

The networked principal

Examining principals' social relationships and transformational leadership in school and district networks

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Abstract

Purpose – While in everyday practice, school leaders are often involved in social relationships with a variety of stakeholders both within and outside their own schools, studies on school leaders' networks often focus either on networks within or outside schools. The purpose of this paper is to investigate the extent to which principals occupy similar positions in their school's network and the larger district network. In addition, the authors examined whether principals' centrality in both networks can be attributed to demographic characteristics and transformational leadership (TL).

Design/methodology/approach – Using social network analysis, correlational and regression analysis, and an advanced social network technique, namely p2 modeling, the authors analyzed data collected among 708 educators in 46 Dutch elementary schools. The authors also offer a visualization of the district social network to explore principals' relationships with other principals in the district.

Findings – Results suggest that principals who occupy a central position in their school's advice network are also more likely to occupy a central position in their district's collaborative leadership network. Moreover, TL was found to affect the extent to which principals are central in both networks.

Originality/value – The study is unique as it simultaneously explores principals' social relationships in schools and the larger district. Moreover, the authors advance the knowledge of TL as a possible mechanism that may shape the pattern of these relationships, thereby connecting two streams of literature that were until now largely disconnected. Limitations to the study warrant further qualitative and longitudinal research on principals' social relationships in schools, districts, and the larger community.

Keywords Principals, Educational administration, Transformational leadership, Teachers, Networks

Paper type Research paper

Introduction

In the past decades, views on leadership have increasingly focussed on the importance of collaboration and social relationships for successful leadership in a variety of contexts, such as business, sports, and education (Hargreaves *et al.*, 2014). Nowadays, leadership is no longer regarded as an individual attribute or an economic exchange

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between leaders and followers, but rather as a “complex social dynamic” that emerges in the social relationships between individuals (Avolio, 2007; Avolio *et al.*, 2009; Hallinger, 2010).

Recently, social network theory has gained traction to understand how leadership takes place through social relationships (Hoppe and Reinelt, 2010; Scott, 2000). According to this theory, leadership can be interpreted in terms of occupying a central position in a social network (Balkundi and Kilduff, 2006; Cross and Parker, 2004). As principals interact with teachers and other principals in the larger district, they form relationships that act as conduits for the transfer of resources such as work-related information, advice, and social support (e.g. Daly *et al.*, 2014a; Moolenaar *et al.*, 2012a). The resulting web of relationships may offer opportunities, but also constraints, for the extent to which principals can exert control over their environment (e.g. Burt, 2005; Daly and Moolenaar, 2011; Obstfeld, 2005).

In education, Spillane and colleagues have started an important line of research that focusses on the role of the principal as a formal leader in the school (e.g. Pitts and Spillane, 2008; Spillane *et al.*, 2010; Spillane and Kim, 2012). This research underscores the role of principals’ social relationships with teachers as main conduits through which principals have access to knowledge and insights into how teachers are working and where they may need support. Another line of network research on educational leadership, instigated by Daly and colleagues, explores principal leadership in the context of the larger district network, for instance by examining principals’ social relationships with other principals and district leaders (e.g. Daly, 2010; Daly and Finnigan, 2010, 2011; Daly *et al.*, 2014b). Such relationships among principals have been deemed important as they support instructional coherence across schools within a district and offer principals with opportunities to share experiences and access to expertise among peers.

Until now, a comprehensive understanding and systematic exploration of principals’ simultaneous role in multiple networks (e.g. in schools and districts) is missing. Therefore, in this study we explore principals’ leadership by comparing and contrasting principals’ social network position in two different contexts, namely in their school’s network and the larger network of district principals. Such an exploration might increase our insights into the extent to which there is universality in principals’ network positions, meaning, the extent to which principals’ network positions may be similar across different contexts (cf. Bass, 1997).

Although examining leadership from a social network perspective may yield insights into principals’ opportunities to access and influence the resource flow in schools and the larger district, limited knowledge exists on how principals come to occupy such a central position. One explanation may come from transformational leadership (TL), a view on leadership that has attracted much interest in educational research over the past decades (e.g. Avolio and Bass, 1995; Bass, 1985; Bass and Avolio, 1994; Hallinger, 2003; Leithwood *et al.*, 2008; Leithwood and Jantzi, 2006; Walumbwa *et al.*, 2007, 2008; Yukl, 2013). Transformational leaders are characterized by the ability to increase their followers’ commitment and engagement and stimulate them to do more than they expected (Bass and Avolio, 1994; Leithwood and Jantzi, 2006) in achieving individual and organizational goals. By placing a strong emphasis on behaviors that stimulate social identification, intrinsic motivation and augmentation of individual and collective efficacy, transformational leaders may mobilize their interpersonal relationships for the enactment of leadership (Hallinger and Heck, 1998; Hallinger, 2010).

Given that both the theory of TL and social network theory foreground the importance of social relationships in schools aimed at fostering educational reforms and innovation, scholars have recently started to examine the relationship between TL practices and school leaders network position (Bass *et al.*, 2003; Moolenaar *et al.*, 2010). Although the few available studies provide some evidence for a relationship between TL and network position, more research is needed to provide valuable knowledge on how leadership behavior and principals' network position in different contexts are related.

This study will contribute to the literature on leadership behavior and leaders' social network position by investigating the extent to which TL behavior affects principals' centrality in the school and district network. In this paper, the main premise is that principals may occupy similar network positions in their school and district social networks. In addition, we argue that TL behaviors may explain why some principals occupy more central positions in their networks than others.

In this paper, we explore the pattern of principals' social relationships within their school with teachers, and across schools with other principals in a large Dutch school district. The following research questions guided our study:

RQ1. To what extent is principals' social network position (measured by degree centrality, closeness centrality, and betweenness centrality) in the district's collaborative network related to their social network position within their school's advice network?

RQ2. To what extent is TL behavior associated with principals' social network position both within and across schools?

Theoretical framework

A social network perspective on leadership

One way to better understand principals' social relationships is by applying a social network perspective to leadership (e.g. Daly and Moolenaar, 2011; Moolenaar, 2012). Complementary to traditional views on leadership, organizational scholars are increasingly exploring leadership as a relational process, and conceptualizing leadership by examining a leader's position in a social network (Balkundi and Harrison, 2006; Balkundi and Kilduff, 2006; Brass *et al.*, 2004; Uhl-Bien, 2006). This work suggest that leaders' social network position may offer opportunities for exchanging resources, leveraging social capital, and brokering between others in the organization. To empirically examine leadership in networks, researchers often focus on the concept of network centrality (Sparrowe *et al.*, 2001).

Network centrality reflects the notion that when an individual holds a central position in a social network, s/he is "in the middle" of the flow of resources (such as information, materials) and therefore has greater access to these resources, greater opportunities to hoard and distort these resources, and disproportionately influence which resources are distributed where, how fast, and with how much ease (Brass and Krackhardt, 1999; Mumford *et al.*, 2002). Being "central" in a network is often equaled with being in a position of power and control (Brass, 1995; Brass and Burkhardt, 1993; Burt, 1992, 2005; Cross and Parker, 2004; Ibarra and Andrews, 1993). Leaders' network centrality has also been related to group performance, leader effectiveness, and reputation (Balkundi and Harrison, 2006; Mehra *et al.*, 2006; Sparrowe *et al.*, 2001). However, a central position can also come at a cost; a highly centralized network places

a disproportionate burden on a few in the organization, and managing many relationships requires high investments in terms of time, attention, and effort (Daly and Moolenaar, 2011). Nevertheless, a central network position is regarded as a position of power, whereas individuals who are isolated or at the network periphery are seen as less involved in the organization's flow of resources.

