Research Papers in Education

ISSN: 0267-1522 (Print) 1470-1146 (Online) Journal homepage: http://www.tandfonline.com/loi/rred20

Share and succeed: the development of knowledge sharing and brokerage in data teams' network structures

Mireille D. Hubers, Nienke M. Moolenaar, Kim Schildkamp, Alan J. Daly, Adam Handelzalts & Jules M. Pieters

To cite this article: Mireille D. Hubers, Nienke M. Moolenaar, Kim Schildkamp, Alan J. Daly, Adam Handelzalts & Jules M. Pieters (2018) Share and succeed: the development of knowledge sharing and brokerage in data teams' network structures, Research Papers in Education, 33:2, 216-238, DOI: 10.1080/02671522.2017.1286682

To link to this article: https://doi.org/10.1080/02671522.2017.1286682

RESEARCH PAPERS IN EDUCATION, 2018
VOL. 33, NO. 2, 216–238
https://doi.org/10.1080/02671522.2017.1286682

Routledge
Taylor & Francis Group

Share and succeed: the development of knowledge sharing and brokerage in data teams' network structures

Mireille D. Hubers[a], Nienke M. Moolenaar[b], Kim Schildkamp[a], Alan J. Daly[c], Adam Handelzalts[a] and Jules M. Pieters[a]

[a]Institute for Teacher Training and Professional Development, University of Twente, Enschede, The Netherlands; [b]Department of Education, University of Utrecht, Utrecht, The Netherlands; [c]Department of Education Studies, University of California San Diego, San Diego, USA

ABSTRACT

The data team intervention was designed to support Dutch secondary schools in using data while developing a solution to an educational problem. A data team can build school-wide capacity for data use through knowledge sharing among data team members, and knowledge brokerage between the team and other colleagues. The goal of this mixed-methods study is to understand how knowledge sharing and brokerage regarding data use and an educational problem changed over time. Social network data were collected twice at eight schools. These data were used to analyse (1) how well team members were connected with each other (density), (2) whether team members' relationships were mutual (reciprocity) and (3) whether all team members were equally important for the data team network (centralisation). Moreover, different types of knowledge brokering (inward, outward and forward) were examined to further understand knowledge exchange between data team members and their colleagues. Qualitative data were analysed to triangulate these findings for four particular cases. Among other things, findings illustrated that while knowledge sharing and knowledge brokerage both changed over time, there were considerable differences between teams in the extent and direction of change. It appeared that the dissemination of knowledge within the organisation requires more explicit attention.

ARTICLE HISTORY
Received 15 July 2016
Accepted 18 January 2017

KEYWORDS
Knowledge sharing; knowledge brokerage; data use; data teams; capacity building; social network analyses

Introduction

Data-based decision-making in education has become increasingly important in a number of countries (Datnow, Park, and Kennedy-Lewis 2013; Schildkamp and Kuiper 2010). Data-based decision-making entails the collection and organisation of information representing some aspect of a school, and is used to improve the quality of education (Lai and Schildkamp 2013). These data can be quantitative or qualitative, and can represent any relevant information about students, teachers, schools and parents. One of the reasons why data-based

CONTACT Mireille D. Hubers m.d.hubers@utwente.nl
[§]Present address: Adam Handelzalts, VU University, The Netherlands

decision-making – or data use, for short – is important, is that such decisions are more likely to be effective than decisions based on intuition and experience (Schildkamp, Poortman, and Handelzalts 2016). Furthermore, data can support teachers' reflective processes and provide insight into their strengths and weaknesses, which can be used in turn to improve their own functioning (Schildkamp and Kuiper 2010; Visscher and Ehren 2011).

Data can also be used to establish learning goals for students, to monitor the extent to which those goals are reached, and to decide how support can best be provided (Earl and Katz 2006). As a result, students' achievement is likely to improve (Carlson, Borman, and Robinson 2011). However, despite the benefits associated with data use, most schools do not use data in their decision-making processes or use it ineffectively (Lai and Schildkamp 2013). Therefore, several programmes have been developed to support schools in the effective use of data (see Coburn and Turner 2011 for an overview).

The data team intervention is one such programme (Schildkamp, Poortman, and Handelzalts 2016). In this intervention, teams consisting of six to eight educators learn how to use data to analyse and solve an educational problem in their school (e.g. high grade retention rates). The data team intervention has two goals. The first goal is professional development of the data team members. To accomplish this, data team members need to collaborate and share their knowledge with each other about data use in general and about the specific educational problem they are studying. The second goal is school improvement by solving the educational problem and increasing colleagues' level of data use. To meet this goal, data team members are expected to build capacity in their school through brokering (diffusing) to their colleagues their knowledge about data use and about the educational problem.

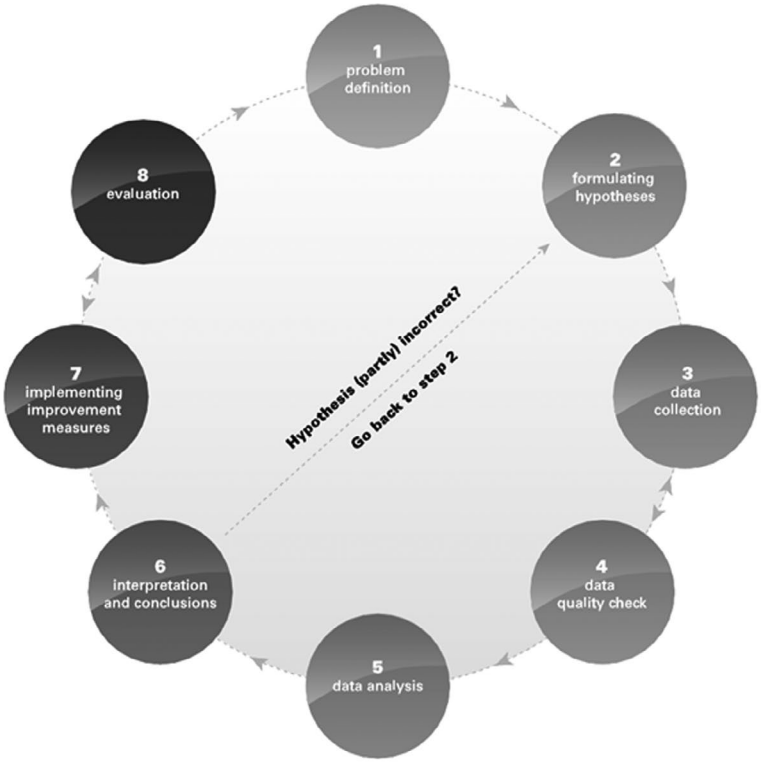
Given the interactive and collaborative nature of knowledge sharing and brokerage, a social network perspective is used to study the process of knowledge sharing and brokerage. Social network analysis is grounded in the idea that relationships among teachers and/or school leaders can provide individuals and groups with resources (e.g. knowledge) that may be utilised to achieve goals, such as data use (Degenne and Forse 1999). Along these lines, one could expect, for example, that data team members would be more likely to share their knowledge which each other when they interact frequently.

Up until now, limited attention has been paid to the role of relationships in the process of school improvement (Moolenaar, Daly, and Finnigan 2013; Muijs, West, and Ainscow 2010), and even less with regard to data use (see Daly 2012 for a review). Such information is crucial to come to a deeper understanding of the dynamic between an intervention, and the resulting on-the-ground responses and actions, such as how data are being used (Coburn and Turner 2011). This study uses social network data to explore how the development of relationships can be related to knowledge sharing and knowledge brokerage. This study will help us understand how and why some schools and teams are able to build capacity for data use and educational problems while others are not. Furthermore, it will improve our general understanding of how network structures can be used to study the implementation of new practices.

Theoretical framework

Capacity building through working with the data team intervention

A data team consists of six to eight educators at the same school: 1–2 school leaders, 4–6 teachers and, if possible, the quality manager, who has access to the data (Schildkamp, Poortman, and Handelzalts 2016). Data team members meet on average twice a month for



1. An educational problem on which team members want to focus their efforts is defined.
2. A hypothesis about the cause of the educational problem is formulated.
3. Quantitative and/or qualitative data are collected to study the hypothesis.
4. The validity and reliability of the data are determined.
5. The data are analyzed (e.g., descriptive or correlational analyses).
6. The outcomes are interpreted and conclusions are drawn. If the hypothesis turns out to be false, a new hypothesis needs to be investigated (back to step 2). If the hypothesis turns out to be supported, the data team members proceed to step 7.
7. Actions for improvement are developed and implemented. The team also comes up with ways to determine the effectiveness of these actions.
8. The effectiveness of the actions is evaluated and they are modified if necessary.

