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Educational Administration Quarterly 2013 49: 610 originally published online 18
March 2013

DOI: 10.1177/0013161X12468148

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Educational Administration Quarterly
49(4) 610-644

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DOI: 10.1177/0013161X12468148

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Abstract

Purposes: This study investigates the role of formal and informal leaders in the diffusion of external reforms into schools and to teachers' practices. Formal leaders are designated by their roles in the formal organization of the school (e.g., principals, department chairs, and instructional coaches) and informal leaders refer to those who do not have any formal leadership roles but are nominated by other colleagues as influences on their instructional practices. In the context of implementing reading policies associated with No Child Left Behind (NCLB) 2001 legislation, this study aims to examine (a) how formal and informal leaders promote instructional changes through professional interactions with teachers and (b) which types of instructional practices are most responsive to which types of leaders. *Research Methods:* The authors analyze longitudinal data concerning both professional interactions about teaching reading and instructional practices of teachers and leaders in nine K-8 schools in a single state. *Findings and Implications:* Formal leaders convey influence on general teaching practices such as setting standards, selecting materials, and assessing students while informal leaders convey influence on specific pedagogical practices (e.g., the use of particular

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strategies for teaching basic reading skills). Findings contribute to the theoretical and methodological development of both distributed leadership and policy implementation within schools. Moreover, this study suggests the importance of and several strategies for developing a strong instructional leadership team that recognizes and supports the complementary influences of formal and informal leaders.

Keywords

formal and informal leaders, policy implementation, NCLB, teacher collaboration, longitudinal analysis

Introduction

This study investigates the role of formal and informal leaders in the diffusion of external reforms into schools and to teacher's practices. External demands from federal, state, or local sources contribute to the institutional context of the classroom, both constraining and enabling instructional change (Dacin, 1997; Elmore, 2000; Scott, 1995). But external institutions may not penetrate schools uniformly, as local forces within a school retain some agency in selecting classroom practices (Penuel, Frank, Sun, Kim, & Singleton, 2013; Ingersoll, 2003; O'Day, 2002). In particular in this study, we focus on how formal and informal leaders can influence the ways in which teachers respond to external pressures to change their practices (Schein, 1992; Moolenaar, Daly, & Slegers, 2010).

School leadership, as a social influence relationship between leaders and followers around specific tasks under local contexts, does not inhere in a single role; rather, it is evident that in the enactment of external reforms leadership is distributed across multiple actors within the school (e.g., Camburn, Rowan, & Taylor, 2003; Chemers, 2002; Riggan & Supovitz, 2008; Spillane, Halverson, Diamond, 2004; Spillane & Zuberi, 2009). Some of these actors are formal leaders who are designated by the school formal structure and include principals, department chairs, and instructional coaches. These leaders have the potential to influence other teachers' behaviors or beliefs by the authority attached to their formal positions. Others are informal leaders who do not have any formal leadership positions in the organization but influence other teachers' practices by providing resources (e.g., teaching strategies and knowledge of their implementation) and values in the process of professional interactions (Smylie, Conley & Marks, 2002; Spillane & Zuberi, 2009).

Some studies have documented that formal and informal leaders might have distinctive influences on how reforms are implemented to change instructional practices (Coburn, 2001; Printy, 2008). These studies suggest formal leaders provide teachers with opportunities to learn about new practices, whereas informal leaders can be instrumental in helping implement those practices. However, there has been limited longitudinal quantitative evidence demonstrating the dynamics of social influence between leaders and followers and the differential distribution of leadership on instructional tasks. In this study we extend such research by attending specifically to the networks through which formal and informal leaders influence different types of instructional practice. This will help explain how different teachers within the same school can be exposed to variable norms of practice depending on the particular networks in which they are embedded. In particular, we discuss (a) how formal and informal leaders influence instructional practices and (b) which types of instructional practices are most responsive to which types of leaders. Ultimately, studying leadership through networks within schools will help explain how schools as social organizations respond to external demands on teachers' practices.

The context of our study is the implementation of new reading policies concurrent with the passage of No Child Left Behind 2001 (NCLB). Leadership within schools may be especially important in adopting instructional strategies as part of this reform because accountability-based reform seeks to tighten the coupling between the formal structure of schools and the technical core of teaching (Elmore, 2000; Rowan, 2006; Spillane & Burch, 2006). Furthermore, whereas the consequences for poor performance are formally prescribed, changes in instructional practices that may shape the outcomes of interests are left up to each school to navigate (Hess & Petrilli, 2006; O'Day, 2002). In this context, instructional leadership becomes critical to how teachers' change their practices in response to a reform (Rowan & Miller, 2007).

To probe into the affects of formal and informal leaders on the change of instructional practices in the context of accountability reform, we analyze longitudinal data on both interactions on instructional matters and instructional practices of teachers and leaders in nine schools in a single state in the United States. In particular, we use social network analysis to investigate the conjecture that when schools encounter the institutional force of the new reading policy associated with NCLB, formal leaders may influence the degree to which teachers adopt general changes to what they teach (i.e., goals for learning) and how they assess learning, while informal leaders may influence specific pedagogical practices (e.g., reading teaching strategies). We

first discuss the larger, institutional context of the study, review literature on distributed leadership in the diffusion of external institutions, and then hypothesize how formal and informal leaders enact influence on different instructional tasks.

Reading Policy Associated With NCLB: A New Institution Penetrating Schools

Although most accountability-based reforms have not historically made specific demands on teachers' pedagogical practices (Hess & Petrilli, 2006; O'Day, 2002), concurrent with the emergence of high-stakes, federally-mandated accountability associated with the passage of NCLB in the United States has been an unusual level of coherence in federal reading policy. This coherence formed around a National Research Council report (National Reading Panel, 2000) that culminated the period of focusing reading instruction on the basic skills required to decode print, especially phonological awareness and phonics. Such emphasis has been highlighted in federal funding programs (U.S. Department of Education, 2006). Soon after the report was published, states passed reading initiatives that reflected its recommendations (Allington, 2006; Miskel & Song, 2004; Pearson, 2004). The confluence of heightened accountability and a coherent vision for instructional change constituted a new "regulatory regime" (Schneiberg & Clemens, 2006) that defined both specific norms and constraints on action, a hallmark of institutionalization (Meyer, Boli, & Thomas, 1994).

At the same time, one direct policy pressure on all of the schools in this study came from the state. Each of these schools had adopted one of two (at the time) curricula that had been adopted by the state for teaching reading. Both of these claimed strong alignment with the framework of the National Reading Panel. Although our study focuses not on curriculum but on instructional practices of teachers, the implementation of curriculum and reading policy constituted strong external demands on changes in reading instruction. Moreover, the NCLB-associated accountability system placed both positive and negative incentives on schools to adopt these externally defined curricula—"what to teach." However, the question of how to teach was left to individuals who were closely working with students in schools to figure out. The extent to which external demands change internal processes within schools with the hope of improving student learning is very up to the successful diffusion of external expectations within schools (O'Day, 2002).

