of variation among the participating coaches on our measure of instructional quality. This is an important area for future research. However, we were able to examine teachers' perceptions of coaches' capabilities. We found that the teachers' decisions to turn to the coach for advice about teaching mathematics were influenced by: (a) the coach's familiarity with the curriculum, (b) the coach's years of experience teaching mathematics, (c) the teachers' perceptions of the coach's coaching ability, and (d) their prior history of working with the coach. These findings are consistent with studies that have examined professionals' advice-seeking behavior (Adler & Kwon, 2002; Borgatti & Cross, 2003; Bryk, et al., 2010; Coburn & Russell, 2008; Tschannen-Moran & Hoy, 2001). The teachers' did not assess their coach's instructional expertise in terms of the alignment of their

practices with the districts' goals for mathematics instruction. Instead, teachers focused on coaches' familiarity with the curriculum and their years of teaching experience. We conjecture that teachers' perceptions of coach expertise might be specific to the problems of practice on which they are are currently working and might be based on coach characteristics that are relatively easy to determine.

We found that scheduling time for groups of mathematics teachers to work together did not, by itself, influence the extent to which coaches were central in teachers' social networks. However, we did find that in the schools where coaches were central, coaches led regularly scheduled teacher meetings that focused on instructional issues (e.g., discussing possible solution strategies to mathematics tasks). Prior research indicates the important role that more knowledgeable others can play in professional learning communities (Louis & Kruse, 1995) and teacher networks in supporting teachers' improvement of their instructional practices (Coburn & Russell, 2008; Penuel, et al., 2009; Peterson, McCarthey, & Elmore, 1996). Additionally, the types of activities in which teachers engage impact their opportunities to improve their practices (Horn & Little, 2010). Our findings suggests that if teachers and a coach establish routines for working together on instructional practice during regularly scheduled meetings, teachers might then turn to the coach for instructional guidance outside formal meetings.

Several studies have indicated that content-focused coaches require the support and backing of school principals to perform their responsibilities effectively (Grant & Davenport, 2009; Matsumura et al., 2009; Mangin, 2005, 2007; Smylie, Conley & Marks, 2002; Youngs & King, 2002; Marks & Printy, 2003). Our work adds to the findings of prior studies by identifying a set of specific principal practices that appear to support coaches in becoming a central source of expertise. These practices include regularly attending teacher collaborative

meetings, observing classroom instruction, and meeting with the mathematics coach one-on-one to discuss teachers' current instructional practices and the coach's working in supporting them to improve those practices. In the two schools where the principals enacted these practices, the principal assumed joint responsibility for supporting teachers' improvement of their instructional practices with the coach, thereby contributing to the centrality of the coach.

This analysis has several implications for district leaders as they develop and implement content-focused coaching designs. First, we found that the two coaches who were central in teachers' networks led regularly scheduled teacher collaborative meetings that focused on instructional issues. We hypothesize that routines for working together on instructional practice become established in such meetings, and that it then becomes customary for teachers to talk to the coach about matters of instruction outside the formal teacher collaborative meetings. Our findings therefore suggest that coaches should lead teacher collaborative meetings and that principals should ensure that these meetings focus primarily on matters of instruction.

Second, we found that principals supported coaches' work both directly and indirectly in the two schools where coaches were central in teachers' social networks. Based on our findings, we hypothesize that principals' participation in teacher collaborative meetings that focus on instructional issues might support their understanding of high-quality instruction, thus enhancing the depth of their classroom observations and the feedback they give to teachers. We further hypothesize that principals will then be better positioned to make substantial contributions to one-on-one meetings with the mathematics coach that focus on improving the quality of classroom instruction. Our findings therefore suggest that principals (or a school leader responsible for mathematics instruction) should attend teacher collaborative meetings, observe

classroom instruction and provide feedback on a regular basis, and meet regularly with the mathematics coach to plan how to support teachers in improving the quality of instruction.

This study suggests two broad directions for future research. First, we have proposed several hypotheses that are based on our findings. Future studies might investigate these hypotheses in order to further our understanding about how particular coach and school characteristics can influence the extent to which coaches are central in teachers' networks. Second, in addition to understanding what influences whether coaches become central resources for teachers, it is also essential to identify the types of coaching activities that are effective in supporting teachers' improvement of their instructional practices. In conducting such investigations, it will be important to consider the types of activities in which coaches can engage individual teachers (e.g., modeling instruction) and groups of teachers (e.g., solving instructional tasks together in order to identify their mathematical potential). It will also be important to investigate what influences coaches' selection of types of activities that prove to be productive and to understand what is involved in enacting these activities effectively. The study we have reported in this article contributes to this broader program of research that focuses on the development and implementation of effective coaching designs.