Figure 1. The data team intervention (Schildkamp and Ehren 2013, p. 56).

two years, during which time they collaboratively work on a problem in their own school (e.g. high grade retention rates). They use a cyclical procedure to do so (see Figure 1), which includes an extensive set of guidelines and activities. In between meetings, the data team members collect data and prepare for the meetings, with a data coach from the university providing support. Additional information on the intervention and its effectiveness can be found in the work of Schildkamp, Poortman, and Handelzalts (2016).

The goal of the data team is to educate team members in data use. To achieve this goal, data team members need to build capacity within their team. They can do so by sharing knowledge about (at least) two types of content: knowledge about data use in general (e.g. knowing when data are reliable and how to analyse data), and knowledge about the educational problem that is the focus of their study (e.g. its underlying causes and how to solve it).

Besides sharing their knowledge to build capacity within their own team, data team members may also broker that knowledge beyond the team and build capacity within the entire school (Coburn, Touré, and Yamashita 2009; Feldman and Tung 2001). Brokerage is a term used to identify knowledge sharing by key individuals responsible for collective capacity building. The types of content important for knowledge brokerage are similar to those required for capacity building within the team: data use in general and the educational problem. When team members successfully broker their knowledge, they build the capacity that is required to increase the school-wide level of data use (Honig 2006). For example, knowledge brokerage is likely to facilitate their colleagues' participation in discussions of school-wide issues and increase school staff's communication about data use and the issues those data indicate to be important (Huffman and Kalnin 2003; Lachat and Smith 2005). Social network analysis can be used to determine how data team members build capacity within their own team and within the school (through knowledge sharing and knowledge brokerage, respectively).

Social networks analysis

Social network analysis is grounded in the idea that ties (relationships) with others determine the extent to which an actor has access to resources in a network, and often the type and quality of resources (e.g. knowledge) as well (Portes and Sensenbrenner 1993). Thus, who you know affects what you know (Nahapiet and Ghoshal 1997). Social network scholars argue that the success of (reform) implementation critically depends on the ability of an organisation to internally distribute the required knowledge, support and resources (Frank, Penuel, and Krause 2015). As such, this research suggests that by increasing the number of relationships within an organisation (e.g. reflected in increased network density), as well as relationships between units within organisations (e.g. reflected in increased brokerage between departments) will support the implementation of innovations (e.g. Coburn and Russell 2008; Daly, Finnigan, Stuart, Moolenaar and Che 2014; Tsai and Goshal 1998). Along these lines, one could expect, for example, that data team members would be more likely to broker within the school their knowledge about data use and/or the educational problem they are studying when they interact with their colleagues frequently than when they are relatively isolated.

Even though the ties between individuals are the 'vehicles' for the exchange of knowledge, the overall configuration of these ties in a social network, such as a school, impacts the development of knowledge within the entire organisation (Nahapiet and Ghoshal 1997). Thus, we must focus our work not only on the individual ties between persons 'A' and 'B', but also on how that dyadic relationship is embedded within a larger context, here: the data team and the entire school. Moreover, whether a reform is successfully implemented critically depends on the ability of an organisation to internally distribute the required knowledge (Frank, Penuel, and Krause 2015). This makes (reform) implementation an inherently dynamic phenomenon, which requires that attention is paid to the way in which networks change over time.

Network structures indicating knowledge sharing within the data team

The network of relationships between data team members is likely to reflect the sharing of knowledge within the data team. Three characteristics are often identified to describe

the relational structure of a team. The first is *density*. Previous research has indicated that teams are more likely to achieve their goals when their connections are dense, meaning a high number of ties between the team members, than when their connections are sparse (Balkundi and Harrison 2006). The second characteristic is *reciprocity*, in which team members have a mutual tie (Daly 2012). Reciprocity may provide opportunities for deeper exchanges, because these ties are likely to reflect trust and support the transmission of complex knowledge (Honig and Ikemoto 2008). The third characteristic is *centralisation*, which reflects the (un)equal distribution of resources, such as knowledge, within a team (Hanneman and Riddle 2005). When a team is highly centralised, members with a central position are more likely to contribute to the decisions being made, regardless of whether they are qualified to do so (Pitcher and Smith 2001). In a sense, these actors have disproportionate influence over the exchanges in a network. As a result, it might be more difficult for team members to share their knowledge.

In sum, it is assumed that over time, knowledge is most likely to be shared when the structure of the data team becomes denser, less centralised and when relationships are more often reciprocated (see also Keuning et al. 2016). When such knowledge is shared, it is likely to contribute to realisation of the professional development goal of the data team intervention.

Network structures indicating knowledge brokerage by the data team

The network of relationships between data team members and their colleagues is likely to reflect team members' knowledge brokerage. Gould and Fernandez (1989) used both a statistical model and empirical data to define and validate different brokerage measures. Subsequently, these measures have been used in other empirical studies, e.g. by Daly et al. (2014). Three conceptually different brokerage roles can be distinguished in which resources (e.g. knowledge), are moved from an individual, to a broker, to another individual, taking group membership into account (Gould and Fernandez 1989). In the present study, group membership is defined as being a member of the data team or not, so that the broker is always a member of the data team. Furthermore, knowledge brokerage is aggregated at the level of the data team to examine knowledge brokerage by the team as a whole to the group of colleagues as a whole. As a result, three types of aggregated knowledge brokerage can be distinguished, see Figure 2:

- *Outward* brokerage: data team members diffuse their knowledge (their output) to the colleagues. For example, a data team member exchanges data on the number of students who repeat a grade with the broker. After that, the broker exchanges this data with another colleague.
- *Inward* brokerage: colleagues provide individual data team members with knowledge that can be used as input for the activities of the data team. An example of this is a colleague providing a possible hypothesis on the cause of the educational problem to the broker. The broker uses this input when he is discussing the educational problem with a fellow data team member.
- *Forward* brokerage: the data team forwards knowledge from one colleague to another colleague, thereby building bridges between the colleagues. For example, a colleague talks with the broker about the educational problem, and then the broker talks about this conversation with another colleague.

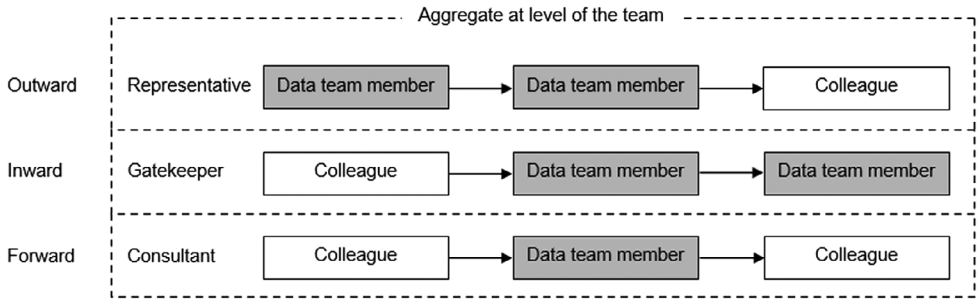


Figure 2. Three different types of knowledge brokerage.
Note: The middle rectangle represents the broker. The arrows represent the diffusion of knowledge.

These distinctions are useful for gaining detailed insight into data team members' brokerage. For example, are they able to broker their knowledge in all three ways, or do they struggle with one specific type? In sum, it is assumed that all three types of knowledge brokerage will increase over time. Taking the aforementioned together resulted in the following research questions:

(1) In what ways do the data teams' knowledge sharing structures regarding data use and the educational problem change over time in terms of their density, reciprocity and centralisation?
(2) How does data teams' knowledge brokering about data use and the educational problem to their colleagues change over time and which aspects (outward, inward and forward) seem to occur most often?

Method

Context

This mixed-methods study took place in the Netherlands. Dutch schools have considerable freedom in determining what subject matter they teach, what textbooks, assessments and instructional strategies they use, and the religious or ideological beliefs to which they adhere (Kuiper et al. 2006). However, schools are held accountable by the Dutch Inspectorate for the quality of education they provide. Therefore, schools increasingly prioritise data use. In 2012–2013, only 8% of the secondary schools studied by the Dutch Inspectorate used data (Dutch Inspectorate of Education 2014). According to the Dutch Ministry of Education, this needs this needs to increase to at least 90% by 2018 (Verbeek and Odenthal 2014). Important data sources available to them include: external national assessment data; student achievement data; data on intake and transfer; and student, teacher and parent questionnaire data.