In this study, we focus on three often-used measures of principals' social network position that reflect the extent to which they are central in the flow of knowledge, namely degree centrality, closeness centrality, and betweenness centrality (see also Friedkin and Slater, 1994). These measures have been extensively studied and cited as they each offer a related, yet distinct view on principals' network centrality (Kilduff and Krackhardt, 2008; Moolenaar *et al.*, 2010; Wasserman and Faust, 1997). Degree centrality simply captures the number of social relationships in which a principal is directly involved. In a directed network, meaning a network in which the direction of the relationships is taken into account, degree centrality can be assessed in terms of in-coming ties (in-degree) as well as out-going ties (out-degree). Principals who are sought by many others have high in-degree centrality (many in-coming ties) and thus to be relatively "popular" in a social network (Balkundi and Kilduff, 2006). Principals who turn to many others to seek network resources are considered to have high out-degree centrality (many out-going ties) and thus to be relatively "active" in terms of seeking resources. Closeness centrality also takes into account the larger network structure by examining how many "steps" it will take for others to reach the principal through the web of social relationships. Finally, betweenness centrality reflects the extent to which a principal takes on a brokerage role "in between" disconnected others in the network (Burt, 2005; Daly *et al.*, 2014b; Kilduff and Tsai, 2003). As a "betweenness" position offers a principal the opportunity to control the flow of resources between people who would otherwise be less well connected to each other, it is therefore often interpreted as a position of power (Ibarra and Andrews, 1993).

Social networks in education

In empirical research on social networks among educators, a broad distinction can be made between studies that examine social networks of educators within schools and studies that focus on educators' networks across schools (cf. Moolenaar, 2012; Penuel *et al.*, 2006).

Networks within schools. The first line of network studies in education (e.g. Coburn *et al.*, 2012; Moolenaar, 2010; Penuel *et al.*, 2009) consists of studies that attempt to understand knowledge exchange and development by examining social networks within schools. A "network" in this sense can be regarded as the pattern of relationships between educators in a bounded group that reflects their purposive interaction. Recently, studies have suggested that such a pattern of relationships in schools matters for a wide range of outcomes, such as the implementation of educational reform (Coburn and Russell, 2008; Coburn *et al.*, 2010; Daly *et al.*, 2010; Datnow, 2012), the perception of innovative climates and adoption of innovations and new technology (Daly *et al.*, 2014a, d; Frank *et al.*, 2004; Moolenaar *et al.*, 2011), and instructional practice and student achievement (Frank *et al.*, 2014; Leana and Pil, 2006; Moolenaar *et al.*, 2012b; Penuel *et al.*, 2012; Pil and Leana, 2009; Yasumoto *et al.*, 2001).

Studies examining leaders' social networks within schools have provided valuable insights into the distribution of formal and informal leadership in schools (Coburn,

2005; Pitts and Spillane, 2008; Spillane and Kim, 2012). This work seems to suggest that there is large variation among principals in the extent to which they occupy a central position in the work-related and personal networks in their school. Moreover, school leadership may be distributed over various actors in the school team, such as principals, teacher leaders, and informal leaders, with or without a formal hierarchical mandate to lead (e.g. Bedeian and Hunt, 2006; Spillane, 2006). Studies have shown that in some schools, lines of informal communication among educators only weakly reflect the school's formal hierarchical structure (i.e. the way in which formal roles such as principal, coaches, and teachers are organized) (Penuel *et al.*, 2010; Spillane *et al.*, 2010; Tuytens *et al.*, 2014). Similarly, educators in formal roles do not always enact their intended advisory roles as prominently as expected (Coburn and Russell, 2008; Spillane and Healey, 2010). Finally, principals' centrality in school networks has been associated with school outcomes such as school performance (Friedkin and Slater, 1994) and schools' innovative climate, suggesting that principals who occupy more central positions in their schools' advice networks are leading schools in which teachers are more open toward innovations (Moolenaar *et al.*, 2010).

Networks across schools. The second line of network studies in education focusses on knowledge exchange among educators in networks across schools (e.g. Bidwell, 2001; Lieberman, 2000; West, 2010). Networks, in this sense, are defined as "at least two organizations working together for a common purpose for at least some of the time" (Muijs *et al.*, 2010). Such collaborative initiatives that transcend traditional school boundaries have become more common practice in support of educators' professional development and school improvement (Díaz-Gibson *et al.*, 2014; Hofman and Dijkstra, 2007; Rienties and Kinchin, 2014; Van Waes *et al.*, in press).

In current years, school districts around the world have been developing initiatives to stimulate the exchange of knowledge among principals and other leaders in the district (Ainscow, 2010; Chapman, 2008; Daly and Finnigan, 2010, 2011; Hite *et al.*, 2010; Honig and Venkateswaran, 2012; Muijs *et al.*, 2010; Rorrer *et al.*, 2008; Veugelers and Zijlstra, 2002; West, 2010). Such initiatives are often designed to support instructional coherence across district schools and address the increasing complexity of accountability policy and demands of comprehensive educational reforms, especially in support of students that have traditionally been "left behind" (Finnigan and Daly, 2010; Honig, 2006, 2008; Honig and Coburn, 2007; Honig and Hatch, 2004). In such "district networks," principals engage in social relationships with other principals to exchange information, give and receive advice, collaborate on specific issues, and learn from each other, often in formally organized collaborative professional development meetings (with or without support or guidance of a district central office). While principals within a single district often have the same opportunities to collaborate with each other across the district, Daly and Finnigan (2010) found that there is considerable variation between school leaders in the extent to which they are involved in the flow of knowledge in district leadership networks.

Similarity of principals' social network positions in schools and districts

As studies either examine school leaders' network positions within schools or their ties to expertise outside schools, this raises an interesting question with regard to leaders' network position that warrants further examination, namely; how universal relevant is a leader's network position over different settings? For instance, do school leaders occupy similar network positions in school and district networks?

A principal who is engaged in many collaborative relationships in the district will have access to a wide range of resources, which they may subsequently share with teachers. Vice versa, principals who have many close ties with teachers in their schools may also have more information to share in collaborations with other principals in the district. Principals are increasingly regarded the main conduits between districts and schools and are expected to “broker” information between districts and their staff (Daly *et al.*, 2014b; Honig and Hatch, 2004; Honig and Venkateswaran, 2012). By virtue of increased access to resources in both networks, being more central in the district’s collaboration network may also be related to a more central position in the school’s advice network.

Additionally, networking behavior by principals may also be an intentional strategy (e.g. Moolenaar *et al.*, 2014a), and perhaps a more dispositional behavior that transcends specific contexts and is relatively stable over time and different settings (e.g. Kilduff and Krackhardt, 2008). When principals occupy a similar network position in their school and the larger district, there may be underlying characteristics (e.g. experience, political skills, personality, network intentionality, leadership behavior) that influence some principals to be more central in the flow of information than others in multiple networks. While the search for antecedents of educators’ social network positions is still in its infancy (Moolenaar *et al.*, 2014b; Spillane and Kim, 2012), insight in such characteristics may offer valuable leads as to factors that may strategically support principals’ access to resources.

Therefore, we expect that principals who occupy a more central position in the district’s collaboration network (in terms of in-degree, out-degree, closeness and betweenness centrality) also occupy a more central position in their school’s advice network (*H1*).

TL

Leadership is widely regarded as playing a significant role in school improvement and educational change, especially as it is inspired by the concept of TL (Leithwood *et al.*, 1999; Leithwood and Slegers, 2006). This concept of leadership, as developed by Burns (1978), fundamentally aims to foster capacity development and higher levels of personal commitment to organizational goals on the part of the followers, leading to increased effort and productivity (Bass, 1985; Bass and Avolio, 1994; Burns, 1978). Drawing on Burns’ theoretical ideas, Bass (1985) proposed a model of leadership that included two separate but interdependent dimensions, namely transactional and TL.

Transactional leadership is most associated with “transactions” between leaders and followers, and is believed to be sufficient for sustaining the status quo. Transformational leaders differ from transactional leaders in that they do not merely recognize the needs of followers, but also attempt to elevate those needs from lower to higher levels of development and maturity (Bass, 1985; Bass and Avolio, 1994; Marks and Printy, 2003). TL augments transactional leadership by focussing on the development of followers for the purpose of change as well as addressing the goals of the leader, follower, group and organization (Bass and Avolio, 1990).

