Describing and measuring leadership within school teams by applying a social network perspective

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ABSTRACT

Despite the growing number of studies that acknowledge a crucial role of distributed leadership within schools, limited knowledge exists on how to describe and measure this multi-faceted concept. In a social network study with 130 respondents, from 14 Dutch school teams carrying out collaborative innovation, we theoretically describe three core aspects of the social interaction process of distributed leadership: *collective, dynamic,* or *relational.* Furthermore, we empirically explore how to measure all these three aspects of distributed leadership from a social network perspective, whereas most research focuses on either collective or dynamic. Our findings indicate that three network measures (density, reciprocity, indegree centralization) form a coherent combination to measure distributed leadership in school teams in terms of collective, relational, and dynamic, respectively. Furthermore, based on the combination of measures we found differences in distributed leadership between school teams. Thus, adding the relational aspect in addition to the collective and dynamic aspects seems to be informative to measure distributed leadership. Our study motivates to take a social network perspective, instead of the mostly used aggregation approaches, to measure distributed leadership in school teams.

1. Introduction

The studying of solely the role of formal leaders in innovation, which has long been the focus (Hansen & Pihl-Thingvad, 2019; Liu & Werblow, 2019; Molines et al., 2020; Ospina, 2017; Sun & Xia, 2018), is an approach losing currency (Angelle, 2010; Ospina, 2017). In most theoretical frameworks, leadership has commonly been defined as individuals exerting influence over others to structure activities and relationships, knowledge, and skills (Daniëls et al., 2019; Yukl, 2002). Distributed leadership theory postulates that multiple team members can be considered leaders, thus both school principals and teachers, as they are able to influence the motivation, knowledge, or practices of other team members (Daniëls et al., 2019; Harris & Spillane, 2008; Spillane, 2005).

A growing body of literature acknowledges a crucial role of distributed leadership for successful innovations in schools (Brown et al., 2020; Daniëls et al., 2019; Fullan, 2016; Hulpia et al., 2009; Jambo & Hongde, 2020; Law et al., 2010; Meijer, 2014; Ricard et al., 2017; Sullivan et al., 2012; Tian et al., 2016; Tummers & Knies, 2013; Vogel & Masal, 2015). This is in line with the international call for a more social, collaborative, and networked approach to school innovations (Liou et al., 2020). Sinnema et al. (2020) states that sharing responsibilities brings teachers the opportunity to benefit from the capacities

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of multiple members. Furthermore, teachers can develop a fuller appreciation of the interdependence between and support structures among each other (Azorín et al., 2020) and as a result, this can have powerful impact on arriving at more innovative and democratic solutions (Sinnema et al., 2020; Snoek et al., 2019). However, despite the growing number of effect studies, limited knowledge exists on how to describe and how to measure the multi-faceted concept of distributed leadership (D'Innocenzo et al., 2016; Daniëls et al., 2019; Harris, 2013; Liu & Werblow, 2019; Tian et al., 2016).

The aim of our study is to theoretically describe and empirically explore how to measure distributed leadership within school teams from a social network perspective. Previous studies that proposed to measure distributed leadership with such a perspective were explorative and based on small samples but argue the relevance of applying the social network perspective well (e.g. Brown et al., 2020; Liou et al., 2014). Distributed leadership is a social networked process of distributing leadership practices and responsibilities (Sinnema et al., 2020), and the strength of the social network perspective is that it includes all these social relations in a network of team members (Cullen-Lester & Yammarino, 2016; D'Innocenzo et al., 2016; Sinnema et al., 2020). By combining distributed leadership theory with a social network perspective, we follow a growing number of scholars that call for contributing to *'the lack of research into bringing to the forefront both emergent paradigms'* (Naumov et al., 2020, p. 9). To this purpose, we study Dutch school teams that all implemented the same collaborative innovation programme during the study period, which was aimed at enhancing collaboration between teachers and school principals. We therefore address the following research question: *How can distributed leadership in school teams be described and measured by applying a social network perspective?*

2. Theoretical framework

2.1. Distributed leadership as a social interaction process

Distributed leadership theory is well-known in both the academic world and school practice (Gronn, 2002; Spillane, 2005). However, limited studies exist that theoretically describe and afterwards empirically measure distributed leadership (D'Innocenzo et al., 2016; Daniëls et al., 2019; Harris, 2013; Tian et al., 2016). Within this study, we attempt to more comprehensively describe and measure distributed leadership. To be able to measure distributed leadership, we first need to describe the concept. We therefore conducted a search on how distributed leadership is described until now in educational and organizational literature (e.g. Azorín et al., 2020; García Torres, 2019; Gronn, 2002; Harris & DeFlaminis, 2016; Spillane, 2005). By studying the descriptions of the concept, we dissected three core aspects of distributed leadership that are often part of these descriptions, namely, *collective, dynamic*, and *relational*, and we describe these below.