The present study was part of a larger project funded by the Dutch Ministry of Education. In total, 25 secondary schools voluntarily signed up for this project by sending in a preliminary general statement of a problem on which they wanted to focus their efforts. Of this group, ten schools were selected based on their statement of a problem and their geographical location, so that various parts of the Netherlands were represented. All schools chose high grade retention rates as the educational problem on which they wanted to focus their efforts. They all had little experience with data use, and were thus comparable at the beginning of the project. All data team members voluntarily joined the team.

Participants

All school leaders, teachers and team members were invited to participate in a social network survey twice. The response rates were determined at each point in time and over both time-points. The first part of the research determined changes in knowledge sharing within the data teams. Two schools were removed from the sample due to low response rates by the data team members. The average response rate of the data team members in the remaining eight schools was 94%. However, in the analyses, all team members who were part of the team at both points in time were included, regardless of whether or not they responded to the questionnaire. This provided a more accurate description of each team as a whole. In total, 50 data team members were included, of which 29 (58%) and 11 (22%) worked as teachers and school leaders, respectively. The remaining 20% worked as a quality manager or as part of the support staff (e.g. student administration).

The second part of the research focused on changes in knowledge brokerage by the data team members. Data from one school were not used in the second part because the colleagues were spread over multiple locations and there were no clear-cut rules about which colleagues from which locations knew each other, while in some locations brokerage could not even occur because there was only one team member (at least two team members are required for outward and inward brokerage).

The average response rate for colleagues in the remaining seven schools was 41.26%. No apparent differences in grade levels, educational levels being taught and subjects being taught were evident between the participants and the non-participants. Additional sample characteristics are included in Table 1.

Table 1. School characteristics.

School[1]	*N* Locations	Educational[2] level	School size: *N* students	Relative size**	Denomination[3]	*N* Data team members	Response data team members (%)	*N* Colleagues	Response Colleagues (%)
Fairview	2	Low/low	543/464*	–/–	Religious	7	100	16/14*	36/38
Highland	1	Interm. – High	1079	=	Public	9	89	20	28
Jefferson	4	Interm. – High	2752	=	Religious	5	100	***	***
Lincoln	1	Low – High	1261	+	Religious	6	100	49	49
Maple Grove	1	Low – High	1223	–	Public	5	80	33	34
Oak Grove	1	Low – High	1185	+	Religious	6	83	42	55
Pine Grove	1	Interm. – High	1007	–	Religious	6	83	31	43
Roosevelt	1	Low – High	964	–	Public	6	100	34	47

*Data on Fairview 1 and Fairview 2, respectively; **School size in relation to the educational level. + above average, = average, – below average; ***This school was excluded from the second part of the study.

1. School and participant names are pseudonyms.

2. In the Netherlands, there are three main educational tracks. The lowest track (4 years) prepares students for vocational education. The intermediate track (5 years) prepares students for college/higher education. The highest track (6 years) prepares students for university education. These tracks are quite segregated, which means that most students who enter a track stay within that track until graduation.

3. A school is considered public when it does not have a religious denomination.

Table 2. Participants' characteristics for the four cases.

Name	Location	Years of experience	Function	Subjects
Fairview				
Mr. Anderson	1	20	Teacher, school leader	Dutch
Mr. Johnson	1	12	Assistant principal	–
Ms. Smith	1	9	Teacher	English
Mr. Williams	1	8	Teacher, quality manager	Science, Chemistry
Mr. Jones	2	35	Teacher, school leader	Mathematics
Ms. Lee	2	10	Teacher	History, Geography
Mr. Miller	2	31	Teacher, school leader	Mathematics
Highland				
Mr. Adams	–	5	Teacher	Mathematics
Mr. Bell	–	22	Teacher	Dutch
Mr. King	–	30	School leader, teacher	Geography
Ms. Morgan	–	11	Educational specialist	–
Ms. Murphy	–	15	Teacher	PE
Mr. Roberts	–	8	Teacher	PE
Ms. Stewart	–	7	Head ICT & Education*	–
Mr. Taylor	–	20	School leader	–
Mr. Turner	–	15	Teacher	History, Civics
Lincoln				
Ms. Brown	–	32	Teacher	Music, Arts
Ms. Clark	–	13	Support staff	–
Ms. Harris	–	30	School leader	–
Mr. Martinez	–	15	Teacher	Mathematics
Mr. Wilson	–	9	Teacher	Chemistry
Ms. Young	–	20	Teacher	Mathematics
Roosevelt				
Mr. Barnes	–	27	Teacher	French
Ms. Collins	–	20	School leader	–
Mr. Evans	–	20	Assistant principal, Teacher	Chemistry
Ms. Jenkins	–	14	Teacher	Arts
Mr. Myers	–	30	School leader	–
Ms. Powell	–	32	Teacher	Biology

*Abbreviation of Information and Communication Technology.

As will be illustrated in the results section, qualitative data on four particular cases were used to triangulate the quantitative data. Characteristics of the team members on these teams are given in Table 2. Overall, the four teams appeared to be comparable in their working climate, as the coach characterised these teams over time as: 'interested in each other, willing to learn' (Highland); 'enthusiastic, willing to carry out each other's ideas' (Fairview); 'enthusiastic, professional' (Roosevelt); and 'open, enthusiastic' (Lincoln).

Quantitative instrument: social network questionnaire

An online questionnaire was developed to determine the network structures. This questionnaire was administered twice: once near the beginning and once at the end of the school year. This time frame was chosen in order to determine whether data team members' differ from the beginning onwards in the extent to which they share and broker their knowledge. Moreover, none of the teams had yet found the cause of their problem at the end of the first year, which made them comparable in their progress.

The present study focused on network structures related to: 1) exchanging data and 2) discussing the educational problem. For each question, participants could select one or more of their colleagues from a list of all possible alternatives. This procedure is in line with previous social network research (Moolenaar 2012). The first question

was: 'In the past month, with which colleague or colleagues did you exchange data (for example, test results, answers on questionnaires or retention figures)?', which identified relationships related to data use. The second question was: 'In the past month, with which colleague or colleagues did you discuss the low retention rates at [educational level at which the team members focused their efforts]?' which identified relationships related to the educational problem. This resulted in non-valued (binary) and non-symmetric (directional) network data.

Qualitative instrument: log files

To triangulate findings from the network data, qualitative data on the development of knowledge sharing and knowledge brokerage were collected. The data coach from the university supervised all data teams included in the present study. After each meeting, she wrote a log file in which she reflected on the team's functioning and progress. All log files for the four cases (12 on Fairview, 11 on Highland, 8 on Lincoln and 9 on Roosevelt) were included in this study.

Quantitative data analysis

To study knowledge sharing and knowledge brokerage related to data use and the educational problem, various network measures were computed using the network data in UCInet 6.0 (Borgatti, Everett, and Freeman 2002). The networks were also visualised in Netdraw (Borgatti 2002). The descriptive statistics for all measures under study are presented in Table 3.

Knowledge sharing in the data team

At the level of the data team, density, reciprocity and centralisation were computed.

Density

This measure represents the percentage of observed relationships relative to the maximum number of possible relationships (Hanneman and Riddle 2005). The resulting scores can range from 0 (no relationships are present) to 100 (everyone is connected with everyone else) and indicate network cohesion. Furthermore, it provides insight into the extent to which team members have access to resources of the network (e.g. knowledge).

Table 3. Descriptive statistics for the network structure measures.

	Data use				Educational problem			
	T1		T2		T1		T2	
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Knowledge sharing								
Density	31.90	7.25	23.41	3.74	43.98	6.27	50.54	3.63
Reciprocity	19.31	4.78	15.79	5.01	25.42	6.72	37.52	8.34
Centralisation	27.40	5.12	33.62	5.52	33.30	8.33	34.29	4.70
Knowledge brokerage								
Outward	2.96	0.85	1.51	0.47	5.62	1.96	5.14	1.31
Inward	2.21	0.64	0.95	0.34	3.08	0.66	3.43	0.59
Forward	0.63	0.11	0.38	0.12	1.73	0.79	1.29	0.53

Reciprocity

This measure reflects the percentage of pairs of team members having a reciprocated relationship relative to the total number of connections between pairs. The reciprocity can range from 0 (no pair has a reciprocated relationship) to 100 (all pairs have a reciprocated relationship) (Hanneman and Riddle 2005).

Centralisation

Freeman's in-degree centrality measure reflects the central tendency of a social network. It assesses whether the relationships are evenly dispersed or whether some individuals are highly important to the network. Thus, the centralisation measure reflects how (un)equally relationships are distributed at the individual level. These relationships are expressed as a percentage of the theoretically most unequal distribution of relationships. Thus, a high percentage indicates that a small number of individuals are highly important for the network, and a low percentage indicates that a large number of people are more or less equally important for the network (Hanneman and Riddle 2005).