Distributed Leadership in Diffusing New Institutions

The diffusion of new institutions within schools emphasizes the role that local actors—teachers and administrators—play in the process (Barley & Tolbert, 1997; Béland, 2005; DiMaggio, 1991; Scott, 2008). Successful diffusion depends in part on the allocation of human, social, and material capital necessary for implementation, as capacity must often be built as part of any reform effort (Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000; Cohen & Barnes, 1993). In addition, sensemaking by local actors mediates the implementation of reforms: What is enacted in policy is ultimately the work by “street-level bureaucrats” who jointly interpret the demands of new policies and adjust their practices to align with and sometimes resist those policies (Weick, 1995; Wildavsky, 1979). In one analysis, Coburn (2001) highlighted how school members collectively make sense of institutional messages about reading instruction through conversations with colleagues about goals, strategies, and details of implementation, and how school leadership shapes the focus of teachers’ conversations.

Our examination of leadership in the diffusion of external institution is from a distributed leadership perspective, which emphasizes ways that leadership is distributed across persons, tools, and practices. The theory of distributed leadership traces its origins to analyses of cognition in practice, which emphasizes the ways that complex mental functioning often requires coordination across people, tools, and processes (Hutchins, 1996; Pea, 1993). The theory of distributed leadership moves beyond analyses of leaders and their characteristics to consider leadership practice. Furthermore, similar to analyses of distributed cognition, analyses of distributed leadership focus on the ways that the practice of leadership is accomplished by multiple people, using different kinds of tools, and through both structured, formal and unstructured, informal interactions (Spillane, Halverson, & Diamond, 2001).

This article focuses on what Spillane (2006) calls the “leader-plus” aspect, namely that different functions of leadership—in our case, supporting the implementation of reforms—are distributed across leaders with formal authority and informal leaders who are influential by virtue of their positions within the professional network of a school. It also focuses on the “practice” aspect of distributed leadership, namely that leadership is enacted through interactions between leaders and followers on specific tasks. We investigate in our study a particular way that leadership is distributed through collective distribution when two or more leaders coperform a leadership routine by working separately but interdependently (Spillane, 2006, p. 60).

There are many possible reasons for formal and informal leaders to distribute leadership practice through collective distribution. Formal and informal leaders differ with respect to their authority and thus their capacity to allocate resources to support implementation (Spillane, Hallett, and Diamond, 2003). Formal leaders typically can purchase materials and provide professional development opportunities for the school that are related to specific school goals. By virtue of their authority, they also filter for teachers and guide interpretation of the demands of standards, accountability, and new mandates from outside the organization (Coburn, 2006; Honig & Hatch, 2004). At the same time, compared to informal leaders who teach in the classroom, formal leaders' knowledge of how externally demanded standards and curricula can be successfully implemented in the diverse classroom settings may be limited. Thus, teachers may value less their inputs on pedagogical strategies in the classroom (Kennedy, 2005; Smylie, 1989). Such proximity to teachers' own practice may be particularly important for transfer of knowledge about classroom instruction because such practice in knowledge-intensive fields like teaching includes many tacit dimensions that are difficult to make explicit and communicate (Nonaka, 1994).

In a related line of argument, Stein and Nelson (2003) proposed leadership content knowledge in four layers: The inner two layers include knowledge of teaching and learning of subject matter in the classroom and the outer two layers include knowledge of how to facilitate teaching and learning. Correspondingly, different levels and types of leaders may exercise distinct impacts on instruction given their content knowledge, including pedagogical and subject knowledge as well as of the social processes of the classroom and school. Because the implementation of any new, external reform on instruction needs leadership with both subject content knowledge and leadership knowledge, we hypothesize that the success of implementation requires the collective distribution of leadership across different types of leaders in a school.

Some empirical research supports this particular hypothesis. Camburn et al. (2003) examined the leadership structure across a large sample of elementary schools that implemented different Comprehensive School Reform programs. They found principals and assistant principals performed as "generalists," spreading their efforts across a range of leadership functions including instructional leadership, building management, and boundary spanning (for a detailed explanation of these functions see Camburn et al., 2003, pp. 368-369). The generalist nature of the principalship and assistant principalship contrasted with instructional coaches and other leaders who specialized in instructional leadership. However, their analysis considered as leaders

only people who had formal leadership positions in the organizational structure; it did not include other regular teachers as possible informal leaders.

Informal leaders can be teachers who have the expertise in teaching and learning and depend largely on means of cooperation and interactions with their colleagues to influence the practice of their colleagues (Yarger & Lee, 1994; York-Barr & Duke, 2004). Such influence can promote the kinds of direct changes to instructional practice that formal leadership exercised by principals may not be as easy to accomplish. A number of recent studies have pointed to the importance of peer help or advice in supporting instructional change (Crowther, Ferguson, & Hann, 2009; Supovitz, 2008; Supovitz, Sirinides, & May, 2010; York-Barr & Duke, 2004). In our own past research, we found that teachers who interacted more with expert peers were more likely to implement reforms their schools had adopted than were those who interacted less often with such peers (Penual, Frank, & Krause, 2006). In a more recent study of writing teachers, we found that above and beyond direct effects of professional development received in writing, teachers' instructional practices in writing were shaped by collegial interactions (Sun, Penuel, Frank, Youngs, & Gallagher, 2011). In both these studies, *expertise* was defined in relation to the specific practices targeted in the reform or professional development. That is, an *expert* was defined narrowly as someone who engaged in more of the target practice at the time a teacher received help from them. No doubt, other forms of expertise are relevant to knowledge transfer between teachers, including social skill in providing help on instructional matters, but this proxy for expertise stands in for an important dimension of teachers' expertise, namely their knowledge of practice. Previous level of implementation represents the complex understanding of how to adapt an innovation to a particular setting (Casson, 1994).

Although prior literature has shown that social interactions and distributed leadership affect the implementation of external reforms, our study offers unique contributions. First, none of the prior studies collected quantitative evidence to examine leadership practices during the implementation of reading policy associated with the passage of the NCLB legislation. The nature of these new institutions as elaborated previously may configure and activate the leadership structure differently from other reform programs. Second, *leadership* has been defined as a social influence process (Chemers, 2002; Spillane et al., 2004). However, there has been limited longitudinal quantitative evidence to demonstrate the dynamics of social influence between leaders and followers and the differential distribution of leadership on instructional tasks. In this study we extend previous research by attending specifically to the networks through which formal and informal leaders influence changes in

different types of instructional practice. In the next section we draw on literature to develop a set of hypotheses concerning how the new reading policy associated with NCLB is implemented within schools through teachers' interactions with formal and informal leaders.