Taking the work of Burns (1978, 1979) and Bass (1985) as a point of departure, research on TL in education was initiated in Canada by Leithwood and colleagues (Leithwood and Jantzi, 1991). Since then, empirical studies in a wide range of educational contexts have yielded evidence that principals’ TL is positively associated with different school and teacher conditions, such as teacher satisfaction and organizational commitment, participation in decision-making, and motivation to

implement accountability policies (e.g. Geijsel *et al.*, 2003; Griffith, 2004; Leithwood and Jantzi, 2005; Leithwood and Sun, 2009). In addition, TL has been linked with student engagement and student performance, both directly and indirectly (Koh *et al.*, 1995; Leithwood and Jantzi, 2006; Leithwood and Sun, 2012).

In general, three dimensions can be discerned in literature on TL in education, namely:

- (1) Vision Building, concerning the extent to which a leader involves others in developing a shared vision, goals and priorities.
- (2) Individual Consideration, concerning the extent to which a leader attends to individual teachers' personal feelings and needs.
- (3) Intellectual Stimulation, concerning the extent to which a leader supports teachers' professional development and challenges them to constantly re-evaluate their practice and their thinking (Geijsel *et al.*, 2009, 2001; Leithwood and Jantzi, 2006; Thoonen *et al.*, 2011; Yu *et al.*, 2002).

Given that the work of transformational leaders foregrounds the importance of social relationships to achieve school goals, recent research has suggested that transformational school leaders occupy a more central position in their school's social network than non-transformational leaders (Moolenaar *et al.*, 2010). Transformational leaders may reach out to others more to ask for advice (in network terms: higher out-degree centrality), encourage relationships among their staff and colleague principals so that they can quickly reach others (creating shorter network paths, thus increasing closeness centrality), and try to exert influence by connecting educators that are themselves unconnected (higher betweenness centrality). In addition, as transformational leaders involve teachers in building a shared vision and setting clear goals for their school, show individualized attention to the needs and aspirations of teachers, and stimulate and challenge teachers to try new approaches, they may also be sought more for advice and collaboration (higher in-degree centrality) in schools and districts than less transformational leaders.

In addition, research has suggested that TL may transcend organizational boundaries, and as such be universally relevant in different kind of situations and contexts (Bass, 1997; Nguni *et al.*, 2006; Yukl, 2013). These findings suggest that principals may display similar TL behaviors in their schools as well as in the larger district. However, there is limited empirical research that simultaneously focusses on principals' social network positions in different contexts, as well as into factors that may explain this network position. Based on these arguments, we hypothesize that TL behaviors will be positively associated with principals' network centrality (in terms of in-degree, out-degree, closeness, and betweenness centrality) in both their school's advice network and the district's collaboration network (*H2*).

To test our hypotheses, we employ social network analysis, correlational analysis, regression analysis, and an advanced social network technique called p2 modeling using data from 41 Dutch elementary schools. We will control for certain "fixed" demographics that may also explain principals' tendency to occupy a central position in their networks, such as principals' experience, team size, and gender (Moolenaar *et al.*, 2014b; Spillane and Kim, 2012; Van Waes *et al.*, 2013). As this is one of the first studies to examine principals' social relationships in a larger district setting, we further provide a visualization of the district's collaborative network structure.

Method

Context

We conducted our study in 46 elementary schools from a single school district in the south of the Netherlands. School principals in the Netherlands are formally responsible and held accountable for policy-making of their school (including instructional, personnel, and financial decisions) within the boundaries of the local and national legal and policy frameworks as developed and monitored by the Dutch Department of Science, Culture and Education. We selected this school district as it was undertaking a large-scale reform effort that focussed on improving district and school organizational effectiveness and efficiency. As part of the reform strategy, schools were clustered into five regional areas to stimulate knowledge exchange among the principals within the areas. The school principals who participated in our study were therefore expected to attend professional development meetings aimed at increasing knowledge exchange in the district as a whole, and within the areas in particular. The data used in this study were part of a larger data collection in the district (see Moolenaar, 2010). We selected a subsample of 46 schools out of the total of 54 district schools to exclude schools with fewer than six instructional staff members and schools for special education[1].

Sample

The sample consisted of 41 principals that provided leadership to 46 elementary schools (grades K-6). While most principals provided leadership to a single school, the sample also included principals who were in charge of multiple schools. Specifically, three principals each provided leadership to two schools and one principal provided leadership to three schools. These principals distributed their time roughly evenly over the schools, which were located in close proximity to each other and were transitioning to form single schools due to a decrease in the number of prospective students.

We included data from 667 teachers, representing an average school response rate of 85.5 percent. School team size ranged from six to 31 teachers per school ($M = 15.5$, $SD = 6.8$). While most of the principals were male (76.1 percent), the majority of teachers was female (75.3 percent), which approximately reflected the gender distribution in schools across the Netherlands at the time of study. Principals' average age was 50.4 years ($SD = 7.6$ years, range 33-61), and teachers' average age was 45.5 years ($SD = 11.1$ years, range 21-63). Additional sample demographics are presented in Table I.

Data collection

Principals' network position within their school. To assess principals' social network position within their own schools, we included the following prompt in the paper surveys for principals and teachers: "In your school, whom do you ask for work-related advice?" We chose to focus specifically on the advice relationships between principals and teachers following previous research (Copeland *et al.*, 2008; Obstfeld, 2005) as advice relationships between principals and teachers are important conduits for principals to support teachers in their work.

Principals and teachers could then indicate whom they asked for work-related advice using a list of checkboxes with letter codes. A school-specific list of these letter codes and corresponding names was attached to the survey. These school-specific name lists were compiled based on information provided by the school district and

Table I.

Sample characteristics of schools ($n = 46$), principals ($n = 41$) and teachers ($n = 667$)

	<i>n</i>	Min.	Max.	<i>M</i>	SD
<i>School</i>					
Gender ratio ^a	46	59.0	92.9	75.9	9.9
Number of students	45	61	545	226	118.5
Team size	46	6	31	15.5	6.8
Socio-economic status (SES) ^b	45	0.4	47.3	8.2	10.2
			Principals (%)		Teachers (%)
Gender	Male		31 (75.6%)		161 (24.7%)
	Female		10 (24.4%)		492 (75.3%)
FTE ^c	75% or less				288 (43.2%)
	More than 75%		41 (100.0%)		352 (52.8%)
	Unknown				27 (4.0%)
					111 (16.6%)
Age	< 30 years				105 (15.7%)
	31-40 years		4 (9.8%)		161 (24.1%)
	41-50 years		8 (19.5%)		155 (23.2%)
	51-55 years		13 (31.7%)		126 (18.9%)
	> 55 years		16 (39.0%)		9 (1.5%)
	Unknown				112 (16.8%)
					222 (33.3%)
Years of experience at the school ^d	0.5-3 years		22 (47.8%)		321 (48.1%)
	4-10 years		10 (21.8%)		12 (1.8%)
	> 10 years		14 (30.4%)		
	Unknown				
Years of experience as a principal	0.5-3 years		12 (29.3%)		
	4-10 years		16 (39.0%)		
	> 10 years		13 (31.7%)		
	Unknown				

Notes: ^aGender ratio is calculated as the ratio of female to male team members with 100 percent referring to a team with only female team members; ^bSES is calculated as the weighted percentage of students with special needs for whom the school receives extra financial resources from local and national government agencies; ^cFTE reflects the percentage of hours worked at school (fte), with 100 percent reflecting a full-time work week; ^dfor principals, $n = 46$ as it was answered more than once by principals who worked at more than one school

checked by the principals prior to the survey. For each school, we then calculated several network measures for each of the principals that reflected the extent to which each principal was involved in advice relationships with teachers in the school. For each principal, we calculated in-degree and out-degree in the school's advice network (both raw and normalized scores), closeness centrality, and betweenness centrality. Normalizing the network measures facilitated comparisons among principals of schools with different team sizes.