Knowledge brokerage by data team members

At the level of the data team within the school, brokerage was examined by computing the representative, gatekeeper and consultant brokerage roles while taking group membership into account (Gould and Fernandez 1989). Group membership was defined by being either a member of the data team or a colleague who works at the same school but does not participate in the data team. For each type of brokerage, the total number of brokerage ties within the data team was calculated and expressed as a percentage of the maximum number of brokerage ties the team could theoretically have had. This resulted in the aggregated and normalised outward, inward and forward brokerage scores,[1] which could range from 0 (no brokerage exists) to 100 (all data team members are brokers for every colleague).

Qualitative data analysis

Development of knowledge sharing and brokerage

In the present study, the quantitative data were used as input for the selection of cases for the qualitative research (Teddlie and Tashakkori 2008). Log files from four particular schools were used to triangulate the quantitative findings with qualitative data. First, all log files were read and all information related to the development of knowledge sharing between team members and knowledge brokerage between the team and their colleagues was flagged. Second, clusters of information that re-occurred in multiple files, for example, division of tasks and activities undertaken to involve colleagues, were summarised in a table. Third, the summaries for the different teams were compared and contrasted, and issues that occurred in all four teams (e.g. comments made about task division) were used in the Results section. The findings from the logs corroborated findings from the quantitative data. For example, in teams that increased their knowledge sharing (quantitative data), the team members were described as participating equally and actively (qualitative data), whereas in teams that decreased their knowledge sharing, some team members were described as passive and not-participating. The researchers interpreted and discussed the log files in a

cyclical and iterative manner, thereby ensuring the reliability and internal validity of their findings (Poortman and Schildkamp 2012).

Results

First, the changes in knowledge sharing structures related to data use and the educational problem will be described. Second, the changes in knowledge brokerage related to data use and the educational problem will be described. Qualitative data for four data teams that showed the most striking changes over time will be used throughout this section to explore how differences in knowledge sharing and brokerage between teams might be reflected in practice.

Knowledge sharing within the data team

In the theoretical framing it was argued that an increase in density and reciprocity and a decrease in centralisation are likely indicators of an increase in knowledge sharing. The results, see also Figure 3, were interpreted in the light of this pattern.

Knowledge sharing about data use

To support the interpretation that will be made of the social network measures, sociograms for the four cases at both time-points are presented, see Figure 4. For example, the figures for team Lincoln illustrate that a large number of ties were no longer reported at time 2, and that several team members were no longer connected to each other. Furthermore, a clear division between these team members occurred.

It appeared that only the Highland team increased its knowledge sharing. This was reflected in all three measures. For example, density increased from 33.3% to 36.1%, indicating that another 2.8% of all possible relationships between data team members were acknowledged at time 2 with regard to sharing of knowledge concerning data use. Moreover, reciprocity increased from 20% to 23.8%, whereas centralisation decreased from 37.5% to 33.9%. This indicates that another 3.8% of the pairs of data team members had a reciprocated relationship for knowledge sharing concerning data use at time 2, whereas the inequality of the distribution of knowledge about data use decreased with 3.6%, respectively. The Fairview team displayed an increase in density and reciprocity as well, but their centralisation also increased somewhat. Pine Grove displayed a similar pattern to Fairview, but centralisation increased far more. The remaining teams (Lincoln, Oak Grove, Jefferson and Maple Grove) decreased their knowledge sharing, which was reflected in the decreased density and reciprocity, and increased centralisation.

When these findings were triangulated with the log files, it appeared that the coach noticed that Fairview and Highland's team members tried to increase their knowledge sharing. In both teams, one or two members were especially skilled in the use of data, and were willing and able to provide team members with good explanations. For example, the coach noted in her log file on the second meeting at Fairview: 'Mr. Williams visualised the data in a clear manner, and gives an explanation of the data.' Moreover, she noted that team members contributed equally during the meetings. This indicates that all team members were involved in the use of data, which confirms the increase in knowledge sharing.

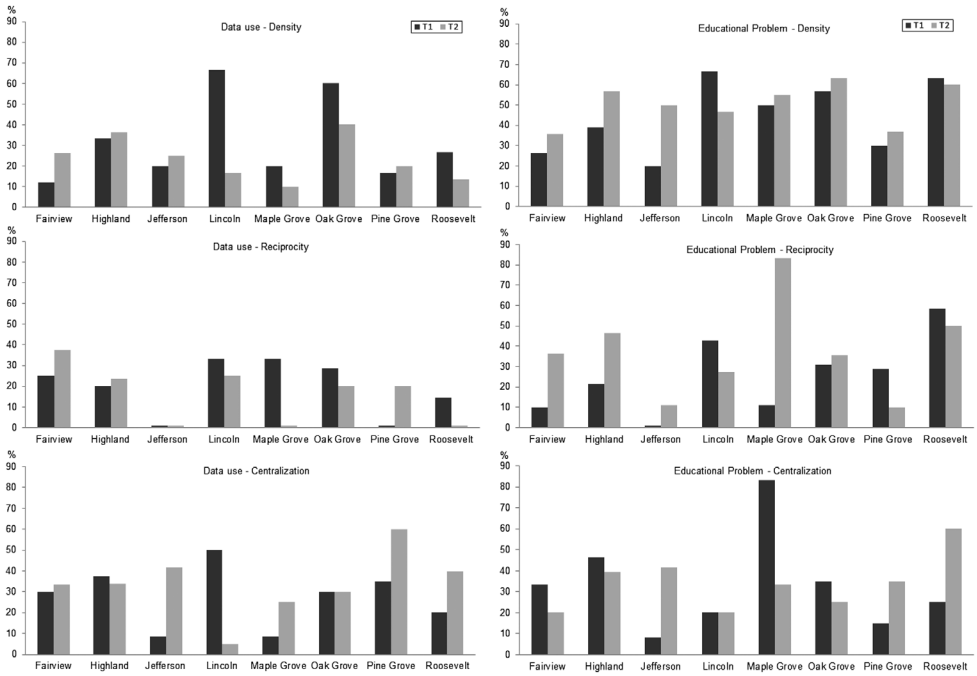


Figure 3. Changes in network measures of knowledge sharing over time.

In contrast, the coach noticed that Lincoln and Roosevelt's team members decreased their knowledge sharing. Even though one of Lincoln's members was skilled in the use of data, the coach never noted that this expert was also willing and able to explain this to the other team members. For the Roosevelt team, it appeared that no team member was especially skilled in data use. Their data were primarily collected by a quality manager who was not part of the data team. Moreover, the coach noted repeatedly that team members did not contribute equally during the meetings at Lincoln and Roosevelt. For example, she noted about the third meeting at Lincoln: '*Ms. Clark and Mr. Martinez were very passive*'. This indicates that not all team members were involved in the use of data, which confirms the decrease in knowledge sharing.

Knowledge sharing about the educational problem

To support the interpretation of the measures, sociograms for the four cases at both time-points are presented in Figure 5. For example, the figure illustrates that in team Highland, multiple new ties were formed over time for sharing knowledge about the educational problem. These changes led to better connections between team members.

It appeared that half of the teams increased their knowledge sharing about the educational problem, which was reflected in the increased density and reciprocity, and the decreased centralisation (see also Figure 4). This was the case for Oak Grove, Maple Grove, Highland and Fairview. In contrast, team Lincoln and team Roosevelt displayed a decrease in density and reciprocity, along with stable or increased centralisation. For example, density at team Roosevelt decreased from 63.3% to 60.0%, indicating that 3.3% of all possible relationships between data team members were no longer acknowledged at time 2 with regard to sharing