Hypothesizing the Distinctive Influences of Formal and Informal Leaders on Instruction

Formal leaders have been conceptualized as taking the roles of boundary spanning between external demands and instructional activities within the school (Honig & Hatch, 2004; Louis, Febey, & Schroeder, 2005; Rorrer & Skrla, 2005; Rutledge, Harris & Ingle, 2010). When external institutions penetrate schools, new information about standards, curriculum, and assessment travels first to formal leaders who are at the upper level of the hierarchy and closer to the external agencies, and then it spreads to other teachers. Moreover, formal leaders' roles as authorities capable of allocating resources like curriculum materials and assessment tools to support implementation of reforms can affect teachers' general practices in related areas in ways that are congruent with institutional pressures. We thus hypothesize,

Hypothesis 1: Formal leaders influence teachers' general practices associated with setting standards, selecting materials, and assessing students.

In contrast to formal leaders, informal leaders have the knowledge of practice related to classroom instruction and share the same contexts with other teachers. Interactions with informal leaders are more likely to lead to changes in teachers' practice congruent with institutional pressures on specific strategies for teaching basic reading skills when informal leaders provide help on such matters.

Hypothesis 2: Informal leaders influence teachers' specific pedagogical practices of teaching basic reading skills.

To succeed in changing practices in ways that align with external institutional pressures, the distribution of leadership practice between formal and informal leaders must influence teachers' practices in complementary and congruent ways. For instance, formal leaders who set up the instructional goals and coordinate resources around teaching basic reading skills can establish the platform for informal leaders to influence classroom teaching

toward these goals. In contrast, if formal and informal leaders' influences send inconsistent messages to other teachers, the successful implementation of external reform within schools can be jeopardized, as teachers encounter role ambiguity. Formal and informal leaders' influences must be congruent, in that the effects of exposure to different types of leaders are in the same direction in alignment with external institutional pressures.

Hypothesis 3: Collective distribution of leadership can be successfully accomplished when formal and informal leaders' influences over these distinct aspects of practice are congruent.

Sample and Measures

Sample

To examine these hypotheses, we used data from a large-scale, longitudinal project to investigate teachers' implementation of reading instructional practices associated with the passage of NCLB legislation. The original sample included 11 elementary and middle schools from eight school districts located in urban and suburban areas near major cities in northern and southern California. Two of these schools were not included in the final data analysis because of missing data on either formal leaders' influence or informal leaders' influence.¹ The new, potentially powerful institutional wave in reading starting since 2000, if past history is a guide, could be expected to crest between 3 and 5 years (Cuban, 1990). Thus our study, featuring data collected in the 2006-2007 and 2007-2008 school years, is ideally situated to measure the affects of the reading institutional wave.

We surveyed all school staff who were faculty members in the schools, including all regular faculty members in schools and specialized staff whose chief assigned function in their school was to promote the school-wide initiative. In our study, furthermore, teachers could name any member of the school staff (including the principal) as someone who provided them with expertise or resources to help with reading instruction. Thus, our social network data included positional school leaders defined by nominations on a sociometric questionnaire. School faculty members in the selected schools were surveyed four times (2003, 2005, 2007, and 2008).

Table 1 shows basic characteristics of schools in the 2007-2008 sample. The schools included eight elementary schools and one middle school, with the grade span indicated in the second column of Table 1. School size ranged from 288 to 898 with an average of 541. Six schools had a majority

Table 1. School Demographic Information in 2007-2008.

School	Grade Span	Student Enrollment	Percentage White	FTE Teachers	Title I School	Met AYP? ^a	Reading First District
Pomo	K-5	441	56.0	25	No	Yes	No
Pasteur	K-6	898	0.7	43	Yes	No	No
La Plaza Charter	K-6	542	14.6	27	No	Yes	Yes
Glade	K-8	646	0.3	29	Yes	No	No
Forest	K-8	538	27.1	26.8	Yes	Yes	No
Crosswinds	K-5	619	37.6	33.3	No	Yes	No
Hermosa	5-8	554	70.6	22.2	No	Yes	No
Sage	K-4	342	64.6	19.2	No	Yes	No
Dickersen	K-5	288	25.7	18.6	Yes	Yes	No

FTE = full-time equivalent; AYP = Adequate Yearly Progress. All school names are pseudonyms.

a. Yes = the school met AYP in both reading and math; No = the school did not meet AYP in either reading or math except that Pasteur did not meet AYP in reading but met AYP in math.

Data sources: Common Core of Data from the National Center for Education Statistics for the 2007-08 school year; Reading First Eligible District from California Department of Education.

non-White student population. The number of full-time equivalent teachers ranged from 18.6 to 43 across schools. Four were Title I schools and most of schools in the sample met requirements for Adequate Yearly Progress in reading. Only one sampled school had funded Reading First programs in the district; however, the school itself was not a Reading First school.

At the fourth wave of data collection, the average teaching experience of the sample was up to 13 years, and the mean of years working at the current school was 7.41 (as indicated in Table 2). The sampled teachers' relatively longer working experiences in the current schools give this study a great advantage in studying the effects of stable relations across years. The majority of the teachers had full certification (advanced professional, regular/standard/probationary) in their main assignment fields.

Measures

Formal and Informal Leaders. This study aims to identify paths by which formal and informal leaders affect other teachers' instructional activities. From a total of 175 school actors were nominated by other colleagues as providing help with teaching reading, we identified 64 formal leaders given their formal roles: 5 administrators (e.g., principal and assistant principal); 2 school reform/school improvement coaches or facilitators; 10 reading, literacy, or English program coordinators; 26 master/mentor teachers or teacher

Table 2. Demographics of School Staff From the 2008 Survey ($N = 228$).

Variable	Characteristics of Only Nominators ($n = 168$)	Characteristics of All Faculty ($n = 228$)
Working experience ($n = 168^a$)		
Mean years teaching	13.00	13.09
Mean years working at the current school	7.47	7.41
Teacher credential status ($n = 168^b$)		
Partial certification (temporary, provisional, or emergency state certificate)	3 (1.79%)	26 (11.40%)
Full certification (advanced professional, regular/standard / probationary)	165 (98.21%)	202 (88.60%)

a. The sample includes all teachers who received help from others and who were involved in the final data analysis.

consultants; and 45 committee or team leaders² (Camburn et al., 2003). The other 111 leaders who did not have such formal roles were designated as informal leaders.

As shown in Table 3, the average teaching experience of formal leaders was 13.98 years and the mean of years working at the current school was 8.85 years, which were slightly longer than those of informal leaders, who averaged 12.24 years of teaching experience and 7.22 years of working experience at the current school. One formal leader and four informal leaders did not have full certification in their main assignment fields (advanced professional, regular/standard/probationary). However, the differences between the formal and informal leaders were not statistically significant.

Dependent Variables

General practices of implementing NCLB-related standards, curricula and assessments in 2008. The measure of implementation of NCLB in 2008 was constructed as an index averaging teachers' responses (1 = not at all, 2 = to a limited extent, and 3 = to a great extent) to the question "Whether NCLB is affecting your work" in the following five areas ($\alpha = 0.93$): "the curriculum materials I use with students," "the curricular activities I use with students,"

Table 3. Demographic Characteristics of Formal and Informal Leaders (N = 228).