School in-degree. We counted the principals' raw in-degree score as the number of teachers who indicated to seek their advice (principals' in-coming ties). Principals' in-degree centrality was then normalized[2]. In-degree centrality therefore represents the percentage of teachers who ask the principal for advice. This measure may therefore be interpreted as principal's "popularity" in the school's advice network.

School out-degree. We also counted the principals' raw out-degree score as how many teachers they indicated to seek advice from (principals' out-going ties). We then calculated principals' out-degree centrality by normalizing the raw out-degree score[3]. Out-degree centrality thus reflects the percentage of teachers whom the principal turns to for advice. As such, the out-degree measures may be interpreted as a principal's self-reported "activity" in the school's advice network.

School closeness centrality. We computed principals' closeness centrality in their school's advice network as the inverse of "farness," which represents the sum of the distance of the principal to the teachers, with distance being calculated based on the number of undirected advice ties connecting the principal to each teacher in the network. We then normalized this measure to facilitate comparisons among principals. A closeness centrality measure can be interpreted as how "long" it will take for advice to travel between the principal and other network members. A high closeness centrality score means that principals' advice can quickly reach the teachers in their network, whereas a low closeness centrality score indicates that principals' advice has to go through multiple steps to reach other teachers in the school's network.

School betweenness centrality. Betweenness centrality is assessed by first calculating the proportion of times that a principal is connecting ("in between") two teachers that are themselves unconnected. Then, to normalize this measure in order to allow for comparisons across schools, this measure is divided by the maximum possible betweenness that the principal could have had based on the school's team size. The higher a principal's betweenness centrality in his/her school's advice network, the more this principal uses the opportunity to connect, or "broker between" teachers who are not seeking advice from each other.

Principals' network position within the district. To assess principals' social network position within the school district, we used a social network prompt that was included only in the principals' paper survey. To delineate the district collaboration network, we asked the principals the following social network question: "With which principal(s) do you like to collaborate?" We purposefully selected the collaboration network as it reflected the aim of the reform effort that the school district was undertaking at the time of the study (Moolenaar, 2010).

The social network prompt was followed by an empty space where the principals could write the letter codes that represented the names of their colleague principals in the district. These letter codes and names were listed on a separate attachment to the survey (e.g. Principal T.F. Lyman, St Lucas Elementary School = AF[4]). The list of principal names was compiled using information from the school district. Respondents could name as many principals as they liked.

Using the responses to this social network question, we constructed the collaboration network among the principals in the district (see Figure 1). We then calculated several network measures for each principal that reflected the extent to which each principal was involved in collaboration relationships with other principals in the district, namely district in-degree, district out-degree, district closeness centrality, and district betweenness centrality.

District in-degree. We first calculated principals' raw in-degree score by counting the number of in-coming ties for each principal in the district collaboration network. Then, we calculated principals' in-degree centrality score by normalizing the raw in-degree score[5].

District out-degree. We also counted the number of out-going ties for each principal in the district collaboration network, which summed up to principals' raw out-degree score. Then, we computed principals' out-degree centrality score by normalizing the raw out-degree score[6].

District closeness centrality. We calculated principals' in-closeness centrality in the district network by taking the inverse of the "in-farness" index, which represents the sum of the distance of all other principals in the district network to the focal principal

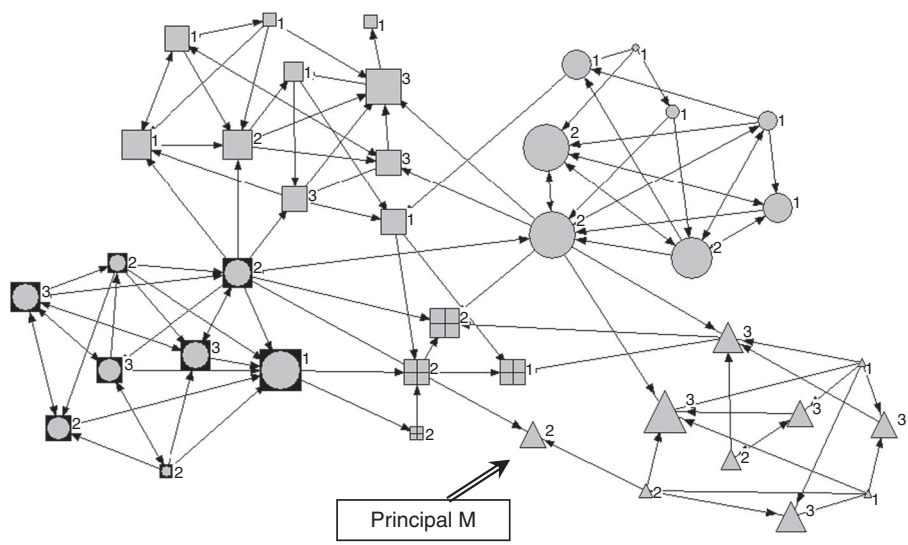


Figure 1.
Visualization of
the district
collaboration
network

Notes: Node size based on in-degree (larger nodes, higher in-degree). Node shape based on principals' formal clustering in regional areas. Node labels based on dummy coding of transformational leadership measure (1 = low, 2 = medium, 3 = high)

(see Hanneman and Riddle, 2005). This distance was calculated based on the number of incoming collaborative ties[7] connecting the principal to each other principal in the district network. This measure is then normalized relative to the highest in-closeness centrality score in the network[8].

District betweenness centrality. Betweenness centrality is measured as the proportion of times that a principal is connecting two other principals in the district who are themselves unconnected. As such, this measure reflects the extent to which a principal uses the opportunity to “broker” between unconnected principals in the district collaboration network.

TL. We measured TL and the related three dimensions (e.g. Vision Building, Individualized Consideration, and Intellectual Stimulation) using existing scales and items that were validated in the Dutch context in previous studies (Geijssel *et al.*, 2009; Thoonen *et al.*, 2011, 2012). Vision Building referred to the degree to which a principal initiates and identifies a vision for the school's future. This scale consisted of five items (e.g. “The principal of my school refers explicitly to our school's goals during decision-making processes”). Individualized Consideration was defined as the degree to which the principal offers personalized support to teachers and acknowledges their individual work. This scale was measured with five items (e.g. “The principal of my school takes opinions of individual teachers seriously”). The third scale, Intellectual Stimulation, concerned the degree to which a principal challenges teachers' thinking. This scale consisted of eight items (e.g. “The principal of my school encourages teachers to experiment with new didactic strategies”). In the previous studies, the reliability coefficients (Cronbach's α) for the scales varied from 0.87 to 0.91 (Vision Building), from 0.87 to 0.92 (Individualized Consideration), and from 0.88 to 0.93 (Intellectual Stimulation) (Geijssel *et al.*, 2009; Thoonen *et al.*, 2011, 2012).

Teachers could rate their principal's TL on a Likert-type scale ranging from 1 (disagree) to 4 (agree). A principal component analysis with varimax rotation yielded a three-factor solution that explained 73.8 percent of the variance. The items and factor loadings of this principal component analysis are summarized in Table II.

As the separate TL scales were highly interrelated we combined all items in a single scale ($\alpha = 0.96$) (cf. Avolio *et al.*, 1999; Bono and Judge, 2003; Jung and Sosik, 2002; Kark *et al.*, 2003). This higher-order factor explained 58.5 percent of the variance. Following previous research into TL (Avolio *et al.*, 2004), we then aggregated the TL measures to the school level to reflect the perceptions of the teacher team as a whole. To justify this approach, we evaluated the scales' interrater reliability as assessed by the ICC[1] and ICC[2] (cf. Bliese, 2000; LeBreton and Senter, 2008) and the scales' interrater agreement as assessed by $r_{wg}[j]$ (cf. James *et al.*, 1984). For each of the scales, the three measures were found to be within the acceptable range to support aggregation (cf. Moolenaar *et al.*, 2010).