Table 1

Counts and Measures of Coach Centrality

School	# Math Teachers to Network Survey	# Teacher Responses to Network Survey	Response Rate	#Teacher-Coach Ties	In-degree centrality	Coach Centrality
1	12	4	33.3%	4	1	Central
2	9	6	66.7%	2	0.333	Not
3	20	14	70%	4	0.286	Not
4	12	8	66.7%	2	0.25	Not
5	14	9	64.3%	6	0.667	Central
6	6	6	100%	5	0.833	Central
7	7	7	100%	4	0.571	Somewhat

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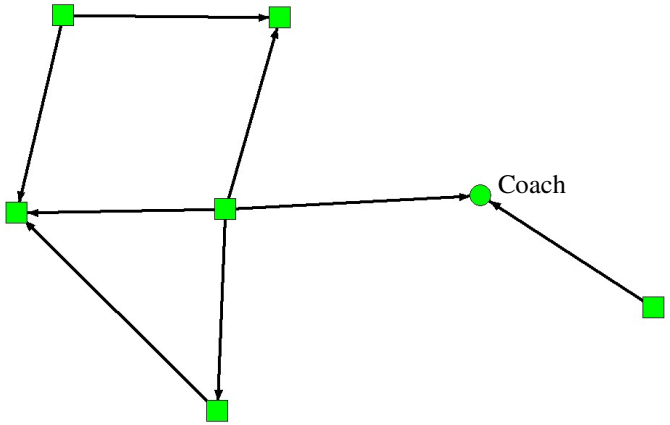
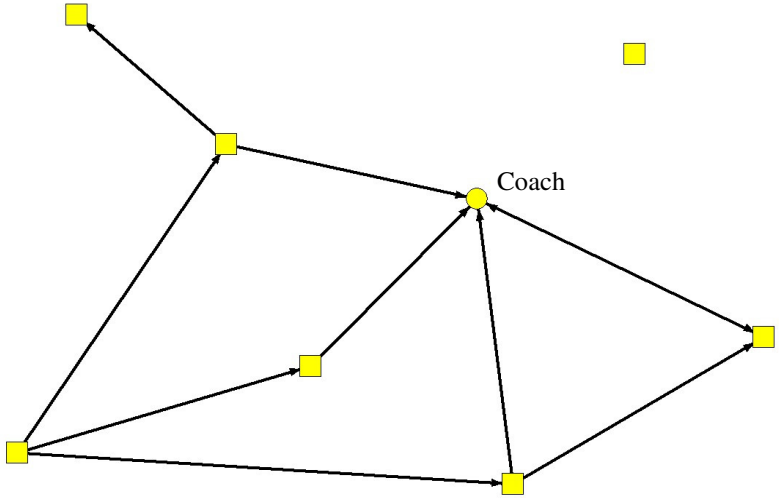
Appendix A. School sociograms of mathematics teacher networks [Square nodes are teachers and circular nodes are coaches. The arrows indicate the direction of the advice-seeking relationship.]

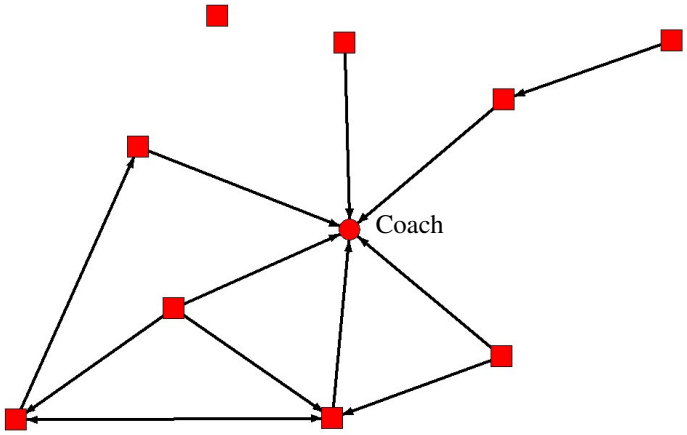
School 2- Not central coach



School 7-Somewhat central coach



School 5-Central coach



School 6-Central coach