Variable	Formal Leaders (n = 64)	Informal Leaders (n = 110)	Not Nominated (n = 54)
Working experience			
Mean years teaching	13.98	12.24	13.65
Mean years working at the current school	8.85	7.22	6.15
Teacher credential status			
Partial certification (temporary, provisional, or emergency state certificate)	1 (1.56%)	4 ^a (4.44%)	1 (1.85%)
Full certification (advanced professional, regular/standard/probationary)	63 (98.44%)	86 ^a (95.56%)	53 (98.15%)
Expertise as approximated by prior practices			
Mean of prior general practices of implementing No Child Left Behind–related standards, curricula and assessments in 2007	1.09	1.26	0.99
Mean of prior specific pedagogical practices of teaching basic reading skills in 2007	3.77	3.57	3.00

a. Twenty cases were missing on this measure. On these measures, there were no statistically significant differences between formal and informal leaders.

“the content standards to which I teach,” “the number of topics I cover in a particular subject area,” and “the ways I assess student learning.” These five items measured the same latent construct based on factor analysis results (factor loading = 0.795–0.892; Eigenvalue = 3.307).

Specific pedagogical practices of teaching basic reading skills in 2008. Teaching basic reading skills is one of the key specific teaching practices targeted by NCLB. To measure such pedagogical practice, in the 2008 survey we asked each teacher to rate how often they had students complete a series of activities as part of reading instruction on a 5-point scale: 1 = almost never, 2 = one or two times a month, 3 = one or two times a week, 4 = almost every

day, and 5 = one or more times a day.³ Based on factor analysis results, we aggregated nine items into one composite variable ($\alpha = 0.90$), including “blend sounds to make words or segment the sounds in words,” “read stories or other imaginative texts,” “practice dictation (teacher reads and students write down words) about something the students are interested in,” “use context and pictures to read words,” “clap or sound out syllables of words,” “drill and practice sight words, e.g., as part of a competition,” “use phonics-based or letter-sound relationships to read words in sentences,” “use sentence meaning and structure to read words,” and “practice letter-sound associations” (factor loading = 0.588–0.888; Eigenvalue = 4.091). These items were designed to measure teachers’ pedagogical practices of teaching reading—the ways in which teachers represented basic reading skills to students and formulated classroom activities to help students learn these skills (Segall, 2004; Shulman, 1986). The content of reading, referring to what should be taught in elementary and middle schools (such as phonemic awareness among a variety of basic reading skills), was defined in the state curriculum and standards and was in alignment with a National Research Council report (National Reading Panel, 2000; Shanahan, 2006). Our measures were intended to capture how teachers taught this content of reading in sampled elementary and middle schools as well as the change in ways of teachers taught such content over years; hence, we labeled this measure as pedagogical practices of teaching basic reading skills.

Independent Variables

Teachers’ exposure to formal and informal leaders’ general and specific practices. The key to our models is to approximate teachers’ exposure to formal and informal leaders through professional interactions. In our 2008 teacher survey, we asked teachers to report which colleagues in their schools had helped them in the past 12 months with reading instruction. Teachers could nominate up to eight colleagues and rate the frequency of interactions on a 4-point scale: 1 = once or twice a year, 2 = monthly, 3 = weekly, and 4 = daily. We then followed Frank, Zhao, & Borman (2004)’s approach and defined *exposure* as a function of the extent of help provided by one teacher to another (approximated by the frequency of help provided), the type of knowledge and norms conveyed through help (approximated by the prior practices of the provider of help), and the capacity of the provider to convey such knowledge and norms (approximated by the total number of colleagues helped by the provider).

For example, assume Bob indicated receiving help from three formal leaders: Daily (4) from Lisa, who had a prior NCLB implementation of 2; monthly

(2) from Tom, who had a prior NCLB implementation of 3, and daily (4) from Alice, who had a prior NCLB implementation of 1. Then Bob's exposure via Lisa is $4 \times 2 = 8$, via Tom is $2 \times 3 = 6$, and via Alice is $4 \times 1 = 4$. The norm of Bob's exposures is then $(8 + 6 + 4) / 3 = 6$. More formally, the preliminary measure of exposure to formal leaders is specified as follows:

$$\begin{aligned} & \text{Preliminary measure of direct exposure to formal leaders' influence}_i \\ &= \frac{1}{n_i} \sum_{\substack{i'=1, \\ i' \neq i}}^{n_i} (\text{Help}_{ii'}) \times (\text{Providers' prior implementation}_{i'}) \end{aligned} \quad (1)$$

where n_i is the total number of formal leaders from whom teacher i received help.

In addition, we weighted the providers' help by the frequency with which they helped others because we reasoned that those who were listed by many others as helpful were better at conveying their knowledge and practices (Frank et al., 2004). In the above example, if Lisa helped four others, Bob's exposure to Lisa would be $32 = 4 \times 2 \times 4$. Thus the final expression for exposure was

$$\begin{aligned} & \text{Final measure of direct exposure to formal leaders' influence}_i \\ &= \frac{1}{n_i} \sum_{\substack{i'=1, \\ i' \neq i}}^{n_i} (\text{Help}_{ii'}) \times (\text{Providers' prior implementation}_{i'}) \times (\text{Total number of others helped}_{i'}) \end{aligned} \quad (2)$$

Given the complex metric of the exposure term, we will report results associated with exposure in units of standardized regression coefficients in the next section. By designating actor i' as either a formal or informal leader, Equation 2 was used to separately construct measures of exposure to informal and formal leaders.

Prior general practices of implementing NCLB-related standards, curricula, and assessments in 2007. Teachers' instructional practices, to some extent, are consistent over time (e.g., Frank et al., 2004). Our measure of the NCLB effect on prior general practices in 2007 is based on the same items and procedures as for the 2008 measure ($\alpha = 0.92$).

Prior specific pedagogical practices of teaching basic reading skills in 2007. To derive the measure of prior specific practices, we asked how often teachers engaged students in activities concerning learning basic reading skills as part of reading instruction in 2007. The measure included a subset of items from the measure of teaching basic reading skills in 2008 but based on the 2007 survey, with slightly different rating scales for each item (1 = not at all,

2 = one or two times per month, 3 = three or four times per month, 4 = five or six times per month, 5 = more than six times per month). We derived a composite variable by taking the mean of the items including “read stories or other imaginative texts,” “use phonics-based or letter-sound relationships to read words in sentences,” “use context, pictures, and/or sentence meaning and structure to read words,” and “blend sounds to make words or segment the sounds in words” ($\alpha = 0.87$).⁴

Exposure to professional development in 2008. Teachers may change their behaviors based on exposure to external professional development (Cohen & Hill, 2001; Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001). Therefore, we developed two measures of the extent to which teachers received professional development: NCLB-related and reading-related. The components of the NCLB-related professional development included “using achievement data for decision making,” “strategies for teaching students from different ethnic/cultural subgroups,” “strategies for teaching English language learners,” and “strategies for teaching students with disabilities” ($\alpha = 0.77$, these items all are loaded on one factor, factor loading = 0.61~0.89; Eigenvalue = 1.633) The variable scaled from 0 to 3 (0 = none at all, 1 = 1 to 8 hours, 2 = 9 to 16 hours, 3 = more than 16 hours). Teachers also reported the frequency of attending professional development focusing on reading instruction on the same scale.