Demographics. At the school level, we included the following demographics: team size, gender ratio (assessed as percentage of female teachers in the school), fte ratio (assessed as the percentage of teachers in the school that works at least 0.75 fte),

Transformational leadership ($\alpha = 0.96$)	I	II	III
<i>The principal of my school ...</i>			
Vision Building			
1. Refers explicitly to our school's goals during decision-making processes	0.25	0.14	0.80
2. Discusses the consequences of the school's vision for everyday practice	0.28	0.24	0.79
3. Explains the relationship between the schools' vision and initiatives of the school district, collaborative projects, or the government	0.26	0.30	0.78
4. Uses all possible moments to share the school's vision with the team, the students, parents and others	0.30	0.26	0.78
5. Incorporates the school's vision and goals for the future to talk about the current issues and problems facing the school	0.28	0.39	0.74
Individualized Consideration			
6. Takes opinions of individual teachers seriously	0.28	0.81	0.26
7. Listens carefully to team members' ideas and suggestions	0.26	0.81	0.29
8. Is attentive to problems that teachers encounter when implementing innovations	0.32	0.78	0.27
9. Helps teachers talk about their feelings	0.31	0.76	0.26
10. Shows appreciation when a teacher takes initiatives to improve the education	0.35	0.76	0.23
Intellectual Stimulation			
11. Encourages teachers to experiment with new didactic strategies	0.80	0.10	0.27
12. Involves teachers in a constant discussion about their own professional personal goals	0.76	0.31	0.22
13. Helps teachers to reflect on new experiences	0.74	0.40	0.21
14. Encourages teachers to try new strategies that match their personal interests	0.73	0.34	0.24
15. Motivates teachers to look for and discuss new information and ideas that are relevant to the school's development	0.70	0.28	0.38
16. Stimulates teachers to constantly think about how to improve the school	0.69	0.30	0.37
17. Offers enough possibilities for teachers' professional development	0.63	0.34	0.25
18. Helps teachers talk about and explain their personal views on education	0.61	0.53	0.24

Note: $n = 667$ teachers

Table II.
Items and factor
loadings of the
scales used in
the study

teachers' average age, teachers' average experience at the school, since these demographics have been directly related to the structural characteristics of social networks (Cole and Weinbaum, 2007; Heyl, 1996; Tsai, 2001). We also included student SES, number of students, and average student score on the Dutch standardized test that is administered in the final year of elementary school (CITO) as demographics at the school level. Schools in more high-needs communities may feel a greater need to experiment with new approaches to meet the specific needs of their challenging student population, which may promote close contacts between teachers as well as increased TL (Sunderman *et al.*, 2005). For the principals, we included the following demographics: gender, age, years of experience in the school, years of experience as a principal, and years of experience in education as these have been indicated as potential predictors of TL (Geijsel *et al.*, 2001). We examined whether these demographics were correlated with the network variables and TL. Demographic characteristics that were found to be uncorrelated with the study variables were excluded from further analyses.

Data analysis

Inferential and descriptive statistics. We calculated inferential and descriptive statistics for the social network measures and the scales assessing TL.

Social network analysis. The social network calculations and visualization were performed using the software programs UCINET 6.0 and Netdraw (Borgatti *et al.*, 2002). SPSS 21.0 was used to calculate descriptive statistics and correlational and regression analyses to examine the relationships between demographic characteristics, principals' social network positions, and TL.

For our first set of hypotheses, we use correlational analysis to examine the association between principals' centrality measures within schools and within the district, as these measures may be related but we do not pose a hypothesis on the direction or causality of the relationship. We test our second set of hypotheses using regression analysis as we argue that principals' centrality in both networks may be affected by principals' TL behavior. To complement the regression analysis, we use an advanced social network technique called p2 modeling to examine principals' likelihood of being engaged in dyadic collaborative relationships[9].

There are two reasons for including this additional p2 analysis. First, while regression analysis examines network centrality as composite characteristics that reflect a principal's centrality in the network as a whole, a p2 analysis examines the dyadic (one-to-one) relationships of principals, which offers the opportunity to examine the likelihood of principals to be engaged in relationships, as well as potential factors that may affect this likelihood, such as demographics and leadership behavior. Second, a p2 analysis will allow for the inclusion of predictors that examine so-called homophily effects that assess the likelihood of a relationship given a similarity between actors. For example, in this study we will take geographical clustering into account to examine whether principals are more likely to collaborate with principals that are from the same area, and we will test whether this effect would "trump" the effect of TL. As such, a p2 analysis provides us with additional depth in exploring the relationship between TL and principals' relationships in the district network.

Testing the hypotheses. We used the p2 program within the StOCNET software (Van Duijn *et al.*, 2004) to run the p2 modeling. A p2 model resembles a logistic

regression model and is specifically designed to account for the interdependent nature of dichotomous social network data. The p2 model is designed to predict the likelihood of “seeking relationships” (a “sender” effect) and the likelihood of “being sought for relationships” (a “receiver” effect) based on certain characteristics of senders and receivers in a given network. For instance, in our study we examine the likelihood that principals are “seeking” and “being sought for” collaborative relationships in the district network, and whether this likelihood is dependent upon their TL behavior. A positive effect signals that the independent variable (e.g. TL, or “being from the same area”) has a positive effect on the likelihood of collaborative relationships with other principals in the district network[10] [11]. The significance of the effects is calculated using the Wald statistic (Long, 1997; Spillane and Kim, 2012).

Results

Descriptives

Findings indicate that principals in this sample differ in the extent to which they occupy central network positions, both within schools as well as within the district (see Table III). When we examine the in- and out-degree centrality measures of principals in their school networks, we find that principals are sought for advice by approximately a third of their teachers (33.6 percent). Moreover, the findings indicate that principals that participated in our study seek advice from about a quarter of their teaching staff (26.3 percent). In the district, principals indicate to collaborate with about 8 percent of their colleague principals.

We also find that principals in this sample vary in closeness centrality, both within schools as well as within the district. While some principals have direct advice ties with all teachers in their school (a score of 100 percent), other principals need more “steps” to reach all other teachers in their school ($M = 57.8$ percent, $SD = 17.2$ percent). In addition, we find that although the district network consists of a single connected component, the network is rather unconnected (see Figure 1), resulting in a relatively low closeness centrality score compared to the school networks ($M = 5.0$ percent,

	Min.	Max.	<i>M</i>	SD
<i>School network position</i>				
In-degree centrality(%) ^a	3.3	88.9	33.6	17.6
Out-degree centrality(%) ^a	0.0	100.0	26.3	20.1
Closeness centrality(%) ^a	22.1	100.0	57.8	17.2
Betweenness centrality	0.0	54.8	8.2	11.0
In-coming ties (raw in-degree)	1	17	5.0	3.6
Out-going ties (raw out-degree)	0	23	3.5	3.5
<i>District network position</i>				
In-degree centrality (%) ^a	0.0	18.2	7.6	0.04
Out-degree centrality (%) ^a	0.0	22.7	7.2	0.05
Closeness centrality (%) ^a	2.2	10.4	5.0	2.5
Betweenness centrality	0.0	15.9	2.2	3.3
In-coming ties (raw in-degree)	0	8	3.3	1.8
Out-going ties (raw out-degree)	0	10	3.2	2.2
Transformational leadership ^b	2.12	3.87	3.01	0.37

Notes: $n = 46$. ^aNormalized measures to allow for comparisons across schools. ^{**} $p < 0.01$; ^{*} $p < 0.05$

Table III.
Descriptive statistics
for principals’ social
network position in
the school and the
district and
transformational
leadership

SD = 2.5 percent). This means that on average, it takes multiple steps to connect a principal with other principals in the district through collaborative relationships.

For principals' betweenness centrality in the sample schools, results suggest that there is considerable variation among principals in the extent to which they occupy such a "brokerage" position their school's advice network ($M = 8.2$ percent, $SD = 11.0$ percent). In schools, principals occupy on average about 8 percent of the maximum potential "brokerage" positions. In contrast, in districts, principals occupy on average only 2 percent of the maximum possible brokerage positions ($SD = 3.3$ percent). This suggests that principals tend to broker more relationships within their schools than within the district network.