Firstly, many researchers, among others Gronn (2002), Harris and DeFlaminis (2016), Liljenberg (2015), and Spillane (2005), interpret distributed leadership as a fluid co-performance process executed by multiple members of a team. This means that not only the formal leader is leading but also teachers or other staff members, for instance co-determination and decision making of teachers in policies. We consider this to be the *collective* aspect of distributed leadership. Spillane and Sherer (2004) observed that both school principals, as formal leaders, and teachers, as informal leaders, performed leadership practices. They observed that multiple members were interacting and motivating and influencing each other to come up with new ideas and knowledge, and by doing so, they collectively performed leadership practices.

Secondly, the before mentioned researchers and among others, Gronn (2002), state that leadership can be claimed by those with the required expertise for the task or challenge at hand. Distributed leadership does not mean that everyone leads (Harris, 2008). Rather, whoever takes responsibility for a particular task and thus a leadership role depends on the specific situation (Spillane, 2005). We consider this to be the *dy-*

namic aspect of distributed leadership. Spillane and Sherer (2004) observed that teachers perform leadership roles by offering their expertise in the form of relevant examples from their own practice, advising other teachers in similar situations.

Thirdly, among others Gronn (2002), Harris and DeFlaminis (2016), and Pitts and Spillane (2009), conclude that distributed leadership revolves less around individuals and personal leadership acts, and more around relations, interactions, and dialogues between team members in complex school organizational and professional environments. It is concerned with reciprocal interdependencies between members through which tasks are accomplished, since 'one leader's practice becomes the basis for another leader's practice and vice versa' (Spillane, 2003, p. 344). We consider this to be the *relational* aspect of distributed leadership. Spillane and Sherer (2004) noted that knowledge is generated through the interactions of teachers and school principals. For instance, a literacy coordinator within a certain school depended on examples given by teachers in order to move forward with ideas for literacy lessons.

In conclusion, based on literature we define distributed leadership as a contextually embedded social interaction process between all team members, which is *collective, dynamic*, and *relational*. We continue by proposing a social network approach to measure these three core aspects of distributed leadership from literature.

2.2. Social network perspective on distributed leadership

Distributed leadership develops in social interaction and involves relations between persons in a network, such as a school team. Social network theory is concerned with relations between persons or groups and interactions of organizational and relational processes (e.g. Freeman, 2004; Wasserman & Faust, 1994). This social network perspective is argued to be a fitting point of view to study interactions (e.g. Keim, 2011), and is promising for studying distributed leadership practices (e.g. Azorín et al., 2020; Liou & Daly, 2020). The relations between persons and resources of each person (such as information, knowledge, and support (Coleman, 1988)) shape a social network structure. Within this structure, persons have access to and can mobilize resources (Lin, 1999), which is interpreted as social capital and mobilization of social capital (Brouwer et al., 2020; Coleman, 1988; Lin, 1999, 2001; Liou & Daly, 2018, 2020). Coleman (1988) explains that these valuable resources, social capital, can help persons to attain individual goals that they could not reach without these resources. Social capital is often studied in network research by using relational questions, which can target various types of interaction (e.g., advice, (information) exchange) (Brouwer et al., 2020; Liou & Daly, 2018). Pitts and Spillane (2009) state that an advice question '*allows us to move beyond an exclusive focus on the formal organization to attend to the informal organization such as informal interactions that are intended or understood by school staff to influence their practice*' (Pitts & Spillane, 2009, p. 187). Persons reach out for advice, such as information, knowledge or support (Brouwer et al., 2020; Coleman, 1988), to others who they may perceive as someone who can lead their professional development and have relevant expertise (Liu, 2021; Spillane, 2006; Tam, 2019). This means that the person who is asked for advice may perform a leadership role (Sinnema et al., 2020; Yukl, 2002), when he/she exerts influence on someone's knowledge and skills (Moolenaar et al., 2011).

However, until now data gathering and analyses in studies on distributed leadership are largely dominated by aggregation approaches using self-perception questionnaires (D'Innocenzo et al., 2016; Hulpia et al., 2009; Joo, 2020; Liu & Werblow, 2019; Sun & Xia, 2018). These methods do not regard each individual relation but focuses on distributed leadership on team level, since the questionnaires ask team members for perceptions of their team (D'Innocenzo et al., 2016). As previously introduced, there are various reasons for combining distributed leadership theory with a social network perspective, such as that the perspective includes the informal processes, studies each team mem-