Perceived value of NCLB in 2007. Classic innovation diffusion theory suggests that individuals adopt a practice based on the perceived value of the practice (Rogers, 1995). Therefore, we controlled for teachers’ perceived value of NCLB. Specifically, in our 2007 survey, we asked teachers to rate the importance of the following reform activities for improving student achievement (0 = not at all important, 1 = not very important, 2 = neutral, 3 = somewhat important, 4 = very important): “requiring schools to use research-based curriculum materials,” “holding schools accountable for improving achievement of all subgroups at the school,” “giving parents the choice to change schools if the school is failing,” and “giving parents the choice to purchase tutoring services with a school’s federal funds if the school is failing.” Factor analysis showed that only one factor existed (factor loading = 0.55~0.848; Eigenvalue = 2.151) and we thus derived one composite measure by averaging all of these four items ($\alpha = 0.70$).

Highest grade taught in 2008. Under NCLB, all schools and even Reading First schools preserved a high level of agency for teachers with respect to day-to-day instructional decision making. Most elementary schools served grades K-5 or K-6, and the program made funding available only for grades K-3, such that teachers of upper elementary level students had more

discretion with respect to curriculum and instruction. Therefore, we controlled for highest grade taught.

We also included other measures of teachers' background characteristics in our initial data analysis, such as teaching experience, certification status, and others. However, none were close to statistical significance; therefore, we dropped them from the final models.

Data Analysis

To examine our hypotheses of the ways in which the impact of formal leaders differs from the impact of informal leaders on instructional changes, we estimated one model for general practices related to *NCLB* and another for specific pedagogical practices related to teaching basic reading skills. Due to the nested nature of the data (teachers nested within schools), we used Hierarchical Linear Modeling (HLM) in its two-level application (Raudenbush & Bryk, 2002). Before examining effects of any predictors in HLM models, we ran unconditional models to examine the distribution of variance in the two outcome measures. About 36% of the variance of general practices of implementing *NCLB*-related standards, curricula, and assessment resides was allocated at school level ($0.36 = 0.198 / (0.198 + 0.352)$), which is statistically significant ($p \leq .001$). About 33.7% of variance of specific pedagogical practices was allocated at school level ($0.337 = 0.32 / (0.32 + 0.63)$), which is significant at .001 level. The significant amount of school-level variance supports the application of HLM models (Raudenbush & Bryk, 2002).

The dependent variables were examined as functions of interactions with both formal and informal leaders after accounting for individuals' prior practices, exposure to professional development in 2008, perceived values of *NCLB* in 2007, and highest grade taught in 2008 (Frank et al., 2004). Because we included two network exposure variables (exposure to formal leaders' prior practice and exposure to informal leaders' prior practice) in the model, possible multicollinearity⁵ between these two effects had to be considered (Doreian, 1989). The correlation coefficient between formal and informal leaders' exposure terms regarding general practices was 0.235 in Table 4 and, regarding specific practices, 0.313 in Table 6. These are moderate correlations, suggesting the possibility of multicollinearity. Therefore, to analyze the main effects of these two predictors properly, we first added each exposure variable separately to the model along with covariates to generate Models I and II in both Tables 5 and 7. Next we added both exposure terms to the model with the covariates, generating Model III in both tables. If

Table 4. Descriptive Statistics and Correlation Among Variables of Modeling Teachers' General Practices in 2008.

Variable	M (SD)	1	2	3	4	5	6	7
1. General practices of implementing No Child Left Behind (NCLB)-related standards, curricula, and assessments in 2008	1.079 (0.736)	1.000						
2. Prior general practices of implementing NCLB-related standards, curricula, and assessments in 2007	1.108 (0.711)	0.622***	1.000					
3. Exposure to formal leaders' general practices of implementing NCLB-related standards, curricula, and assessments	20.427 (42.374)	0.276***	0.276***	1.000				
4. Exposure to informal leaders' general practices of implementing NCLB-related standards, curricula, and assessments	40.753 (69.82)	-0.041	0.069	0.235**	1.000			
5. Exposure to NCLB-related professional development in 2008	0.728 (0.588)	0.158	0.152	-0.024	-0.061	1.000		
6. Perceived value of NCLB in 2007	2.491 (0.944)	0.153	0.15	0.226**	0.052	0.144	1.000	
7. Highest grade taught in 2008	4.38 (2.347)	0.022	0.005	-0.095	-0.075	-0.079	-0.073	1.000

** $p \leq .01$. *** $p \leq .001$.

multicollinearity existed, the standard errors for the influence terms in Model III (in both Table 5 and Table 7) would have had been much larger than the standard errors in Models I and II. In fact, the standard errors of these two exposure predictors did not change significantly from Model I and Model II to the Model III. Therefore, we concluded that multicollinearity between the two exposure variables was not substantial enough to compromise our interpretations.

Because we analyzed data at two time points, the high turnover of faculty in the sampled schools between 2007 and 2008 led to a large amount of missing data in the analysis, which featured in the analysis and interpretation of results.⁶ In the final analysis, a total of 137 cases were used to model general practices of implementing NCLB-related standards, curricula and assessment; and 147 cases were used to model specific pedagogical practices of teaching basic reading skills in nine schools.

Table 5. Estimated Formal and Informal Leaders' Influence on Teachers' General Practices of Implementing NCLB-Related Standards, Curricula, and Assessments in 2008.

	Model I		Model II		Model III	
	Unstandardized Coefficient	Standardized Coefficient	Unstandardized Coefficient	Standardized Coefficient	Unstandardized Coefficient	Standardized Coefficient
Prior general practices of implementing NCLB-related standards, curricula, and assessments in 2007	0.501 ^{***} (0.075)	0.516	0.493 ^{***} (0.076)	0.508	0.5 ^{***} (0.076)	0.515
Exposure to formal leaders' general practices of implementing NCLB-related standards, curricula, and assessments	0.0024 (0.0015)	0.11	—	—	0.003 ^a (0.0016)	0.124
Exposure to informal leaders' general practices of implementing NCLB-related standards, curricula, and assessments	—	—	-0.0004 (0.001)	-0.026	-0.0007 (0.001)	-0.047
Exposure to NCLB-related professional development in 2008	0.043 (0.084)	0.038	0.033 (0.088)	0.029	0.039 (0.088)	0.035
Perceived value of NCLB in 2007	-0.029 (0.052)	-0.037	-0.019 (0.052)	-0.025	-0.033 (0.053)	-0.042
Highest grade taught in 2008	0.015 (0.022)	0.068	0.013 (0.022)	0.057	0.015 (0.022)	0.065

No Child Left Behind = NCLB; N = 137. Model I includes the effect of formal leaders' influence, while Model II includes the effect of informal leaders' influence. Model III contains partial effects of formal leaders' and informal leaders' influence after controlling for covariates. Moreover, the following list of variables were included in initial models but then excluded from the final models because of their nonsignificance and to save degrees of freedom: years of teaching, years of working at the current school, held full certification, and perception of the legitimacy of NCLB principles. Standard errors are included in the parentheses.

a.t. = 1.875; p = .063.