Finally, descriptive results also indicate that on average, teachers "agree" with most statements on the TL behavior of their principal ($M = 3.0$, $SD = 0.37$).

Similarity of principals' social network positions in their schools and the district

Our first research question focussed on the extent to which principals occupy similar network positions in their school's advice network and the district's collaboration network. We argued that principals who are more central in the district network would also be more central in their school (*H1*). We find a positive correlation between the in-degree centrality scores for the school and district networks ($r = 0.31$, $p < 0.05$) (see Table IV). This suggests that the more a principal is sought for collaboration by other principals in the district, the more this principal is also sought for advice in his/her school network. Also, results indicate that the "closer" a principal is connected to other principals in the district collaboration network, the more closely tied this principal also is to the teachers in the school's advice network (closeness centrality, $r = 0.33$, $p < 0.05$). In other words, principals who are more easily "reached" within the district may also be more easily reached within the school network.

In contrast, the correlation between both out-degree measures is non-significant ($r = 0.11$, ns), suggesting that principals who seek to collaborate with many other principals in this district do not necessarily also seek advice from teachers in their

	School network position			District network position				TL 3
	1b	1c	1d	2a	2b	2c	2d	
1. School network position ^a								
a. In-degree centrality	0.17	0.67**	0.35*	0.31*	-0.04	0.34*	0.00	0.58**
b. Out-degree centrality	1.00	0.38**	0.30*	-0.20	0.11	0.06	-0.13	0.09
c. Closeness centrality		1.00	0.04	0.13	-0.11	0.33*	0.05	0.56**
d. Betweenness centrality			1.00	0.05	0.09	0.02	-0.05	0.06
2. District network position								
a. In-degree centrality				1.00	0.07	0.24	0.43**	0.32*
b. Out-degree centrality					1.00	-0.63**	0.57**	-0.05
c. Closeness centrality						1.00	-0.15	0.33*
d. Betweenness centrality						1.00	1.00	0.04
3. Transformational leadership (TL)								(0.96)

Table IV.
Correlations and internal consistency (Cronbach's α) at the school level

Notes: $n = 46$. ^aNormalized measures to allow for comparisons across schools. Correlations in boxes represent findings regarding *H1*. Correlations in grey represent findings regarding *H2*. ** $p < 0.01$; * $p < 0.05$

school. Findings further suggest that in this sample, principals' betweenness centrality in the school network is unrelated to principals' betweenness centrality in the district network ($r = -0.05$, ns). Meaning, principals who occupy brokerage positions in this district's social network do not necessarily have a higher likelihood to also occupy brokerage positions in their school's advice network, and vice versa. As such, *H1* could be partially confirmed.

Regression analyses of the relationship between TL and principals' social network positions in schools and the district

Our second research question focussed on the extent to which principals' TL behavior is associated with principals' social network position both within and across schools. As correlational analyses show that TL behavior is unrelated to principals' out-degree and betweenness centrality in both the school and district networks (see Table IV), we therefore continued to only perform regression analyses for the network measures that were found to be significantly related to TL behavior, namely in-degree and closeness centrality. In these analyses we also included demographic characteristics of schools and principals that were found to be related to the variables under study[12]. The regression analyses confirm the findings from the correlational analyses (see Table V).

For the school networks, results from the multiple regression analyses suggest that TL is strongly associated with principals' centrality in their school's social network, both in terms of in-degree centrality as well as closeness centrality (both $\beta = 0.53$, $p < 0.001$). In other words, the more principals in our sample were perceived to display TL behavior by developing a shared vision, addressing teachers' feelings and needs, and providing Intellectual Stimulation, the more they were sought out for advice by, and closely linked to their teachers in their school's advice network.

In addition, findings suggest that principals who have more experience as a principal are often more centrally located in their school's advice network. In contrast, principals who have more experience at their school are often less central in their

	<i>B</i>	<i>SE</i>	β	R^2	<i>F</i>	<i>df</i>	<i>p</i>
<i>School network: in-degree centrality</i>							
Constant	-0.391	0.177					
Experience as a principal	0.029	0.010	0.35**				
Experience at the school	-0.036	0.013	-0.34**				
Transformational leadership	0.250	0.525	0.53***	0.49	13.00	3.41	0.000
<i>School network: closeness centrality</i>							
Constant	-0.187	0.172					
Experience as a principal	0.034	0.010	0.42**				
Experience at the school	-0.025	0.012	-0.25*				
Transformational leadership	0.245	0.053	0.53***	0.49	12.87	3.41	0.000
<i>District network: in-degree centrality</i>							
Constant	-0.041	0.046					
Team size	0.002	0.001	0.294*				
Transformational leadership	0.030	0.015	0.274***	0.19	4.90	2.42	0.012
<i>District network: closeness centrality</i>							
Constant	0.089	2.816					
Gender (0 = male/1 = female)	2.043	0.841	0.349*				
Transformational leadership	1.480	0.946	0.224	0.18	5.96	2.42	0.005

Notes: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; **** $p < 0.10$

Table V. Univariate regression analysis results of transformational leadership on principals' position in the school's advice network and the district's collaboration network

school's advice network, meaning that they are less often sought for advice and less closely linked to their teachers[13]. This poses an interesting finding about the role of principal experience in supporting advice-seeking behavior of teachers.

For the district network, findings from the multiple regression analyses suggest that the relationship between TL and principals' network centrality in the district network is influenced by demographic characteristics such as team size and gender. The positive relationship between TL and in-degree centrality in the district is in the expected direction, but just outside the margin of significance ($\beta = 0.27$, $p = 0.06$) as the relationship is more strongly explained by schools' team size. In other words, a principal is more often sought for collaboration by other principals in the district when s/he is leading a larger school, above this principal's TL behavior.

In addition, the relationship between TL and closeness centrality in the district disappears under the influence of gender ($\beta = 0.22$, $p = 0.06$). In other words, female principals in the district collaboration network are more closely linked to other principals than male principals, and this association makes the relationship between closeness centrality and TL disappear. Finally, it is important to note that the explained variances for the district regression models are considerably lower than for the school models, suggesting better model fit at the school level than at the district level.

A p2 analysis of the likelihood of collaborative relationships among principals in the district
We performed a p2 analysis to more closely explore the relationship between TL and the likelihood with which principals seek, and are being sought for collaborative relationships within the district.

First, the default parameters indicate that the district network is sparsely connected, as evidenced by the negative density parameter, and that mutual relationships are more likely to occur than based on chance alone. Moreover, the variance parameters show that there is significant variation between principals in the extent to which they seek, or are being sought, for collaboration within the district. As evidenced by the non-significant sender-receiver covariance effect, principals who are seeking more collaborative relationships do not necessarily have a higher likelihood to also be sought for collaboration.

Furthermore, we find that transformational leaders are more likely to be sought for collaborative relationships (est. = 1.17, $p < 0.05$). In addition, transformational leaders are less likely to seek other principals for collaborative relationships, as evidenced by the negative sender effect (est. = -1.67, $p < 0.01$). So far, these results reflect the regression analyses. In contrast to the regression analyses, we find that principals' gender and the size of their school team are not significantly associated with their likelihood to seek, or being sought for collaborative relationships in the district networks[14].

Finally, the p2 analysis allows us to include a dyadic covariate that tests a homophily effect of area clustering. We find that principals are more likely to engage in collaborative relationships with principals in their own regional area than with principals outside their area, as evidenced by the significant negative parameter for "different regional area" (est. = -1.85, $p < 0.001$). As such, we can conclude that TL influences the extent to which principals seek and are sought for collaborative relationships in the district, even while controlling for gender, school size, and the district's formal organization of collaborative relationships in regional areas (Table VI).

Table VI.