ber's perception and all relations between teachers and school principals within a school team. Therefore, in this study, we follow the growing number of scholars that call for combining the social network perspective with distributed leadership theory (Cullen-Lester & Yammarino, 2016; D'Innocenzo et al., 2016; Naumov et al., 2020; Rodway & Farley-Ripple, 2020, Sinnema et al., 2020). We empirically explore how to apply the perspective to study the *collective, dynamic*, and *relational* aspects, and in this way develop a more comprehensive picture of distributed leadership.
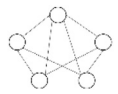
The question arises how to measure all three core aspects of the multi-faceted concept of distributed leadership (collective, dynamic, and relational). The social network perspective includes several measures that might represent various aspects of interaction and thus leadership (see for an overview Borgatti et al., 2013; Gest & Kindermann, 2012). Previous social network studies on distributed leadership mostly included one or two social network measures (e.g. Liou et al., 2014; Mehra et al., 2006) and have been largely based on quite small samples (e.g. De Lima, 2008). In more detail, previous studies on distributed leadership mostly studied graphical sociograms, without including network measures (Mehra et al., 2006; Pitts & Spillane, 2009; Sinnema et al., 2020), or utilized merely one measure to capture one aspect of distributed leadership, mostly density (Carson et al., 2007). Prior studies that utilized two measures, mostly density and centralization (Liou et al., 2014), studied a hypothetical dataset (Mayo et al., 2003), or solely included informal leaders (De Lima, 2008) or utilized it for role identification (Apkarian & Rasmussen, 2020; Smith et al., 2018) and in smaller samples of two schools (De Lima, 2008; Liou et al., 2014; Warfield, 2009) or five schools (Apkarian & Rasmussen, 2020; Brown et al., 2020). Concepts close to distributed leadership are more often studied by a combination of network measures, such as studies on collaboration of teachers (Moolenaar et al., 2012; Sinnema et al., 2020; Smit et al., 2021), research-based practices in networks (Farley-Ripple & Yun, 2021), and leadership of formal leaders or leadership teams (Hooge et al., 2019; Liou & Daly, 2018, 2020, 2020a; Spillane & Sun, 2020; Tuytens et al., 2019). These earlier studies indicate the promise of utilizing a social network perspective to depict relations and interactions. However, until now distributed leadership is studied less with such a social network perspective and thus D'Innocenzo et al. (2016) recommend, based on their meta-analysis on distributed leadership and team performance, to further explore the utility of other network measures in addition to the most often studied density and centralization to reveal different aspects of distributed leadership.

In the current study, each of the three core aspects of distributed leadership that we dissected will be measured with their own social network measure, based on an advice seeking network of teachers and their school principal. Insights from previous studies indicate the potential relevance of the social network measures density and centralization (e.g. Carson et al., 2007; Liou et al., 2014). We recognize these measures to fit the collective and dynamic aspect respectively, and we will study these two measures in our bigger sample of school teams. Furthermore, our second goal is to include the third core aspect, namely relational, and to measure this with the social network measure reciprocity. In this way, we study the relevance of adding another social network measure and the coherence of the three measures. Below we briefly explain how the *collective, dynamic*, and *relational* core aspects are captured within the chosen social network measures (for an overview, see Table 1).

Firstly, *collective* describes the extent to which the team members are actively consulting each other, for instance for advice, which represents the cohesiveness of a network. The more team members consulting each other, the more advice relationships evolve, which results in a more dense (i.e., cohesive) network (Borgatti et al., 2013). The social network measure density helps to study the collective aspect. It indicates how many ties are present within the whole network, and is hence a measure of how connected the team is (Civís et al., 2019; Harris, 2003; Liou et al., 2020; Sergiovanni, 2001).

Table 1

Overview of our proposal how to describe and measure distributed leadership from a social network perspective

Aspect of distributed leadership	Network Level	Network measurement	
		Name	Figure
Collective	Network	Density	
Dynamic	Network and individual	Centrality	
Relational	Dyadic	Reciprocity	

Secondly, *dynamic* is reflected by the degree of centeredness of the network around a few central members. It presents how and whether the dynamics of advice seeking in a network proceeds via multiple persons or a small amount of (or one) central member(s) (Borgatti et al., 2013). A network becomes more centralized around those who are asked for resources (for instance advice) by more others (Borgatti et al., 2013). The social network measure indegree centrality helps to study the dynamic aspect since it describes the distribution of ties by identifying to what extent those ties are organized around one or a few central members (D'Innocenzo et al., 2016; Huang et al., 2020). A high indegree centralization signals that a network is highly dependent on a small number of members and thus not that dynamic. If this is the case, this means that the power of individual members varies substantially, with leadership being rather unequally distributed across team members (Hanneman & Riddle, 2005). A low indegree centralization signals that multiple team members are central and thus advice seeking, and for instance a flow of information, is dynamically spread among team members.

Thirdly, to measure the third core aspect of distributed leadership, namely *relational,* we add a third social network measure to the combination of measures. As described before the relational aspect is about reciprocal interactions. The social network measure reciprocity helps to study the relational aspect since it provides insights into the hierarchy within a team and whether there is an interaction (Liou et al., 2020). Reciprocity presents the number of reciprocated ties on a dyadic level. A team with more reciprocated ties among its members is likely less hierarchical and thus more characterized by a distributed leadership structure.