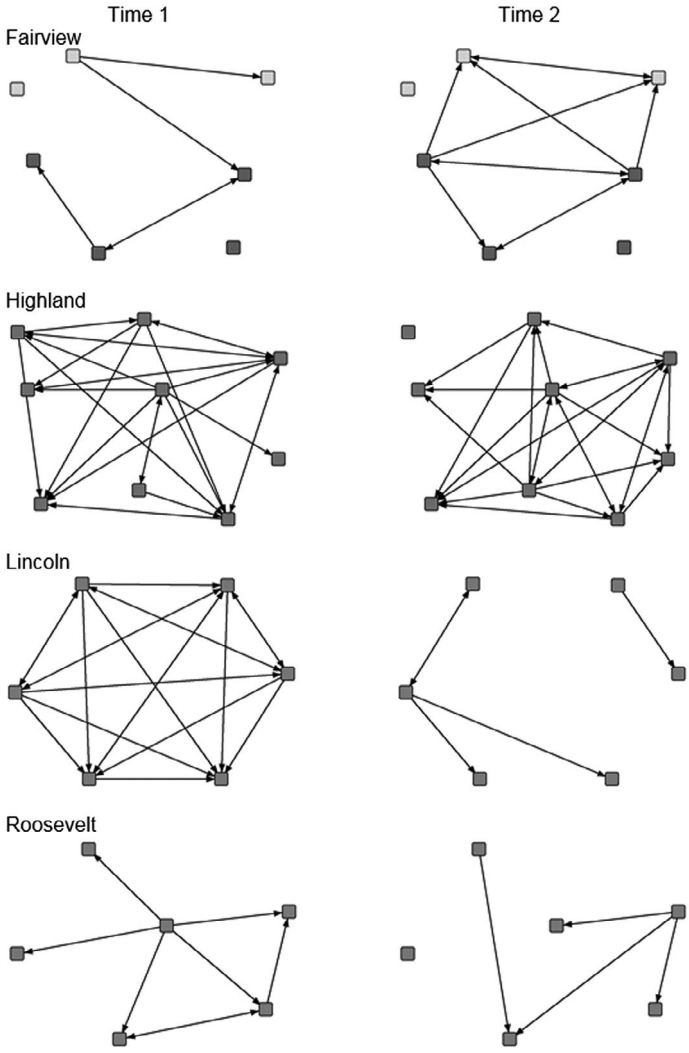


Figure 4. Relationships for exchanging data within four teams.
Note: Data team members from Fairview 1 are represented by the darker boxes, whereas members from Fairview 2 are represented by the lighter boxes.

of knowledge concerning the educational problem. Moreover, reciprocity decreased from 58.3% to 50.0%, whereas centralisation increased from 25.0% to 60.0%.

This indicates that 8.3% of the pairs of data team members no longer had a reciprocated relationship for knowledge sharing concerning the educational problem at time 2, and the inequality of the distribution of knowledge about the educational problem increased with 35%, respectively. The other teams could not be unequivocally assigned to either group. Jefferson displayed an increase in both density and reciprocity, but also a large increase in centralisation, whereas Pine Grove increased in density and centralisation, but decreased in reciprocity. Overall, all scores related to the educational problem are higher than the scores for data use. This indicates that there are more relationships related to knowledge sharing about the educational problem, that those relationships are more often reciprocated, and

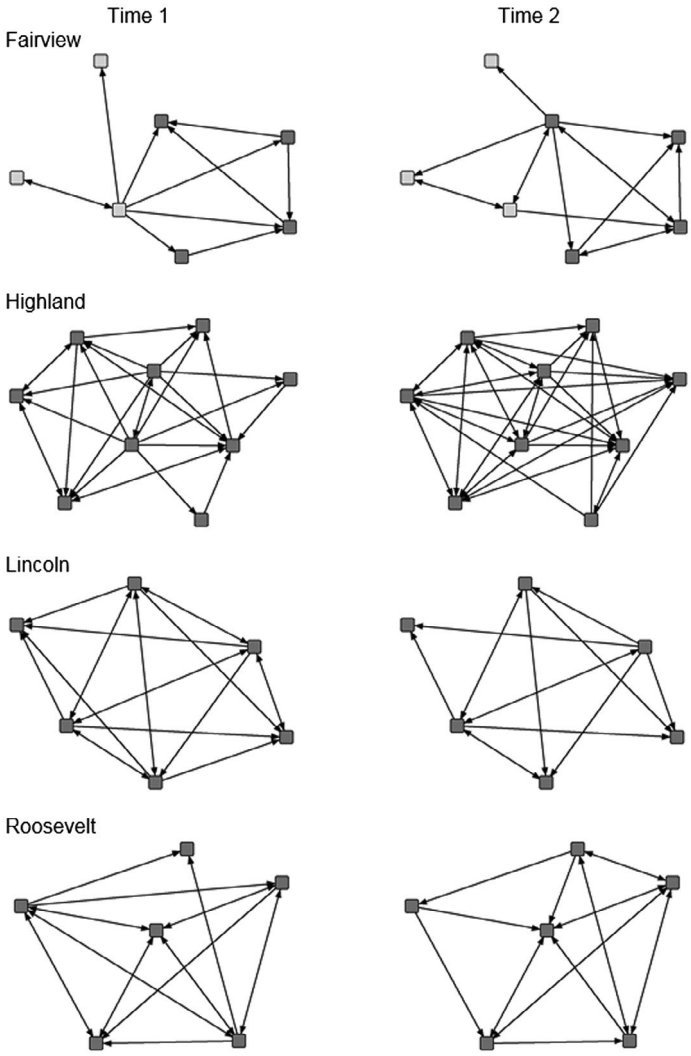


Figure 5. Relationships for discussing the educational problem within four teams.
Note: Data team members from Fairview 1 are represented by the darker boxes, whereas members from Fairview 2 are represented by the lighter boxes.

that knowledge about the educational problem is more unequally distributed than knowledge about data use. Regardless, several individuals did not share knowledge about data use and the educational problem with each other. This indicated that the dissemination of knowledge within the team requires more explicit attention.

When these findings were triangulated with the log files, it appeared that team members at both Highland and Fairview regularly discussed their ideas and beliefs about the educational problem. This indicates that the data team members regularly shared knowledge about the educational problem. For example, the coach noted in her log file at Highland's first meeting: 'Team members are proficient in sharing their beliefs about certain decisions or ideas regarding the educational problem'.

In contrast, it appeared that the Lincoln and Roosevelt teams wanted to work too quickly. They were collecting data almost for the mere sake of collecting it. For example, the coach noted in her log file at Lincoln's sixth meeting: 'What exactly do we want? And why do we choose certain hypotheses?' This indicates that knowledge of the educational problem was discussed little, and several team members were not involved during these discussions.

Knowledge brokerage by data teams to their colleagues

Brokerage about data use

The teams at Lincoln, Oak Grove, Maple Grove, Roosevelt and Highland all decreased in each type of knowledge brokerage, even though the extent of the decline differed between teams (see Figure 6). For example, team members at Lincoln decreased their outward knowledge brokerage from 7.1% to 0.5%. This indicates that 6.6% of their colleagues no longer received team members' knowledge about data use at time 2. Moreover, team members' inward brokerage decreased from 3.6% to 1.5%, and their forward brokerage decreased from 1.0% to 0.2%. This indicates that team members no longer gained input from 2.1% of their colleagues, and 0.8% less bridges were built between colleagues, respectively, at time 2.

Of the remaining teams, Pine Grove decreased in outward and forward brokerage, but increased in inward brokerage. For Fairview 1, it was just the opposite, with the team increasing in outward and forward brokerage, but decreasing in inward brokerage. Fairview 2 remained stable in outward brokerage, declined in inward brokerage and increased in forward brokerage. Overall, outward brokerage occurred most often, whereas forward brokerage occurred least often. In other words, this means that the data teams most often diffused their knowledge to their colleagues, while the teams least often forwarded knowledge from one colleague to another colleague. Regardless, the actual level of knowledge brokerage about data use was low, as the highest brokerage score was 7.1% (Lincoln at time 1, outward brokerage). This indicates that data team members brokered their knowledge to 7.1% of their colleagues.

Brokerage about the educational problem

It appeared that team Maple Grove, Highland and Fairview 1 increased in each type of knowledge brokerage, although the extent of the increase differed between teams (see also Figure 6). For example, team members at Fairview 1 increased their outward knowledge brokerage from 1.0% to 4.2%. This indicates that another 3.2% of their colleagues received team members' knowledge about the educational problem at time 2. Moreover, team members' inward brokerage increased from 1.6% to 5.7%, and their forward brokerage increased from 0.1% to 0.3%. This indicates that team members gained input from another 4.1% of their colleagues, and bridges were built between another 0.2% of their colleagues at time 2, respectively.