Parameter estimates of the p2 model ($N_{\text{principals}} = 40$, $n_{\text{dyadic relationships}} = 1,560$), displaying the relationship between principals' transformational leadership and their likelihood to engage in relationships in the district collaborative network

	Posterior mean	SE	95% CI
<i>Network characteristics</i>			
Overall mean			
Density	-1.96	1.71	
Reciprocity	2.91**	0.95	
Random effects			
Sender variance	1.21*	0.55	
Receiver variance	0.50*	0.25	
Sender-receiver covariance	-0.54	0.33	
<i>Individual covariates</i>			
Sender effects ("seeking")			
Transformational leadership	-1.67**	0.59	(-2.85/-0.56)
Gender	0.43	0.58	(-0.79/1.50)
Team size	0.01	0.03	(-0.06/0.07)
Receiver effects ("being sought")			
Transformational leadership	1.17*	0.49	(0.25/2.13)
Gender	0.01	0.43	(-0.90/0.84)
Team size	0.04	0.03	(-0.01/0.09)
<i>Dyadic covariate</i>			
Different regional area	-1.85***	0.20	(-2.25/-1.47)

Notes: Examination of 1,560 potential relationships and 118 present relationships among 40 principals in a single district. In previous models, we controlled for school level SES, years of experience at the school, and age, which were found to be non-significant. We also found non-significant dyadic effects for gender. ** $p < 0.01$; * $p < 0.05$; *** $p < 0.10$

A visualization of the district collaborative network

Figure 1 displays the social network of principals' collaborative relationships in the district. The nodes in this network represent the principals and the lines represent collaborative relationships, with arrows indicating the direction of the relationship. Nodes are sized by in-degree, meaning that larger nodes receive more incoming collaborative relationships than smaller nodes. The nodes are shaped by regional area, meaning that nodes with similar shapes represent principals whose schools are located in the same district-designated geographically based area. The labels indicate low (1), medium (2) and high (3) levels of TL as perceived by the teachers in each principal's school.

The district network clearly shows clusters of principals who indicate to collaborate with each other, which reflects the district's intentional strategy to stimulate principals from the same geographical areas to collaborate with each other. Although collaborative relationships across areas occur as well, these are less common. It appears that each cluster of principals has one or two informal "liaison" principals, meaning principals who tend to be sought more both within their own area as well as have collaborative relationships with other areas.

Furthermore, as nodes are sized by in-degree, the graph also shows that principals vary in the number of collaborative relationships with some principals being more often sought for collaborative relationships than others. Also, it can be seen that some principals occupy "brokerage" positions in which they bridge relationships between two unconnected other principals in the district (e.g. "principal M").

Finally, the nodes are numbered based on principals' levels of TL. At first glance, there seems to be a relationship between the size of the nodes (reflecting in-degree) and

the label of the nodes (reflecting level of TL). For instance, the two clusters on the right show that principals with a low TL score are less often sought for collaboration (smaller nodes) by other principals. As such, the visualization mirrors the findings from our p2 analysis.

Conclusion and discussion

This study aimed to increase our understanding of principals' social relationships within their schools as well as across schools. This study is among the first to simultaneously explore principals' social relationships in multiple educational contexts and its links with TL. As our results relate to relationships between principals and teachers within a specific sample of Dutch schools, generalizations beyond the sample can only be tentatively suggested. Our study offers a few key themes related to educational leadership research and practice.

Similarity of principals' social network position in schools and districts

This study offers a unique contribution to the field by connecting two streams of network research (within and across schools) that until now have been largely disconnected. While few studies have focussed on principals' social relationships by examining their network positions in schools, research that simultaneously explores leaders' network positions in multiple settings is even scarcer. Yet, both types of studies support a better understanding of how principals' social relationships with stakeholders within and outside schools may allow or inhibit principals' access to resources and power and legitimacy to lead (Balkundi and Harrison, 2006; Balkundi and Kilduff, 2006).

Our study among Dutch elementary school principals suggests that principals who occupy more central positions in the district's collaboration network often also occupy more central positions in their school's advice network. These principals are more often sought for advice by their teachers, and other principals like to collaborate with them. It may be that because of these collaborative relationships, central principals in the district are better able to use district resources to support their teachers, and as such teachers may ask them for advice more often than principals with limited access to district resources. At the same time, perhaps principals engage in more collaborative relationships with other principals in the district when they are more often sought for advice by the teachers in their schools.

It is through their social relationships in schools that principals may offer instructional advice and distribute information in order to create coherence in instructional practices across classrooms (Moolenaar *et al.*, 2010; Honig and Hatch, 2004). In addition, principals' social relationships with other principals in the district may support larger system coherence when implementing large-scale, district-wide reforms (Daly and Finnigan, 2010, 2011). Our work suggests that principals who have disproportionate influence in one setting are also more likely to influence the flow of resources in the other. Principals are increasingly seen as "brokers" of information between the district and their schools (Daly *et al.*, 2014b; Honig and Hatch, 2004; Honig and Venkateswaran, 2012). However, our findings show that principals who occupy brokerage positions among other principals in the district, do not necessarily also occupy such brokerage positions in their own schools. Perhaps this is because to become a broker, an individual has to occupy a structural hole connecting others who are themselves disconnected (Burt, 1992), and the existence of such structural

holes is more prevalent in the largely unconnected district network than in the more densely connected school networks. As such, the district network offers more opportunities for brokerage than school networks. Moreover, our findings showed that a few principals in the sample district took on informal “liaison” roles, a specific brokerage role also found in other recent work on principal brokerage in the US (Daly *et al.*, 2014c). It would be interesting to further explore such brokerage roles using more in-depth qualitative data.

The finding that there is congruency in principals’ network positions in both settings also raises the question whether there are underlying individual characteristics that may explain why some principals occupy more central positions in both settings than others. For instance, similarity in network position across multiple networks may be influenced by underlying, potentially universally relevant characteristics, such as personality, experience, political skills, and network intentionality (e.g. Judge *et al.*, 2002; Kilduff and Krackhardt, 2008; Moolenaar *et al.*, 2014a). Further research into such antecedents of principals’ social network position may provide useful leads as to how principals may be supported in playing a central role in the flow of information in their schools as well as the larger district.

The role of TL in supporting principals’ social relationships in schools and districts

One way to affect a principal’s social network position, according to our findings, may be to invest in TL behaviors. The significant contribution of this study is that TL, in addition to fixed principal characteristics such as gender and school size, may perhaps in part explain why principals become central in the district network.

Future research may help understand the mechanisms through which TL supports network centrality. Through building a shared vision, being attentive to teachers’ needs, and focussing on teachers’ continuous intellectual development, all aspects that involve social interaction, transformational principals may be more focussed on, aware of, and intentional in shaping social relationships than non-transformational leaders, which makes them more sought for social relationships by both teachers and colleague principals (cf. Moolenaar *et al.*, 2014a). Moreover, transformational principals may be more likely to be sought for relationships as they shape a “safe” and trusting climate in which such relationships are nurtured and facilitated (Daly *et al.*, 2014a; Moolenaar *et al.*, 2014c; Tschannen-Moran, 2001, 2003, 2009; Van Maele *et al.*, 2015, this issue).

While TL behaviors of the principals in this sample were found to be related to being sought by (in-degree centrality) and closely linked to their colleagues (closeness centrality), these behaviors were found to be unrelated to principals’ brokerage (betweenness centrality) and seeking of resources (out-degree centrality). This seems to suggest that transformational leaders, who actively involve others in building a shared vision, show individualized attention and intellectually challenge their colleagues, perhaps as a result are sought more for resources. In turn, being sought for resources and being close to others may make it less necessary for these principals to actively seek out others and occupy brokerage positions (cf. Daly *et al.*, 2014b; Moolenaar *et al.*, 2010).

Our study is among the first to suggest that principals’ TL and network centrality may perhaps be universally relevant across settings (cf. Bass, 1997; Nguni *et al.*, 2006). Given that TL was found to play a role in principals’ social network position in both schools and the larger district, this may suggest that such leadership behaviors may “transcend” specific situations and have similar influence on principals’ social

relationships in different contexts. This echoes recent suggestions that TL, given its strong association with personality characteristics, may be in part dispositional and potentially universally relevant (Judge *et al.*, 2002; Yukl, 2013). This is not to say that non-transformational leaders cannot become transformational leaders. Based on our study we may suggest that principals who would like to occupy a more central position in a social network would be advised to increase behaviors that may be perceived as TL.