Table 1 provides an overview of how we aim to describe and measure distributed leadership by a social network perspective. The three social network measures are expected to add to each other since they all capture another aspect of interaction and relation. Where density simply indicates the connectedness of a school team, centrality indicates whether there are central members on which a school team is dependent on, and reciprocity captures whether the relations are reciprocal and thus the hierarchy of the network of a school team. In sum, we aim to study how all three core aspects of the multi-faceted concept of distributed leadership can be measured by applying three social network measures.

3. Method

3.1. Context of the study

3.1.1. Collaborative innovation school programme

The research described in this paper is part of a larger research project investigating the effects of a Dutch programme aimed at enhancing collaborations for innovation in schools, by stimulating the establishment of a learning culture and the sharing of responsibilities between teachers and school principals. Such an approach to innovation

Table 2
Sample information.

School teams	N Total network	N School principals	N Teachers (N coaches)	Response rate	Missing respondents
A (voc)	16	1	12 (2)	81,3%	3 (18,7%)
B (voc)	14	1	11 (1)	85,7%	2 (14,3%)
C (voc)	12	1	9 (1)	83,3%	2 (16,7%)
D (voc)	12	1	10 (2)	91,7%	1 (8,3%)
E (sec)	12	1	10 (1)	91,7%	1 (8,3%)
F (prim)	12	1	10 (2)	91,7%	1 (8,3%)
G (prim)	11	1	8 (1)	81,8%	2 (18,2%)
H (prim)	10	1	9 (2)	100%	-
I (prim)	9	1	8 (1)	100%	-
J (voc)	8	0	7 (1)	87,5%	1 (12,5%)
K (voc)	8	0	7 (1)	87,5%	1 (12,5%)
L (voc)	8	1	6 (1)	87,5%	1 (12,5%)
M (prim)	8	1	4 (1)	62,5%	3 (37,5%)
N (prim)	6	1	5 (1)	100%	-
Total:	148	12	118 (18)	88%	12%

Note. Voc = vocational education teacher teams, sec = secondary education, prim = primary education.

has been described as *'collaborative innovation'* in recent public service organizational literature (Bekkers & Noordegraaf, 2016; Torfing, 2019). The programme was initiated by an independent foundation, after an international study by the OECD (2016) highlighted that the educational quality of Dutch schools is more than sufficient but could be further improved by enhancement of collaboration by educational staff within schools. At present, approximately a thousand Dutch primary, secondary, and vocational education schools have implemented the methodology of this programme (see Appendix A for a short explanation of the Dutch educational sectors).

We studied distributed leadership within schools participating in this programme, as teams in these schools are activated to collaborate and to distribute leadership. The programme uses a methodology that is partly based on 'Agile' principles, meaning a team-based approach to improving processes step by step (see Rigby et al., 2016). The methodology motivates schools to have weekly stand-up meetings where teachers and school principals meet each other and where goals are jointly set, and tasks agreed upon. These meetings are followed by codesigning lessons and classroom observations by colleagues.

The programme identifies three roles within schools, for which there are specific expectations: school principals, coach-teachers, and teachers. School principals are encouraged to set directions, be a role model in working with collaborative innovation (e.g. being present at weekly meetings, perform classroom observations and ask for feedback), and to facilitate their teachers improving themselves and the school's quality. Coach-teachers are teachers who received a training from an external advisor and perform the supervisor role of the implementation phase within the school, training the other teachers to work with the programme. In this way they have a more formal responsibility than the other teachers (Bryant et al., 2020). Teachers are expected to collaborate with their colleagues on a weekly basis, work with the programme, and gradually become co-owners of the school improvement process.

Notably, the programme consists of two phases, with the roles' associated responsibilities changing over time. The first phase entails an intensive implementation period, during one schoolyear, in which external advisors help schools to learn the methodology. The expected outcomes of this phase are enhancement of collaboration and increasingly shared responsibility amongst teachers and school principals. The second phase is focused on sustaining the collaborative innovation processes by aligning the programme with the schools' culture and structure.

3.1.2. Participants

Fourteen school teams that started working with the programme in September 2018 participated in the current study (three school teams were part of one large vocational education institution). The participating schools cover an age range of children from 4 to 16 years and older. The schools were well-spread across the Netherlands, were in rural as well as urban areas, and were all in the first year (the implementation phase). In total, the teams included 148 teachers and school principals, of which we received 130 responses, a response rate of 88% that can be considered excellent (Borgatti et al., 2006).

In social network analyses, instead of the number of participants, relationships are the unit of analysis and, therefore, an indication for the number of observations. The smallest school team had 30 relations (school team N; $6*5$), the largest school team had 156 relations to study (school team A). On average the teams had 80 relations. This sample size is comparable with other social network studies in education (see the sample sizes of e.g. Brouwer et al., 2020; Brown et al., 2020; De Lima, 2008; Sinnema et al., 2020). Table 2, in which the school teams are ordered based on team size, presents sample information. Within all school teams, women are in the majority. The average age of each team is between 35 and 51 years.