***p ≤ .001.

Table 6. Descriptive Statistics and Correlation Between Variables of Modeling Teachers' Specific Pedagogical Practices in 2008.

Variable	M (SD)	1	2	3	4	5	6	7
1. Specific pedagogical practices of teaching basic reading skills in 2008	3.387 (0.905)	1.000						
2. Prior specific pedagogical practices of teaching basic reading skills in 2007	3.549 (1.045)	0.606***	1.000					
3. Exposure to formal leaders' specific pedagogical practices of teaching basic reading skills	65.026 (102.817)	0.281***	0.153	1.000				
4. Exposure to informal leaders' specific pedagogical practices of teaching basic reading skills	101.92 (144.648)	0.302***	0.086	0.313**	1.000			
5. Exposure to reading-related professional development in 2008	1.347 (0.926)	0.278***	0.209**	0.015	0.012	1.000		
6. Perceived value of No Child Left Behind in 2007	2.526 (0.92)	0.268***	0.162*	0.129	0.002	-0.016	1.000	
7. Highest grade taught in 2008	4.259 (2.273)	-0.577***	-0.512***	-0.123	-0.081	-0.147	-0.027	1.000

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

As we mentioned previously, these teachers were nested within nine schools. We fit the data to hierarchical linear models (HLMs) that may provide relatively accurate estimates of standard errors of teacher-level predictors, and we acknowledge that the small sample size at the school level provides few degrees of freedom to support precise estimates of school-level variables. Therefore, we did not include any school level variables in the modeling. At the same time, school random effects would not eliminate all possible unique contextual differences across schools that may confound with formal and informal leaders' influences on instructional change (e.g., the student population schools served, schools' structural configurations, their faculty members, their institutional histories, and their relationships to their districts). To confirm the results from HLMs, we thus conducted analysis by using school fixed effects to account for schools' unique characteristics.⁷ Inferences on both formal and informal leaders' influences from fixed effects are generally consistent with those from HLMs with school random effects.⁸

Finally, we note that by controlling for prior practices we likely accounted for important sources of bias in our estimates as well as added precision (e.g., Cook, Shadish, & Wong, 2008; Shadish, Clark, & Steiner, 2008). We further applied Frank's (2000) robustness index to examine the characteristics of

Table 7. Estimated Formal and Informal Leaders' Influence on Teachers' Specific Pedagogical Practices of Teaching Basic Reading Skills in 2008.

	Model I		Model II		Model III	
	Unstandardized Coefficient	Standardized Coefficient	Unstandardized Coefficient	Standardized Coefficient	Unstandardized Coefficient	Standardized Coefficient
Prior specific pedagogical practices of teaching basic reading skills in 2007	0.289*** (0.059)	0.365	0.267*** (0.056)	0.337	0.273*** (0.057)	0.345
Exposure to formal leaders' specific pedagogical practices of teaching basic reading skills	0.0008 (0.0007)	0.071	—	—	0.0002 (0.0007)	0.02
Exposure to informal leaders' specific pedagogical practices of teaching basic reading skills	—	—	0.0013*** (0.0005)	0.154	0.0012*** (0.0005)	0.143
Exposure to reading-related professional development in 2008	0.155*** (0.057)	0.168	0.15*** (0.055)	0.162	0.155*** (0.055)	0.168
Perceived value of No Child Left Behind in 2007	0.158*** (0.057)	0.149	0.184*** (0.055)	0.174	0.184*** (0.056)	0.174
Highest grade taught in 2008	-0.133*** (0.028)	-0.441	-0.137*** (0.026)	-0.455	-0.134*** (0.027)	-0.445

N = 147. Model I includes the effect of formal leaders' influence, while Model II includes the effect of informal leaders' influence. Model III contains partial effects of formal and informal leaders, after controlling for covariates. Moreover, the following list of variables were included in initial models but then excluded from the final models because of their non-significance and the purpose to save degrees of freedom: years of teaching, years of working at the current school, held full certification, and perception of the legitimacy of No Child Left Behind principles. Standard errors are included in the parentheses.

*p ≤ .05. **p ≤ .01. ***p ≤ .001.

omitted or unmeasured variables necessary to invalidate our inferences. Our estimated effects of exposure to formal and informal leaders' practices on teachers' classroom practices could be spurious because exposure could be confounded with other characteristics of teachers that we did not include as control variables in the models. For instance, teachers' desire or motivations to change (the possible omitted confounding variable) may lead them to seek out help (the independent variable) and more likely to change their instructional practice (the dependent variable). Generally, no matter how strong the controls are in the model, there will be the concern that, as there is in any observational study, estimates are biased and inferences are invalid because of omitted variables from the analysis. We, thus, used Frank's calculation to quantify the extent to which our inference would be robust against such possible unmeasured and omitted confounding variable(s).

Results

Estimating Effects on General Practices of Implementing NCLB-Related Standards, Curricula, and Assessments

Table 4 reports the descriptive statistics and correlations between variables of modeling the formal and informal leaders' influences on change in teachers' general practices from 2007 to 2008. Exposure to formal leaders' general practices is statistically significantly correlated with teachers' general practices in 2008 ($\rho = 0.276$), while exposure to informal leaders' general practices does not have any statistical association with teachers' general practices in 2008. Moreover, the significant association between perceived value of NCLB in 2007 and exposure to formal leaders' general practices ($\rho = 0.226$) indicates that the higher the teachers' perceived value of NCLB in 2007, the more likely teachers would seek for help from formal leaders with regards to implementing NCLB-related standards, curriculum materials, and assessment.

Table 5 gives the fixed-effect estimates in HLMs. As indicated in Model III, the estimate of exposure to formal leaders' influence was on the border of statistical significance at a level of .05 with the unstandardized coefficient of 0.003 and standardized coefficient of 0.124 ($t = 1.875, p = .063$). This suggests the possibility that interactions with formal leaders positively affect teachers' general practices of implementing NCLB-related instructional standards, curricula, and assessments in 2008, which to some extent supports the first hypothesis. In contrast, informal leaders had near zero influence on general teaching practices ($\beta = -0.0007, SE = 0.001$). Not surprisingly, own prior

implementation of NCLB in 2007 was the strongest predictor with a standardized coefficient of 0.515. After controlling for formal and informal leaders' influence and the own prior practices, none of the rest covariates, such as exposure to NCLB-related professional development, perceived value of NCLB, or highest grade taught, was statistically significant.