All other teams – Lincoln, Pine Grove, Roosevelt and Fairview 2 – decreased in each type of knowledge brokerage. Overall, brokerage scores related to the educational problem indicate that all data teams struggled to build capacity among their colleagues. They were relatively best at diffusing their team's knowledge to their colleagues (outward brokerage), and relatively worst at building bridges between their colleagues (forward brokerage). Knowledge brokerage scores were higher for the educational problem than for data use, as was also seen with knowledge sharing between data team members. Regardless, the actual

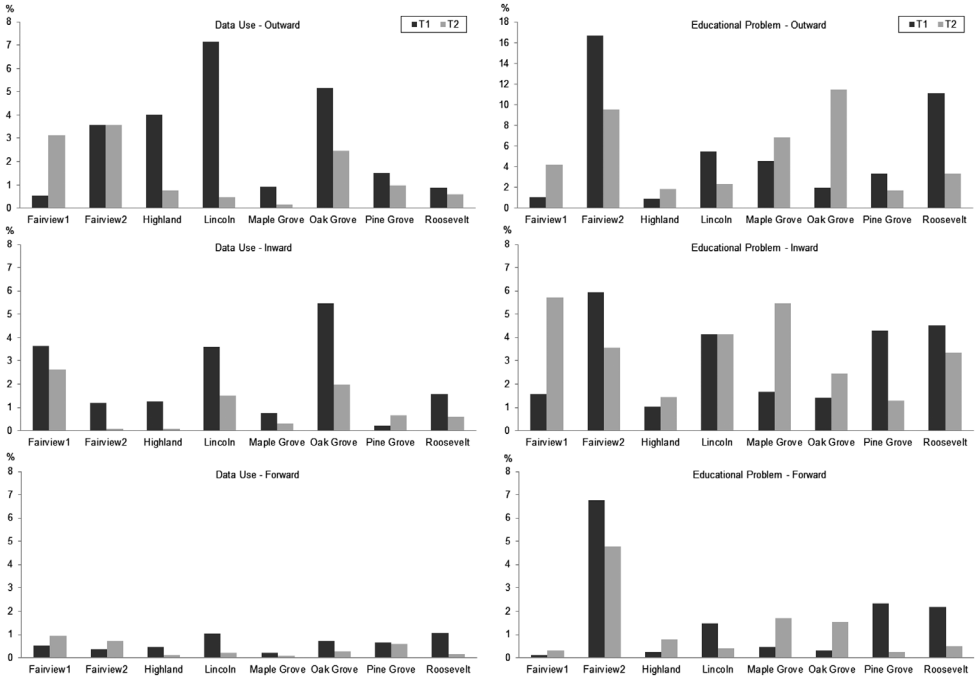


Figure 6. Changes in types of knowledge brokerage over time.

level of knowledge brokerage about the educational problem was low, as the highest brokerage score was 16.7% (Fairview 2 at time 1, outward brokerage). This indicates that data team members brokered their knowledge to 16.7% of their colleagues.

When these findings on knowledge brokerage about data use and the educational problem were triangulated with the log files, it appeared that the coach noticed that Fairview and Highland's team members tried to increase their outward brokerage. For example, the coach wrote in her log file at Highland's fourth meeting: 'Team members thought their communication strategy through and are very enthusiastic about implementing it'. Similarly, she wrote at Fairview's second meeting: 'The team likes to involve the entire school in the progress of the data team.' Moreover, their increases in knowledge brokerage were also reflected in the number and diversity of activities they had undertaken to involve their colleagues. For example, team members from both teams hung up sheets of paper in the teachers' lounge on which their colleagues could write their ideas about possible causes underlying their problem (stimulating inward brokerage). In addition, they wrote articles about their progress for their staff newsletter, and presented their findings to all of their colleagues. These qualitative data also confirm that both Highland and Fairview mainly focused their efforts on outward brokerage (diffusing their knowledge to colleagues), to a lesser extent on inward brokerage (using colleagues' input), and did not carry out specific activities to stimulate forward brokerage (connecting colleagues with each other).

In contrast, it appeared that the coach noticed that Lincoln and Roosevelts' team members did little to diffuse their knowledge to their colleagues. For example, she noted at Lincoln's eighth meeting:

> Ms. Harris really thinks about sustaining the data team intervention in the school and communicating their progress with their colleagues. However, sometimes it remains just a thought. For example, they write a newsletter on the data team, but they do not send it.

This is reflected in their decrease in all three types of brokerage. Moreover, their decreases in knowledge brokerage were also reflected in the number and diversity of activities undertaken by the data team members to involve their colleagues. Team members from Lincoln solely relied on written communication as they wrote only two stories on their progress for their staff newsletter. This confirms that Lincoln's data team members focused exclusively their efforts on outward brokerage: diffusing their knowledge to their colleagues. The data team members from Roosevelt did not undertake any activities to involve their colleagues.

Conclusion and discussion

The current study aimed to determine how social network structures reflecting knowledge sharing and brokerage changed over the first year in which schools started working with the data team intervention.

Conclusions on knowledge sharing

It appeared that the changes in knowledge sharing structures between data team members varied extensively between teams, and that there were considerable differences between teams in the extent and direction of the changes. Even though half of the teams declined their knowledge sharing for both data use and the educational level, the overall level of knowledge sharing was higher for the educational problem. Reflecting on this, it might indicate that data team members are more comfortable with talking about the educational problem, while they might consider data use to be something you should be good at before you can talk about it. As most of the team members were novices at data use, this might explain the lack of knowledge sharing related to this. Regardless, several individuals did not share knowledge about data use and the educational problem with each other. This indicated that the dissemination of knowledge within the team requires more explicit attention.

The differences in knowledge sharing structures between these four teams were also reflected in the qualitative data. Teams who increased their knowledge sharing had quality managers on their team who were willing and able to share their knowledge, and all team members were actively involved in their team's progress and regularly discussed their ideas and beliefs about the educational problem. In contrast, teams who decreased their knowledge sharing did not have such experts, and team members did not discuss their ideas and beliefs about the educational problem. Moreover, some team members were less involved in their teams' progress than others. Wenger (1998) has stated that such a situation, in which team members contribute unequally, leads to both marginality and an inability to learn.

Conclusions on knowledge brokerage

The second research question concerned changes in knowledge brokerage structures between the data team and their colleagues. Similar to knowledge sharing, knowledge brokerage varied extensively between schools, and there were considerable differences between teams in the extent and direction of the changes. Outward brokerage occurred most often,

which means that data team members diffused their knowledge to their colleagues. Forward brokerage occurred least often, which means that the data team members did little to disseminate knowledge from one colleague to another. Furthermore, teams brokered their knowledge about the educational problem more often than their knowledge about data use.

This difference in knowledge diffusion between the educational problem and data use is not surprising, given the current accountability context in which data are often used to explain or defend certain actions or decisions (Datnow and Hubbard 2015). The educational problem influenced data team members' daily working life, whereas they were novices at data use, which was not yet embedded in their daily working life. This could have led to a situation in which they felt committed to solving the educational problem, and using the data team intervention as a tool to 'fix' this specific problem. Instead, they should use it as an approach that that is valuable in and of itself to not only solve their current problem, but also to improve issues that might arise in the future. That way, the overall quality of education will improve. In addition, disseminating knowledge about data use often needed to be accompanied by an explanation of how they analysed their data, which might have been relatively difficult for them to come up with, and/or relatively difficult for their colleagues to understand.

Regardless, the actual levels of knowledge brokerage were low. This means that the data team members rarely built bridges between fellow data team members and colleagues by diffusing their knowledge. Similar conclusions were drawn by Keuning et al. (2016), who indicated that less than 20% of Dutch primary schools' relational potential with regard to data use was used. This means that knowledge brokerage requires more explicit attention.

The differences in knowledge brokerage between teams were also reflected in the qualitative data. It appeared that teams who increased their knowledge brokerage, undertook more activities than teams who mostly decreased in their knowledge brokerage. In so doing, the former used several different activities and used both verbal and written communication. Including verbal communication is a pre-requisite for knowledge brokerage, as this helps with interpreting the relevance of the written documents, negotiating their relevance and connecting it to colleagues' everyday practice (Wenger 1998). In contrast, teams who decreased in their knowledge brokerage relied exclusively on written communication or did not undertake any activities at all.

Limitations

The present study had a few limitations. First, response rates were relatively low within the group of colleagues. Even though there appeared to be no specific clustering in the participants relative to the non-participants, in that teachers from all educational levels, grade levels and courses were included, it might be that a specific sub-set of colleagues completed the questionnaire, for example, those who feel connected to their other colleagues. Second, as the data teams were only halfway through the programme provided by the university, we only have trends about knowledge sharing and brokerage. For example, it is possible that teams put more effort into knowledge brokerage in their second year of participating in the programme, when it is more likely that they would find the causes underlying their educational problem. Third, the qualitative analyses were exploratory; only issues related to knowledge sharing and brokerage that were recorded in multiple files and occurring for all four teams were used. Because of that, other reflections of knowledge sharing and

brokerage might have been neglected. However, the current qualitative data confirmed and illuminated several differences between the four teams, thereby showing the value of this type of data in understanding differences in changes in knowledge sharing and knowledge brokerage between teams.