3.2. Design and procedure

3.2.1. Measurement of distributed leadership: asking for advice

In order to measure distributed leadership in school teams, fitting to the definition of leadership as exerting influence, we adopted an advice instrumental network question based on previous social network studies in education (Bryant et al., 2020; Liou et al., 2014; Moolenaar, 2012; Pitts & Spillane, 2009): 'Who do you turn to for advice on working with the educational program?'

Participants were asked to answer this advice question for each team member from a list of their school team members. This results in a matrix form of data on who turns to whom. Team members were represented with random initials (such as AA, AB, AC etc.) in order to anonymize datasets for analyses (see Appendix B for the matrix form of the advice question).

3.2.2. Procedure

We piloted the advice question and the listing procedure within two school teams that were not part of the sample of this study, but work with the same educational programme. The participants indicated they experienced no constraints when completing the questionnaire. The research was approved by the ethical review committee for social and behavioral sciences of our university (number 20-056).

After the pilot, we started the main phase of our data collection. The participants received a short explanation about the investment required for and the benefits of participating in the study before completing the social network advice question, and all participants agreed.

Furthermore, we chose to set the complete network boundary (Knoke & Yang, 2008) to one teacher team per school, as all schools divided their teachers into sub teams to work on this collaborative programme. Each school chose one teacher team to participate in this study.

3.2.3. Analysis plan

First, we calculated the descriptive network measures (density, centrality, and reciprocity). The advice network question is part of a questionnaire from the larger research project, in which we used a five-point Likert scale. We dichotomized the network measure scores to distinguish between ties being absent (score 0) or present (score 1), by recoding 1 as 0 (absent) and 2 till 5 as 1 (present). Based on matrixes of advice network data, we calculated the social network measures per school team (whole network level) by using Ucinet (Borgatti et al., 2013):

1 *Density* (network level): represents the proportion of directed relationships to the number of possible directed relationships (Wasserman & Faust, 1994). A density of 1 means that everyone asks advice from everyone else (Borgatti et al., 2013).
2 *Centrality* (consists of two measures: network and individual level):
   a Network indegree centralization represents the proportion of the sum of differences in centrality between the most central member in a network and all other members. This indicates whether there is a center (very central members) and a periphery (members with very low centrality scores) regarding the asking for advice (Borgatti et al., 2013).
   b Individual indegree centrality is an index that represents the number of ties any specific member has (D'Innocenzo et al., 2016). The members with the largest number within their team perform the most central roles (Sinnema et al., 2020; Smith et al., 2018; Tsai, 2001).
3 *Reciprocity* (dyadic level): indicates the proportion of observed directed relationships that are reciprocated in a network relative to the number of possible directed relationships (arc-based; Borgatti et al., 2013). When two members turn to each other for advice, this is a reciprocated relationship.

By combining these social network measures, we expect it to represent distributed leadership as follows: relatively high density, high reciprocity, low indegree centralization, and multiple central members (more than one team member). We compared the association between these measures and team members' roles (school principal, coach-teacher, teacher) in order to explore which role most commonly takes up the central position.

Next, we calculated the correlations between density, reciprocity, and centrality within Ucinet. For each network measure, we attributed the individual data to matrices per school team, for reciprocity and centrality we used 'difference' scores between all team members of a team and for density we used the raw scores of ties being absent (score 0) or present (score 1). In this way, we tested the correlation of the three social network measures and especially the added value of the reciprocity measure. Afterward, we compared all school teams' advice networks with a cross-case analysis, to enhance generalizability and to deepen our understanding of how to describe and measure distributed leadership (Miles & Huberman, 1994). By doing so, we ordered the school teams based on low to high scores of density, reciprocity, and centralization, and examined whether we could exploratively differentiate between school teams, based on face validity and discussions with all authors. Lastly, to visualize and further describe the results, we created sociograms within NetDraw and placed the central members in the center, based on indegree centrality. We considered the approach used in this study successful if the correlations between density and reciprocity were positive and the correlations between density and centrality were negative, and if the approach distinguished possible differences between school teams.

Table 3

Minimum and maximum percentages of network descriptives over all school teams.

	Advice-seeking (%)
Density	41 – 86
Reciprocity	42 – 86
Network indegree centralization	10 – 30
Individual indegree centrality (central members)	6 – 62

Table 4

Correlations per school team on advice-seeking.