Estimating Effects on Specific Pedagogical Practices of Teaching Basic Reading Skills

As shown in Table 6, multiple factors have positive association with the outcome measure of specific pedagogical practices of teaching basic reading skills in 2008: Prior specific pedagogical practices ($\rho = 0.606$), exposure to formal leaders' specific pedagogical practices ($\rho = 0.281$), exposure to informal leaders' specific pedagogical practices ($\rho = 0.302$), participation in reading-related professional development ($\rho = 0.278$), and perceived value of NCLB in 2007 ($\rho = 0.268$). The relationship between highest grade taught in 2008 and teachers' specific pedagogical practices in 2008 is negative ($\rho = -0.577$), which indicates the higher grade taught, the less frequently teachers taught basic reading skills in 2008.

The estimates of HLM models are reported in Table 7. As indicated in Model III, after controlling for other covariates, the coefficient for the influence of formal leaders on teaching basic reading skills in 2008 is essentially 0 (less than one third of its standard error and not statistically significant), while the coefficient for informal leaders is statistically significant. One standard-deviation increase in exposure to informal leaders' influence would result in 0.143 standard deviation of increase in teaching basic reading skills in 2008 ($p \leq .01$). Comparing the standardized coefficients, the effect of exposure to informal leaders is near to the effect of exposure to reading-related professional development in 2008 (standard coefficient = 0.168) and near to one half of the teachers' own prior specific pedagogical practice of teaching basic reading skills (standard coefficient = 0.345).

In addition, exposure to reading-related professional development and perception of high values of the NCLB promoted the practices of teaching basic reading skills. Moreover, consistent with the correlation coefficient, teachers who taught the lower grades increased their teaching of basic reading skills more than did colleagues who taught higher grades.

Quantifying the robustness of inference. We used Frank's (2000) calculations to quantify the robustness of the inference of informal leadership on the change in teaching basic reading skills due to any omitted confounding variable (e.g., teachers' motivation to teach basic reading skills).⁹ To express

robustness that accounts for the relationship between a confounding variable and the predictor of interest and between the confounding variable and the outcome, Frank defined the impact of a confounding variable on an estimated regression coefficient as $\text{impact} = r_{yv} \times r_{xv}$. In this expression, r_{yv} is the correlation between a confounding variable, v (e.g., motivation to teach basic reading skills), and the outcome y (e.g., teachers' practice of teaching basic reading skills), and r_{xv} is the correlation between v and x , a predictor of interest (e.g., informal leaders' influence). Frank then quantified how large the impact must be to invalidate an inference. For instance, in this study, the impact of a confounding variable would have to be greater than 0.025 to invalidate the inference of informal leadership on the change in teaching basic reading skills. Correspondingly, to invalidate our inference, the unmeasured confounding variable would have to be correlated with the outcome variable of teaching basic reading skills at 0.15 and with exposure to informal leaders' influence at 0.17. It is also intuitive to compare this impact to that of a measured covariate. Partialling for prior status of teaching basic reading skills, one of the strongest covariates was the variable of received reading-related professional development, with an impact of $(0.021 = 0.109 \times 0.194)$. Thus the impact of an unmeasured confound necessary to invalidate the inference would have to be stronger than the impact of reading-related professional development.

Discussion

This study examines how formal and informal leaders promoted instructional changes in response to external institutions associated with NCLB. As informed by theories of both distributed leadership and social influence processes, we have modeled how teachers' instructional practices were influenced through interactions with formal and informal leaders. Findings in this study have several theoretical and practical implications, yet limitations.

Theoretical Implications

This study provides another source of empirical evidence to support the claim that distributed leadership can support the implementation of external reforms. When the institution of NCLB-related reading policy penetrates schools, formal leaders might affect general practices of setting standards, selecting materials, and assessing students, while informal leaders positively might affect specific pedagogical practices of teaching basic reading skills. What we found is largely consistent with Smith and O'Day's (1991)

suggestion of establishing divisions of authority that draw on the strengths of each level of governance to support a systemic reform, and we extend their suggestions to the within-school leadership structure. Formal leaders have the authority and the capacity to allocate resources and provide direct guidance on implementing these external expectations at general level while informal leaders who share the same contexts of other classroom teachers transfer knowledge and norms on implementing the external institutions in classroom settings.

Moreover, our findings add evidence to Spillane's (2006) typology's collective distribution of leadership. The strength of distributed leadership framework ultimately comes from the alignment between formal and informal leaders' influences on different aspects of the task—in our case, the implementation of external reform within schools. The significant and positive correlations between teachers' exposure to formal and informal leaders in Table 4 and Table 6 show that teachers received generally consistent messages from the two sources in the sampling schools. Although as shown in Table 7 both formal and informal leaders have consistently positive effects on the change in specific pedagogical practices, as shown in Table 5 the influence that teachers received from formal leaders on general practices may be in the different direction of that from informal leaders, although these conflicting influences were not sufficiently supported by our data. If this were the case, this result would have suggested the organizational dysfunction in the sampling schools.

Beyond these theoretical contributions, this study adds methodological value to the emerging interest in using social network data and analytical strategies to provide direct evidence of the effects of educational leadership on teaching practice (e.g., Penuel, Riel, Joshi, & Frank, 2010; Moolenaar et al., 2010; Spillane, Healey, & Kim, 2010). Rather than use characteristics of network structure descriptively or as predictors as these researchers have done in the past, we relied on longitudinal data and used the exposure measure that incorporates both network structure and leaders' attributes to estimate influence. We then created multiple measures of exposure to estimate the different influences of formal and informal leaders, accounting for dependencies within schools using fixed and random effect models.

Practical Implications

Based on the findings of this study, we suggest several practical strategies to develop a strong team to lead the successful implementation of external reforms at the local school level. Schools should be aware that teachers

may respond differently to help from formal leaders and informal leaders. Thus schools must coordinate formal and informal leaders' influences to ensure coordinated impacts on changing different aspects of instructional practices. This can be done through clearly articulating distinct roles of principals, coaches, and informal teacher leaders and through recognizing them for their accomplishments (e.g., as in personnel evaluations). At the same time, it is also useful to provide guidelines and opportunities school faculty to collaborate and for leaders to provide coherent support for instructional improvement. In addition, we may expect senior teachers with instructional expertise to not only be good at their own teaching but also help other teachers and lead instructional reform, which can be included in their job description and annual evaluation (Frank, Sykes, Anagnostopoulos, Cannata, Chard, & Krause, 2008). In alignment with job expectations, to promote informal leaders' helping behaviors, those teachers should be compensated and be given incentives for sharing instructional expertise.

Correspondingly, formal leaders and informal leaders should be supported by professional development programs that emphasize different but coherent knowledge and skills. For example, informal leaders need relatively to improve their specific content knowledge and pedagogical skills as well as their collaboration skills with colleagues and leadership skills to participate in school decision making, while formal leaders need to have clear and sufficient information on how to facilitate teaching and learning under accountability and specific school contexts. Although the content and skills emphasized in professional development for formal leaders and regular teachers may slightly differ, these programs should center on the implementation of instruction and curriculum that ultimately benefit students' learning.