Limitations

We offer several important limitations to our work that warrant further investigation. First, our measure of TL was assessed based on teachers' perceptions of principals' leadership as we assume that principals' TL behaviors can be considered stable over different settings. However, as research has suggested that teachers and principals vary in their perceptions of TL (Moolenaar and Thoonen, 2009; Devos *et al.*, 2013), it may be important for future research to also examine perceptions of principals' TL by their peers in district networks.

Second, although we supported the relationships under study with literature to suggest causal relationships, our methodology is insufficient to empirically claim causality. As transformational principals are more central in their networks, they may also leverage these connections to collectively build a shared vision and support teachers' individual needs and intellectual development. Therefore, TL behaviors and network centrality may mutually reinforce each other in supporting principals to lead.

Third, as we only examined our research questions in a single district with a relatively small sample size of 41 principals, caution should be practiced with generalizing our findings beyond the scope of the study. Various district characteristics may be related to its organizational effectiveness and student achievement, such as district size and financial resources (Bidwell and Kasarda, 1975), and therefore we would suggest that the findings of this study are to be replicated in different districts, educational settings (e.g. secondary and higher education), and countries.

Directions for future research

This study is unique in that to our knowledge, it is the first to simultaneously explore principals' social network positions in schools and the larger district. Moreover, it is the first to connect the similarity of principals' network positions across different settings with TL. Our findings offer implications for leadership research.

First, while a central network position offers many benefits as it may provide control over the flow of resources in the network, such a position may also place a strong burden on a principal's time and efforts due to the large number of relationships to maintain (e.g. Balkundi and Kilduff, 2006). As most network studies predominantly focus on the benefits of strong social networks for school outcomes, future research may also aim to understand more about this "dark side" of social networks.

Second, in addition to TL, other variables such as personality may also affect principals' network position and deserve attention in future research, as studies into such antecedents of social network position are relatively rare (Borgatti and Foster, 2003; Moolenaar *et al.*, 2014b; Spillane and Kim, 2012). Furthermore, it would be interesting to further explore the nature of principals' brokerage relationships as principals are increasingly expected to serve as a conduit, or "broker" between the district central office and teachers (Coburn and Russell, 2008; Daly *et al.*, 2014c; Honig and Hatch, 2004).

Although this study provides unique insights into the similarity of principals' network positions across two settings, in-depth qualitative research may need to provide additional understanding of the content and quality of principals' social relationships and the conditions that may support or inhibit such relationships in both settings. Longitudinal studies of interventions aimed at supporting principals to pursue a more central network position would be ideal to investigate how principals may enhance access to network resources and exert increased influence over their networks.

With regard to leadership practice and training, our findings foreground the potential significance of leaders' awareness of their social network position (Baker-Doyle, 2011; Cross and Parker, 2004) and their intentionality in shaping the network to be optimal for the exchange of resources (Moolenaar *et al.*, 2014a). Our results suggest that such awareness and intentionality may be important and deserves future research, as principals' leadership efforts and behaviors may either be supported or constrained by the extent to which they occupy a central network position. Building on our findings, we see value in further exploring educational leadership from a social network perspective to increase our understanding of social influence processes in the work of educational leaders around the world. This perspective may provide purchase in integrating theories of leadership at multiple conceptual and analytical levels (Avolio, 2007), by locating leadership "not in the attributes of individuals but in the relationships connecting individuals" (Balkundi and Kilduff, 2005, p. 242).

The networked school leader

With increasing accountability and pressures for schools to improve through collaboration, it is crucial for principals to have close social relationships with teachers and other principals to support the exchange of information both within their school as well as in the larger district (Díaz-Gibson *et al.*, 2014). Our work suggests that TL behaviors may in part explain why some principals occupy more central positions in school and district networks. Hence, as the work of leaders is increasingly done "through" social relationships and in interaction with a large number of stakeholders inside as well as outside the school boundaries, our work suggests that a twenty-first century school leader may complement, but not supplant, more traditional leadership behaviors with a focus on social relationships to be a networked school leader.

Notes

1. Smaller schools were excluded as these schools had less than one teacher per grade level and as such may have been less comparable than larger schools. We excluded the district's special education schools as the principals of these schools had a different meeting schedule than the other principals in the district, which may have resulted in different opportunities for across-school interactions.
2. In-degree centrality was calculated as principals' raw in-degree score divided by the total number of actors in the network minus 1 (see Hanneman and Riddle, 2005).
3. Analogous to in-degree centrality (see Hanneman and Riddle, 2005).
4. All names are pseudonyms.
5. In-degree centrality was calculated as principals' raw in-degree score divided by the total number of principals in the network minus 1 (see Hanneman and Riddle, 2005).
6. Analogous to in-degree centrality (see Hanneman and Riddle, 2005).

7. As we used directed (in-coming) ties to calculate closeness centrality in the district network, in contrast to using undirected ties to calculate principals' closeness centrality the school network, the descriptives of district level closeness centrality cannot be unequivocally compared to the descriptives of school level closeness centrality. However, this approach did not impact our results given that all centrality scores were normalized both at the school and district level, thus allowing for equal comparisons between principals' scores.
8. Specifically, in-closeness centrality is calculated as 1 divided by the sum of the distance of the principal to all other people in the network via the principal's in-coming ties, which is then normed relative to the greatest nearness observed in the network (the score of the person with the highest in-closeness centrality). As such, this measure reflects the closeness of the principal relative to the closeness of the most "closely linked" person in his/her network. A high in-closeness centrality score thus means that the principal is (one of) the most "closely linked" actor(s) in the network. A very low closeness score thus means that the principal has relatively few "close" ties with other actors in the network compared to one or more other actors.
9. For most analysis (except the p2 model), we chose the school as the level of analysis, meaning that the data of principals who provided leadership to multiple schools was included for each school separately, resulting in $n = 46$. As the p2 model aims to predict principals' dyadic relationships, we only included one school per principal. For the few principals who provided leadership to multiple schools, we included the data from the school in which s/he formally spent the most time.
10. To facilitate the interpretation of the model, we labeled the proposed homophily predictor "Different regional area." As such, a negative effect would mean that principals from different regional areas are less likely to be engaged in collaborative relationships, thus providing evidence for the suggested homophily effect.
11. Finally, p2 models include a few default parameters that provide information on the network as a whole. The overall mean density effect offers an estimate of the extent to which the network is dense, and whether relationships are in general likely (for a positive parameter) or unlikely (for a negative parameter) to occur. The overall mean reciprocity effect reflects the extent to which mutual relationships are more likely to occur than uni-directional relationships (for a positive estimate) or vice versa (for a negative parameter). Furthermore, p2 models offer default information on variation among principals in the number of people they nominate (sender variance), variation among principals in the nominations they receive (receiver variance), and the degree to which principals who indicate to seek more collaborations ("send") also have a higher likelihood of being sought for collaboration ("receive") (sender-receiver covariance).
12. We included the following demographics in the initial analyses at the school level: team size, gender ratio, teachers' average age, teachers' average experience at the school, student SES, number of students, and average student test scores. For the principals, we included gender, age, years of experience in the school, years of experience as a principal, and years of experience in education. Demographics that did not significantly influence the relationships under study were excluded from the regression analysis.
13. We examined whether multicollinearity played a role in this finding, however experience as a principal and experience at the school were only moderately correlated ($r = 0.39, p < 0.01$).
14. Although this analysis is based on a dyadic approach rather than simple aggregate measures of principals' average in- and out-degree scores and therefore may more accurately reflect the extent to which principals' gender and their school's team size affect their likelihood to be involved in collaborative dyadic relationships, we cautiously suggest future research to account for principals' gender and school size in further examining principals' relationships within school districts.

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