Practical implications

The present study illustrated that it can never be assumed that knowledge will automatically flow through the team or the organisation; this is something that will require explicit attention, focus and considerable effort. Therefore, efforts to improve teachers' data use would benefit from a focus on building collaborative structures (Farley-Ripple and Buttram 2015).

Regarding knowledge sharing, it seems advisable to include experts in the data team who are willing and able to diffuse their expertise. Regarding knowledge brokerage, it seems advisable for the data coach to provide brokers with examples and more support in disseminating their knowledge, as brokers need special skills to be able to diffuse their knowledge (see Akkerman and Bakker 2011 for a review). To stimulate both knowledge sharing and brokerage, the coach could emphasise the value of data use for school improvement and instruction, whereas the accountability purpose should play a less central role. In so doing, specific attention needs to be paid to the transfer of the data team intervention from the team to teachers' daily working life. For example, the coach could illustrate how data team members can collaboratively improve their own functioning (e.g. create and evaluate common standards), by using the same steps of the procedure.

Future research

Future research should continue to determine how capacity for interventions, such as data use, is build. Social network analysis proved to be a helpful tool to do so. An important area for future research includes the different stages involved in implementing new practices. For example, Finnigan and Daly (2012) proposed that when new practices are first being implemented, the main focus is on knowledge sharing, whereas over time, the focus lies more on knowledge brokerage. For a data team this could mean that in the beginning, the main focus is on the building up of a good team in which all members learn the procedure. They involve their colleagues most extensively when they find the cause of the educational problem: their moment of glory. This might also be the time to convince their colleagues to use data and teach them how to do so. Future research should study these implementation stages in more detail.

Conclusion

The present study illustrated that data team members struggled to build their own and their colleagues' capacity for data use through knowledge sharing and brokerage, which might place them at risk for not achieving their professional development and school improvement goals. Previous research stated that such capacity is critical to achieve school-wide changes (e.g. Harris 2011; Honig 2006; Stoll 2010). Therefore, interventions should target the process of capacity building more clearly to support schools in implementing data use.

Note

1. For example, outward brokerage was computed by summing representative scores for the individual data team members and expressing this as a percentage of the theoretical maximum for possible representative brokerage by the team. To illustrate these calculations, an example is provided. The Lincoln data team was composed of 6 data team members and 49 colleagues (see Table 2). The theoretical maximum for possible representative brokerage by one broker is: (N data team members – 1) × 1 × N colleagues). The theoretical maximum for possible representative brokerage by the team is: ((N data team members – 1) × 1 × N colleagues) × N data team members = (5 × 1 × 49) × 6 = 1470. This number reflects all possible combinations in which a data team member diffuses knowledge to the broker (also a data team member), who in turn, diffuses this knowledge to a colleague. In team Lincoln, 105 brokerage relations were actually present for exchanging data at time 1. Thus: (105/1470) × 100 = 7.1% outward brokerage existed for this team at time 1.

Acknowledgement

The authors are grateful to the Dutch Ministry of Education, Culture & Science for funding the data team project. Although government-funded, the present study was independently designed and conducted.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was funded by Dutch Ministry of Education, Culture & Science.

Notes on contributors

Mireille D. Hubers, PhD, is an assistant professor at the University of Twente, Department of Educational Science, in the Netherlands. Her research interests include the influence of knowledge creation and knowledge sharing on teachers' professional development and sustainable school improvement. Recent publications include: Hubers, M. D., Poortman, C. L., Schildkamp, K., Pieters, J. M., & Handelzalts, A. (2016). Opening the black box: Knowledge creation in schools with a data team. *Journal of Professional Capital and Community*, *1*(1), 41–68. doi: 10.1108/JPCC-07-2015-0003

Nienke M. Moolenaar, PhD, is an assistant professor at Utrecht University, The Netherlands. Her research interests include social capital theory, social network analysis, school leadership and large-scale reforms in elementary education. She has published in various journals and edited books, and received grants, scholarships and awards for her work on teachers' social networks in school teams. Recent publications include: Moolenaar, N. M., Daly, A. J., Cornelissen, L., Liou, Y. H., Caillier, S., Riordan, R., Wilson, K., & Cohen, N. A. (2014). Linked to innovation: Shaping an innovative climate through network intentionality and educators' social network position. *Journal of Educational Change, 15*(2), 99–123. doi: 10.1007/s10833-014-9230-4 and Liou, Y. H., Moolenaar, N. M., & Daly, A. J. (2015). Developing and assessing educator beliefs about the Common Core. *Educational Assessment, Evaluation and Accountability*, 1–28.

Kim Schildkamp, PhD, is an associate professor at the University of Twente, Institute for Teacher Training and Professional Development, The Netherlands. Her research interests include data-based decision-making, formative assessment, and professional development. She has published widely in journals and edited books, and received grants, scholarships and awards for her work on data-based

decision-making. She is the developer of the data team procedure, which has been implemented in schools in The Netherlands, Sweden and England. Recent publications include: Schildkamp, K., Lai, M. K., & Earl, L. (2013). *Data-based Decision-Making in Education: Challenges and Opportunities*. Dordrecht: Springer, and Schildkamp, K., Poortman, C. L., & Handelzalts, A. (2015). Data teams for school improvement. *School Effectiveness and School Improvement*. Advance online publication. doi :10.1080/09243453.2015.1056192.

Alan J. Daly, PhD, is chair and professor of the Department of Education Studies at the University of California, San Diego. His research and teaching primarily focus on the role of leadership, educational policy and organisation structures and the relationship between those elements for the educational attainment of traditionally marginalised populations. Alan draws on his methodological expertise in social network analysis in his work and has a book on the topic published by Harvard Press entitled, *Social Network Theory and Educational Change* and a second book with Springer entitled, *Using Research Evidence in Schools*. Recent publications include: Daly, A. J. & Finnigan, K. (in press). *Thinking Systemically: Improving Districts Under Pressure*. American Educational Research Association Publishing Group. Daly, A. J., Moolenaar, N., Liou, Y., & Tuytens, M. (in press). Why so difficult? Exploring negative relationships between educational leaders: The role of trust, climate and efficacy. *American Journal of Education*.

Adam Handelzalts, PhD, is a team leader at the University Teachers College of VU University Amsterdam. His research interests concern teacher collaboration for professional development and school improvement.

Jules M. Pieters, Ph.D, is a professor-emeritus of Applied Psychology at the University of Twente. He was involved in research projects on inquiry and collaboration in professional development of teachers, on co-designing of curriculum materials and learning environments by teachers in teacher design teams, and on knowledge dissemination. Recent publications include: Van Uden, J. M., Ritzen, H., & Pieters, J. M. (2014). Engaging students: The role of teacher beliefs and interpersonal behavior in fostering student engagement in vocational education. *Teaching and Teacher Education*, *37*, 21–32.

References

Akkerman, Sanne F., and Arthur Bakker. 2011. "Boundary Crossing and Boundary Objects." *Review of Educational Research* 81 (2): 132–169. doi:10.3102/0034654311404435.

Balkundi, Prasad, and David A. Harrison. 2006. "Ties, Leaders, and Time in Teams: Strong Inference about Network Structure's Effects on Team Viability and Performance." *Academy of Management Journal* 49 (1): 49–68.

Borgatti, Steve P. 2002. *Netdraw Network Visualization*. Harvard, MA: Analytic Technologies.

Borgatti, Steve P., Martin G. Everett, and Lin C. Freeman. 2002. *UCINET for Windows: Software for Social Network Analysis*. Harvard, MA: Analytic Technologies.

Carlson, Deven, Geoffrey D. Borman, and Michelle Robinson. 2011. "A Multistate District Level Cluster Randomized Trial of the Impact of Data-driven Reform on Reading and Mathematics Achievement." *Educational Evaluation and Policy Analysis* 33 (3): 378–398.

Coburn, Cynthia E., and Jennifer L. Russell. 2008. "District Policy and Teachers' Social Networks." *Educational Evaluation and Policy Analysis* 30 (3): 203–235.

Coburn, Cynthia E., Judith Touré, and Mika Yamashita. 2009. "Evidence, Interpretation, and Persuasion: Instructional Decision Making in the District Central Office." *Teachers College Record* 111 (April): 1115–1161.

Coburn, Cynthia E., and Erica O. Turner. 2011. "Research on Data Use: A Framework and Analysis." *Measurement* 9 (November): 173–206.

Daly, Alan J. 2012. "Data, Dyads and Dynamics: Exploring Data Use and Social Networks in Educational Improvement." *Teacher College Record* 114 (November): 1–38.