Team *(n)*	Density x reciprocity	Density x indegree centralization
A *(13)*	**0.011**	**-0.209***
C *(10)*	-0.065	**-0.333***
E *(11)*	**0.349***	**-0.293***
J *(7)*	-0.113	**-0.317**
M *(5)*	**0.128**	0.128
D *(11)*	**0.100**	**-0.030**
F *(11)*	**0.169**	**-0.349***
B *(12)*	**0.140**	**-0.322***
G *(9)*	**0.190**	0.027
K *(7)*	**0.317**	**-0.585***
I *(9)*	**0.349***	0.069
N *(6)*	**0.293**	**-0.579***
H (10)	**0.374***	0.1
L *(7)*	-0.412*	**-0.490***

Note. Bold printed correlations fit measurement of distributed leadership. * Sig. < .05.

4. Results

4.1. Distributed leadership descriptives in school teams

In order to measure distributed leadership, we calculated social network descriptives for all school teams on team level (see Table 3). The scores indicated moderately to highly dense networks (41% to 86%), which means that moderately to many of the possible ties were present between members in the advice network, though this varied considerably between school teams. The same holds for reciprocity (42% to 86%), which means that moderately to many pairs of team members sought advice from each other. Regarding network indegree centralization, all school teams scored low to medium (10% to 30%). This means that some school teams had central members who were more often asked for advice and a periphery with members who were rarely asked. Other school teams did not show such a difference between central members and members in the periphery, indicating less of a hierarchy exists in asking for advice.

Regarding individual indegree centrality, we studied how many central members were present in each school team and which function they had within their team. Most school teams had more than one central member. In 12 out of 14 teams, teachers performed a central member role. In 4 school teams they were the only central member, in the other teams they shared their central member role with the coach-teacher (in 5 teams) and school principal (in 3 teams). Coach-teachers played a central member role often as well, with a score of 11 out of 14 teams. In 2 school teams, they were the only central member. School principals played a central member role in only 3 out of 14 teams (all three being primary schools), and never performed this central member role alone; in all three cases, they shared the central member role with both a coach-teacher and teacher.

4.2. Correlation of social network measures within teams

Table 4 indicates the correlations between the different network measures, per school team. These correlations are analyzed on matrices, see the Method for the explanation. As expected, the correlations

Table 5
Descriptive network statistics per school team on advice-seeking.

Team (size)	Density	Reciprocity	Centr.	Central members per team			
				% (number of central members)	Principal	Teacher	Coach-teacher
A (13)	0.405	0.456	0.289	6 (1)		x	
C (10)	0.464	0.588	0.273	16 (2)		x	x
E (11)	0.521	0.444	0.273	8 (1)		x	
J (7)	0.551	0.593	0.265	12,5 (1)			x
M (5)	0.686	0.417	0.163	12,5 (1)		x	
D (11)	0.636	0.659	0.207	25 (3)		x	x x
F (11)	0.678	0.659	0.214	16 (2)		x	x
B (12)	0.718	0.589	0.166	28 (4)		x x	x x
G (9)	0.611	0.618	**0.110**	27 (3)	x	x	x
K (7)	**0.857**	**0.762**	**0.122**	25 (2)		x	x
I (9)	**0.764**	**0.800**	**0.125**	11 (1)			x
N (6)	**0.833**	**0.800**	0.200	50 (3)	x	x	x
H (10)	**0.800**	**0.861**	**0.099**	40 (4)	x	x	x x
L (7)	**0.857**	**0.810**	**0.122**	62 (5)		x x x x x	

between density and reciprocity indicated a general positive trend, with some correlations being significant, though with small strength. Furthermore, as expected, the correlations between density and indegree centralization indicated a general negative trend and were mostly significant, with small to moderate strength. Thus, the small to moderate correlations suggest that the three social network measures study and represent distinct aspects of distributed leadership and thus add to each other and using all three can help to comprehensively study distributed leadership.

4.3. Distinguishing differences in distributed leadership between school teams

To distinguish differences regarding distributed leadership between teams, we ordered the school teams based on low to high scores of density, reciprocity, and centralization. Table 5 indicates that school teams that scored high on density also scored high on reciprocity, low on indegree centralization, and had a relatively higher percentage of central members (see the bold printed scores of school teams K to L in Table 5). The reverse is the case as well (see the scores in italics of school teams A to J in Table 5). The bold and italics represent a division of the scores in three parts (the highest score minus the lowest score, divided by three, added to the lowest and highest part, which indicates the boundaries). By utilizing and interpreting this combination of social network measures, we were able to exploratively differentiate between school teams with respect to their level of distributed leadership (see the three different parts in Table 5; school teams with italic scores indicate a relatively low level, the middle group without italics or bold scores a moderate level, and bold printed a high level of distributed leadership).

4.3.1. Visualizing differences between school teams with sociograms

Within social network studies, sociograms are commonly used to visualize results and provide an overview of the network structure. We present sociograms of two school teams that are indicative for two "extremes" regarding distributed leadership in our sample, school team C and school H (see Table 5 for their scores). Fig. 1 (team C) and 2 (team H) present the sociograms of these two school teams. School team C is of a larger size than school team H, with two members more. The circle sizes are based on the indegree and represent by how many members this specific team member is asked for advice. Moreover, black circles represent central members, calculated as the members with the relative largest indegree of their school team, grey circles represent all other team members with lower indegree scores. Furthermore, the thick lines represent reciprocal relationships, whereas the thin lines represent non-reciprocal (one-way) relationships.