Limitations

This study has three key limitations. First, we have analyzed existing social relations in school organizations, which allowed us to describe the stable social structure and to estimate outcomes given on interactions. However, these data did not indicate who initiated the helping relationship. We propose that future studies explore this issue either by collecting empirical data on with whom teachers would like to interact or employing simulation techniques such as agent-based modeling (Wilensky & Resnick, 1999; see Coburn 2005). Moreover, our network measures account for whom and how frequently teachers interacted as well as what might be conveyed through social interactions. Yet our network measures do not include exact measures

on the depth of interactions (specific content and format of interactions), which is a feature of network indicating the extent to which interactions provide opportunities to learn (Coburn & Russell, 2008).

Second, this study only includes data in 2 consecutive years. Future studies should examine the dynamics of how school contexts, including existing instructional practices and collaborative norms, shape formal and informal leadership, which in turn develop new interactions among teachers, and then support the change in instruction and learning. By including data at more than two time points, future studies can also examine how formal leaders' influence on general practices may further affect the change in teachers' specific classroom practices. Moreover, we also suggest future studies to investigate and discuss the extent to which formal and informal leaders' influences vary across grade levels, perceptions of the value of external reform, and current own instructional practices.

Third, our findings are limited by the small sample size. We only included teachers from nine schools located in one state in this analysis; therefore, findings from this study have limited generalizability to the population of public schools in the United States. Moreover, we found that formal leaders in the middle school, Hermosa, were less likely to influence teachers' specific pedagogical practices than were their counterparts in other elementary or K-8 settings in the sample. Because there was only one middle school in the final sample, we did not substantially discuss this finding, yet we suggest that future studies can further explore the distribution of formal leadership across school levels and/or types.¹⁰ In addition, the leadership was examined under the implementation of reading policy associated related to NCLB, which has unique demands and tasks related to accountability. Therefore, some findings may be limited to this context.

Conclusion

The accountability reform of NCLB is one of the major political efforts in American education history. This external institution of schooling has not only highlighted the school formal leaders' role in promoting instructional changes but also activated other regular teachers' leadership roles (Camburn et al., 2003; Elmore, 2000). Relative to the process of implementing practices related to NCLB, we found formal leaders facilitated teaching and learning through influencing general instructional practices, while informal leaders influenced specific classroom practices through interactions. Such distinctive but possibly complementary normative influences require policy-makers' attention to intraorganizational processes of local implementation

through multiple sources of school leadership. Despite the limitations, this study paves the way for future studies to examine the configuration of instructional leadership roles and to design personnel management strategies (e.g., professional development, evaluation, and compensation) that develop an effective leadership team that can provide a coherent supporting system for instructional improvement in schools.

Acknowledgments

We wish to thank core members of the data collection team for their efforts in making these analyses possible: Christine Korbak, Judi Fusco, Christopher Hoadley, Joel Galbraith, Amy Hafter, Aasha Joshi, Amy Lewis, Margaret Riel, Willow Sussex, and Devin Vodicka. The authors thank Leslie Pearlman and Susan Printy for their thoughtful comments on earlier drafts and presentations.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work has been supported by National Science Foundation grants #0231981 and #0624307. All opinions expressed herein are the sole responsibility of the authors.

Notes

1. In one school, there were only five teachers in the sample and none of them had exposure to formal leaders' influence on either general practices or specific pedagogical practices. Another school had five teachers too. All of these five teachers were completely missing exposure to formal leaders' influence, while four of these five teachers were missing exposure to informal leaders' influence. Because the inferences of findings are expected to be implied to the typical situation where teachers have exposure to both formal and informal leaders' influences simultaneously, we excluded these two schools from our analysis.
2. Some formal leaders had multiple roles.
3. We considered recoding to days per year, but this exaggerated the most frequent behaviors, skewing the distribution of responses. The original survey scale used here is roughly the log of days per year.
4. In the 2008 data, the short version of the measure of focus on basic skills is strongly correlated with the full measure (correlation coefficient $\rho = 0.94$).

Therefore this shortened prior measure is sufficient as a measure of prior practice.

5. Multicollinearity is a problem of highly correlated or interrelated predictors, which leads to difficulty in determining the relative importance of formal leaders' influence versus informal leaders' influence.
6. We compared school actors' characteristics between the 2007 sample and the 2008 sample. On average, school actors (including regular teachers and leaders) in the 2008 sample had 1 more year of experience than did those in the 2007 sample. There were no significant differences in the percentage of school actors who had full certification between these two years of sample. Therefore, we tentatively conclude that the 2008 sample represents for the most part of the 2007 sample in terms of measured individual background characteristics. However, we found that teachers who had partial certification or who had less teaching experience in 2007 were more likely to leave in 2008.
7. We controlled for school effects using a set of dummy variables (that is, we treated schools as fixed effects). Any unique characteristic associated with the school from student composition to the general policy environment was captured in the unique effect for each school. To conserve degrees of freedom, we only included four extreme school fixed effects (larger school fixed effect estimates) delineating schools that differed substantially from the others. In this case, we controlled for sufficient school-level variance but also saved degree of freedom to increase the power of the estimation models. We then included all eight school fixed effects in the model (leaving one school as the reference school). The standard errors of estimates of formal teachers' influence increased 50%, which indicates the reduction of estimation power by adding the other four estimates of school weak fixed effects.
8. The only different inference between hierarchical linear models (HLM) and fixed effect models is in the estimate of exposure to informal leaders' prior general practices: the HLM models produced a negative coefficient but not being statistically significant, which is consistent with the result from fixed effect models with all school fixed effects, while the fixed effects model with only extreme schools yields a statistically significant negative coefficient.
9. The online technical support for the calculation is available at <https://www.msu.edu/~kenfrank/research.htm#causal>, then spreadsheet for calculating indices.
10. We checked whether the distribution of leadership functions between formal and informal leaders differed across school types. We ran the HLM models with interaction terms between the dummy variable of Hermosa school (the middle school, at school level) and exposures to formal and informal leaders' prior practices (at teacher level). Thus we created four interaction terms (e.g., dummy of

Hermosa \times exposure to formal leaders' general practices, dummy of Hermosa \times exposure to informal leaders' general practices, dummy of Hermosa \times exposure to formal leaders' specific pedagogical practices, and dummy of Hermosa \times exposure to informal leaders' pedagogical specific practices). The only significant effect among these four cross-level interaction terms was the coefficient of the dummy of Hermosa \times exposure to formal leaders' specific pedagogical practices ($\beta = -0.018$, $SE = 0.008$, $p = .033$). That is, the middle school formal leaders were less likely to influence teachers' specific pedagogical practices than counterparts in elementary or K-8 settings in the sample. All of main inferences in our model were not altered.

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