Daly, Alan J., Kara S. Finnigan, Jordan S. Stuart, Nienke M. Moolenaar, and Jing Che. 2014. "Misalignment and Perverse Incentives Examining the Politics of District Leaders as

Brokers in the Use of Research Evidence." *Educational Policy* 28 (March): 145–174. doi: 10.1177/0895904813513149.

Datnow, Amanda, and Lea Hubbard. 2015. "Exploration and Exploitation in Organizational Learning Instruction: Lessons from the past and Prospects for the Future." *Teachers College Record* 117 (April): 1–26.

Datnow, Amanda, Vicki Park, and Brianna Kennedy-Lewis. 2013. "Affordances and Constraints in the Context of Teacher Collaboration for the Purpose of Data Use." *Journal of Educational Administration* 51: 341–362.

Degenne, Alain, and Michel Forse. 1999. *Introducing Social Networks*. London: Sage.

Dutch Inspectorate of Education. 2014. *De Staat van het Onderwijs* [The State of Affairs in Education]. Utrecht: Inspectie van het Onderwijs.

Earl, Lorna, and Steven Katz. 2006. *Leading Schools in a Data-rich World: Harnessing Data for School Improvement*. Thousand Oaks, CA: Corwin Press.

Farley-Ripple, Elizabeth N., and Joan L. Buttram. 2015. "Developing Collaborative Data Use through Professional Learning Communities: Early Lessons from Delaware." *Studies in Educational Evaluation* 42 (September): 41–53. doi:10.1016/j.stueduc.2013.09.006.

Feldman, Jay, and Rosann. Tung. 2001. "Whole School Reform: How Schools Use the Data-based Inquiry and Decision Making Process." Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA, April 10–14.

Finnigan, Kara S., and Alan J. Daly. 2012. "Mind the Gap: Organizational Learning and Improvement in an Underperforming Urban System." *American Journal of Education* 119 (1): 41–71. doi:10.1086/667700.

Frank, Kenneth A., William R. Penuel, and Ann Krause. 2015. "What is a "Good" Social Network For Policy Implementation? The Flow of Know-how for Organizational Change." *Journal of Policy Analysis and Management* 34 (2): 378–402. doi:10.1002/pam.21817.

Gould, Roger V., and Roberto M. Fernandez. 1989. "Structures of Mediation: A Formal Approach to Brokerage in Transaction Networks." *Sociological Methodology* 19 (January): 89–126.

Hanneman, Robert A., and Mark Riddle. 2005. *Introduction to Social Network Methods*. Riverside, CA: University of California, Riverside.

Harris, Alma. 2011. "System Improvement through Collective Capacity Building." *Journal of Educational Administration* 49 (6): 624–636. doi:10.1108/09578231111174785.

Honig, Meredith I. 2006. "Street-level Bureaucracy Revisited: Frontline District Central-office Administrators as Boundary Spanners in Education Policy Implementation." *Educational Evaluation and Policy Analysis* 28 (4): 357–383. doi:10.3102/01623737028004357.

Honig, Meredith I., and Gina S. Ikemoto. 2008. "Adaptive Assistance for Learning Improvement Efforts: The Case of the Institute for Learning." *Peabody Journal of Education* 83 (3): 328–363.

Huffman, Douglas, and Julie Kalnin. 2003. "Collaborative Inquiry to Make Data-based Decisions in Schools." *Teaching and Teacher Education* 19 (6): 569–580.

Keuning, Trynke, Marieke van Geel, Adrie Visscher, Jean-Paul Fox, and Nienke M. Moolenaar. 2016. "The Transformation of Schools' Social Networks during a Data-based Decision-making Reform." *Teachers College Record* 118 (9): 1–33.

Kuiper, Wilmad, Jan Van den Akker, Hans Hooghoff, and Jos Letschert. 2006. "Curriculum Policy and School Practice in a European Comparative Perspective." In *Curriculum Development Re-invented. Proceedings of the Invitational Conference on the Occasion of the 30 Years SLO 1975–2005*, edited by J. F. M. Letschert, 56–77. Enschede: SLO.

Lachat, Mary Ann, and Stephen Smith. 2005. "Practices That Support Data Use in Urban High Schools." *Journal of Education for Students Placed at Risk (JESPAR)* 10 (3): 333–349.

Lai, Mei K., and Kim Schildkamp. 2013. "Data-based Decision Making: An Overview" In *Data-based Decision Making in Education*, edited by K. Schildkamp, M. K. Lai, and L. Earl, 9–21. Dordrecht: Springer.

Moolenaar, Nienke M. 2012. "A Social Network Perspective on Teacher Collaboration in Schools: Theory, Methodology, and Applications." *American Journal of Education* 119 (1): 7–39. doi:10.1086/667715.

Moolenaar, N. M., A. J. Daly, and K. Finnigan. 2013. "The School District as a Complex Adaptive System: Exploring a Complexity Theory Perspective on Policy Implementation." Invited paper presented at the International Congress on School Effectiveness and Improvement (ICSEI), Santiago, Chile, January 3–6.

Muijs, Daniel, Mel West, and Mel Ainscow. 2010. "Why Network? Theoretical Perspectives on Networking." *School Effectiveness and School Improvement* 21 (1): 5–26. doi:10.1080/09243450903569692.

Nahapiet, Janine, and Sumantra Ghoshal. 1997. "Social Capital, Intellectual Capital and the Creation of Value in Firms." *Academy of Management Review:* 35–39 (April): doi:10.5465/ambpp.1997.4980592.

Pitcher, Patricia, and Anne D. Smith. 2001. "Top Management Team Heterogeneity: Personality, Power, and Proxies." *Organization Science* 12 (1): 1–18.

Poortman, Cindy L., and Kim Schildkamp. 2012. "Alternative Quality Standards in Qualitative Research?" *Quality and Quantity* 46 (6): 1727–1751. doi:10.1007/s11135-011-9555-5.

Portes, Alejandro, and Julia Sensenbrenner. 1993. "Embeddedness and Immigration: Notes on the Social Determinants of Economic Action." *American Journal of Sociology* 98 (6): 1320–1350.

Schildkamp, K., and M. Ehren. 2013. "The Netherlands: From 'Intuition'- to 'Data'-driven Decision Making in Dutch Secondary Schools?" In *Data-Based Decision Making in Education*, edited by K. Schildkamp, M. K. Lai, and L. Earl, 49–67. Dordrecht: Springer.

Schildkamp, Kim, and Wilmad Kuiper. 2010. "Data-Informed Curriculum Reform: Which Data, What Purposes, and Promoting and Hindering Factors." *Teaching and Teacher Education* 26 (3): 482–496. doi:10.1016/j.tate.2009.06.007.

Schildkamp, Kim, Cindy L. Poortman, and Adam Handelzalts. 2016. "Data Teams for School Improvement." *School Effectiveness and School Improvement*: 228–254. doi:10.1080/09243453.2015.1056192.

Stoll, Louise. 2009. "Connecting Learning Communities: Capacity Building for Systemic Change." In *Second International Handbook of Educational Change*, edited by A. Hargreaves, A. Lieberman, M. Fullan, and D. Hopkins, 469–484. Dordrecht: Springer.

Teddlie, Charles, and Abbas Tashakkori. 2008. *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences*. Thousand Oaks, CA: Sage.

Tsai, Wenpin, and Sumantra Ghoshal. 1998. "Social Capital and Value Creation: The Role of Intrafirm Networks." *Academy of Management Journal* 41 (August): 464–476.

Verbeek, Cor, and Linda Odenthal. 2014. "Opbrengstgericht Werken en Onderzoeksmatig Leiderschap in PO en VO." [DBDM and Research Leadership in Primary and Secondary Education.] In *Leidinggeven Aan Onderzoekende Scholen* [Leading Researching Schools], edited by M. Krüger, 67–78. Bussum: Coutinho.

Visscher, Adrie, and Melanie Ehren. 2011. "De Eenvoud en Complexiteit van Opbrengstgericht Werken. Analyse in Opdracht van de Kenniskamer van het Ministerie van Onderwijs, Cultuur en Wetenschap." [The Simplicity and Complexity of Data Based Decision Making. Analysis commisioned by the Dutch Ministry of Education, Culture and Science] Online document, Accessed July 13. http://www.rijksoverheid.nl/documenten-enpublicaties/rapporten/2011/07/13/de-eenvoud-en-complexiteit-van-opbrengstgerichtwerken.html

Wenger, Etienne. 1998. *Communities of Practice*. Cambridge: Cambridge University Press.