We compared the two sociograms of Figs. 1 and 2 on the collective, dynamic, and relational aspects of distributed leadership. First of all,
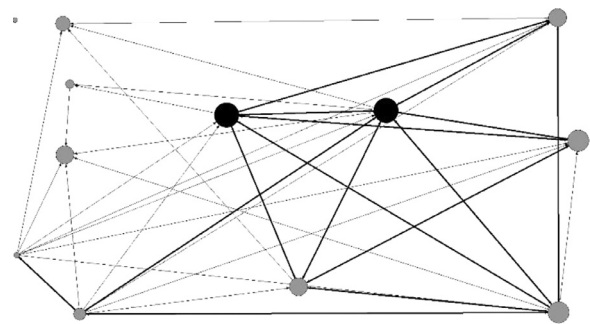

Fig. 1. Sociogram of school team C (n = 12)
Note. Black circles represent central members, those having the largest number of incoming ties. The person on the upper left has no connections with the other team members.
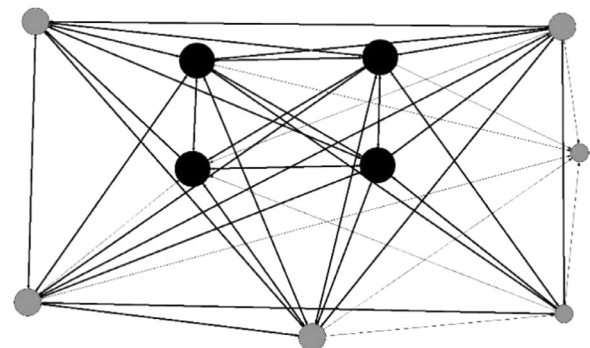

Fig. 2. Sociogram of school team H (n = 10)
Note. Black circles represent central members, those having the largest number of incoming ties.

school team H was more collective than school team C, since team H had relatively more connections and no team members were excluded. However, solely studying this collective aspect does not lead to a reliable conclusion about differences between school teams regarding distributed leadership, since the two sociograms do not indicate large differences. The dynamic aspect strengthens the collective aspect by indicating that school team H was more dynamic than school team C: school team H (see Fig. 2) had three different sizes of circles, all team members were being asked for advice by more than one team member (see Fig. 2 in which no small circles were present), and more central members were present (see four black circles in Fig. 2), compared to school team C (see

Fig. 1), in which eight different sizes of circles, meaning by how many others members are asked for advice, are present. Regarding the roles of central members, within school team C, the two central members were a teacher and coach-teacher; within school team H, the central members were two coach-teachers, one teacher, and the school principal. To draw even more reliable conclusions about the distributed leadership structure within teams, the relational aspect helps to show the hierarchy within a network and indicates another difference between school team H and C. The thick lines in the sociograms indicate reciprocal ties and school team H has distinctly more reciprocal ties than school team C.

In summary, these sociograms visualize distributed leadership, help to indicate that all three aspects contribute to describing distributed leadership within school teams, and suggest that school team H had a less hierarchical network structure, which indicates more distributed leadership than school team C.

5. Discussion

The present study contributes to the growing body of empirical research on describing and measuring distributed leadership. Previous research utilized solely aggregated data or studied one or two of the core aspects of distributed leadership. We firstly theoretically dissected distributed leadership and afterwards measured all three core aspects of distributed leadership that we dissected with a combination of social network measures: density for the *collective* aspect, centrality for the *dynamic* aspect, and reciprocity for the *relational* aspect. This combination of social network measures has an innovative potential for the search of how to measure distributed leadership. The three measures helped to us identify differences in distributed leadership between school teams. Based on the observed correlations between the different network measures, the explored differences between school teams, and the sociograms, we propose that the measures each can help to describe a different aspect of distributed leadership. Studying their combination can help to more comprehensively capture and describe the multi-faceted concept of distributed leadership. Specifically, the correlations between the network measures indicated a relation, which is important for forming a combination of measures, but also showed no strong correlations, indicating each aspect's separate contribution to the informativeness of the combination of measures. Furthermore, the sociograms show the added value of the relational aspect in addition to the collective and dynamic aspect and the strength of interpreting the combination of these three measures to describe and measure distributed leadership in school teams.

The presence of central members, as one key element of the combination of measures, deserves further attention. Identifying central members and whether those are formal or informal leaders is particularly interesting, since it shows how leadership is structured within school teams and helps to reflect whether the leadership is distributed in the way teachers and school principals would like to see it. The latter meaning that teachers and their school principal can talk together about how leadership is structured within their specific team and school and whether they want to change that structure. Furthermore, distributed leadership implies that there is a powerful relationship between vertical and horizontal leadership processes, and that formal leaders have to create cultural conditions and structural opportunities that enable informal leaders to lead and make changes (Harris, 2008). Harris (2008) stated that informal leadership practices are not yet reaching their full potential within schools. Our findings indicated that teachers are most often central members, and that school principals never performed this role on their own. Not only does this indicate a certain level of distributed leadership in schools that were part of this research, but also sounds promising for teachers' professional development (Civís et al., 2019; Sinnema et al., 2020), job satisfaction (e.g. García Torres, 2019), and organizational commitment (e.g. Hulpia et al., 2009). Within the context of collaborative innovation, compared to the school principals, teachers

seem to be more often considered by their own team members to ask for advice. Furthermore, we found that coach-teachers and teachers, as informal leaders, are often the central members together, including the school teams with less distributed leadership. Our findings underline the potential of using a social network perspective to study distributed leadership.

The focus of the present study was to build upon previous studies on how to describe and measure distributed leadership. Follow-up research is needed to determine whether the within team interactions that we studied are indeed representative of distributed leadership as discussed in literature. Besides, additional research can further conceptually dissect the concept of distributed leadership. Furthermore, our study does not offer an explanation for the observed differences in distributed leadership between school teams nor identifies the possible impact of these differences on relevant outcome measures. Therefore, further research is needed to explore whether the differences between school teams can be explained by variables such as school culture, leadership patterns of school principals (de Jong et al., 2020), gender, and teaching experience. To further deepen our understanding of distributed leadership, future qualitative research could expand our initial findings. Specifically, it could help to understand the quality or content of the advice, why members (do not) ask a certain team member for advice and whether this depends on how the team member is perceived, and how the team members are interacting. Additionally, future research could study the sustainability of distributed leadership, as we would expect that distributed leadership increases within teams when they continue working with a collaborative innovation approach for an extended period of time.

Additionally, further research needs to examine the generalizability of our approach to other contexts and countries. The results of the present study have limited generalizability, since we studied the rather specific context of Dutch school teams that all have implemented a specific collaborative innovation programme. However, the strength of our study is that it builds upon previous studies by adding valuable insights into the potential of measuring distributed leadership in schools with three social network measures and we had a robust (in response rate) sample of 14 school teams. We suggest that future research include more than one school team per school. This would provide possibilities for testing team differences within schools in levels of distributed leadership.

A practical application of our study is to interpret distributed leadership measures of schools together with the teachers and school principals of that particular school. In this way, schools will be encouraged to reflect on (the level of distributed) leadership within their teams and as a result improve their collaborative approach to innovation. This forms a response to the recent international call for a more social, collaborative, and networked approach to school innovations (Liou et al., 2020).

6. Conclusion

Despite the growing number of studies on the effects of distributed leadership, limited knowledge exists on how to describe and how to measure the multi-faceted concept of distributed leadership. Thus far, studies on distributed leadership are largely dominated by aggregation approaches, such as studies that used self-perception questionnaires that ask about distributed leadership on team level, rather than a social network perspective, in which distributed leadership is measured by each individual relation in a network. When a social network perspective is used in studies to investigate distributed leadership, which are mostly explorative studies, either the collective or the dynamic aspect is investigated and the relational aspect is missing. We described distributed leadership by three theoretical aspects and selected appropriate network measures for each of these aspects to measure distributed leadership in school teams. The correlations between the three network measures (density, reciprocity, indegree centralization), the sociograms, and the differences between school teams in their level of distributed leadership, suggest that the three network measures form a coherent com-

bination and simultaneously each of the measures refer to one of the aspects of distributed leadership. Thus, adding the relational aspect in addition to the collective and dynamic seems to be informative to study distributed leadership in school teams. Studying this combination of measures can help to more comprehensively describe distributed leadership and enables us to deepen understanding of leadership processes in school teams.

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Appendix A. Dutch educational sectors

The Dutch educational system consists of four educational sectors: primary (students aged 4 to 12), secondary (students aged 12 to 18), and vocational and higher education (students aged 16 and older) schools. Secondary schools are divided into streams, and primary schools recommend a specific stream to each final-year student. Students can choose any secondary school that offers their recommended stream.

Appendix B. Appendix

Who do you turn to for advice on working with the educational programme?

Note: We see asking advice as approaching a colleague of whom you think he/she can help you with the educational programme. By working with the educational programme we mean all activities that you perform regarding the educational programme, such as stand up meetings, activities that result from the stand up meetings, designing lessons together, collaboration with colleagues such as observing each other's lessons.

AA = Sophie Miller
AB = Gerry Smith
AC = Mary Brown
Etc. …

	Never	Seldom	Sometimes	Often	Very often
AA	○	○	○	○	○
AB	○	○	○	○	○
AC	○	○	○	○	○
Etc.	○	○	○	○	○

Figure Appendix B. Example of the advice question, matrix form (names fictitious).

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