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For squad-members only! Why some teachers are more popular to interact with than others in data use

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ABSTRACT

Teacher interactions are seen as a source for teachers' professional development. To better understand this potential, research is needed into who is consulted in data use. Therefore, this study investigates whether Flemish teachers' popularity in data use discussions can be attributed to formal aspects of the formal school organization, similarity among teachers, proximity and informal bonds between teachers. A multi method study combining social network analysis and interview data was designed. The results reveal that informal bonds between teachers may not be overlooked in how interactions are formed. Because the participants do not seem to choose the colleagues they interact with for data use purposefully, the potential of these interactions for their professional development is questionable. Future research should invest in examining how conscious teachers are of the knowledge and skills of their colleagues in data use and how this knowledge affects the formation of data use interactions.

1. Introduction

Data use is a complex practice. Research has shown that the transformation of data into information and knowledge *and* the translation of this knowledge into meaningful decisions requires a wide range of knowledge and skills (Mandinach & Gummer, 2016). Knowing that teachers often get stuck in this complex process, the literature has underlined that collaboration is essential in data use (Hubbard, Datnow, & Pruyn, 2014; Jimerson, 2014; Means, Chen, DeBarger, & Padilla, 2011; Wayman, Midgley, & Stringfield, 2007). The expertise of colleagues is seen as essential to succeed in effective data use. And, teacher interactions are also as a means for teachers' professional development in data use (e.g., in terms of data literacy) (Van Gasse, Vanlommel, Vanhoof, & Van Petegem, 2016).

Recently, the emerging evidence base on data use has taken to investigating teacher interactions (e.g., Hubers, Poortman, Schildkamp, Pieters, & Handelzalts, 2016; Keuning, Van Geel, Visscher, Fox, & Moolenaar, 2016). Data use interactions have been explored in various educational contexts by using and combining diverse research approaches. Throughout, however, similar conclusions that give cause for pessimism regarding teachers' interactive behaviour and learning in data use have been drawn. Firstly, research has shown that the occurrence of data use interactions is fairly limited (Farley-Ripple & Buttram, 2015; Hubers et al., 2016; Keuning et al., 2016). Given teachers' individual struggles in data use, being involved in limited interactions implies that teachers' support in data use is under pressure. Secondly, teachers tend to interact with only a restricted set of colleagues when it comes to data use (Farley-Ripple & Buttram, 2015). Therefore, they are not exposed to a wide range of (data use) knowledge and skills of colleagues. And, finally, *if* interactions occur they are often loose in nature and do not involve high personal engagement, which subverts their potential for teachers' professional learning (Van Gasse, Vanlommel, Vanhoof, & Van Petegem, 2017b; Hubers et al., 2016). All these quite pessimistic findings on data use interactions across different educational contexts imply that more effort is needed to better understand data use interactions. More evidence on the processes and mechanisms underlying data use interactions is urgent in order to grasp their potential for, for instance, teachers' professional development fully.

Despite the fact that efforts are being taken to thoroughly describe *how* teachers interact in data use, a great lacuna remains with regard to *why* those interactions do or do not occur. Studies attempting to explain the occurrence of interactions are scarce and they tend to primarily focus on examining the interaction-seeking behaviour of teachers (e.g., Van Gasse, 2019). However, when it comes to fostering insight into data use interactions and their potential for teachers' professional development, it is crucial to also consider *who is involved*. After all, teachers might

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interact with many of their colleagues, but when these colleagues do not provide them with the necessary insights and skills, the act of interacting in itself will not contribute to their professional development. Therefore, it is essential to explore what drives teachers to interact with certain colleagues rather than others and why some teachers are more popular to interact with in data use than others.

A sound way to gain in-depth insights into the social patterns that occur in teacher networks is to draw on social network analysis (Finnigan & Daly, 2012). The method combines information of the different actors involved in the interactions established. As a result, this method is powerful way to determine which are the more popular actors in data use networks and why this would be.

The general aim of this study is to identify why teachers are consulted by their colleagues for data use purposes. In doing so, we need to look at a number of explanatory factors. In this respect, the literature has proposed four main categories in which influences on interactive behaviour can be classified: organizational aspects, homophily (or the fact that people tend to call on others who are similar to them), informal influences and structural influences (Coburn & Russell, 2008; Hopkins & Spillane, 2014; McPherson, Smith-Levin, & Cook, 2001). Although these different factors may all play a certain part in whom teachers choose to consult for data use purposes, it is essential to also systematically investigate *how* these factors affect teachers' interactive data use behaviour. Consequently, our main research questions are:

1 Which factors explain the extent to which teachers are consulted by colleagues for data use purposes?
2 How do these factors affect teachers' interactive data use behaviour?

2. Theoretical framework

2.1. Data use and data use interactions

The aim of data use is to map processes within schools, to align them to school-wide goals and to analyse data to improve these processes (Schildkamp & Kuiper, 2010).

The concept 'data use' is a somewhat simplistic linguistic merger of 'data' and 'use'. Data are not central in data use. Data use is a complex and sequential process in which data are transformed into information and knowledge (Coburn & Turner, 2011; Marsh, 2012). To do so, different activities need to be taken to interrupt the tendency to jump from data to decisions (Schildkamp, Poortman, & Handelzalts, 2016). Data need to be read and discussed and interpreted correctly. Subsequently, potential causes and explanations are hypothesized and checked through analysis and diagnosis. The aim is to end with formulating appropriate improvement actions (Van Gasse et al., 2017b; Mandinach & Gummer, 2016; Marsh, 2012). However this sequence appears straightforward in outline, the literature has repeatedly shown that in practice complexity arises because the sequence of activities is often interrupted or teachers return to previous phases (Marsh & Farrell, 2015).

The above described sequence includes numerous potential pitfalls for teachers. For example in the interpretation of data or in diagnosing problems (Datnow & Hubbard, 2016). Therefore, teacher interactions are considered as essential for effective data use processes. The interpersonal connections in collaborative data use bear, for example, potential for data use support, the construction of shared ideas, the transfer of knowledge and skills, and for building new knowledge (Bertrand & Marsh, 2015; Hubers et al., 2016; Keuning et al., 2016). Therefore, the conviction has grown that teacher interactions provide a supportive environment in which individual data use struggles can be overcome (Bertrand & Marsh, 2015; Hubers et al., 2016). Moreover, interaction in the context of data use has been identified as conducive to a professional learning environment for teachers (Van Gasse et al., 2016).

When it comes to interactions in data use, they cannot be considered isolated activities. In fact, how teachers interact with others for data use purposes is quite similar to their regular professional interactive behaviour (Farley-Ripple & Buttram, 2015). This does not need to be surprising, since data use activities relate to the core of improving teaching and learning in teachers' classroom practice. Therefore, when examining teachers' data use interactions, their day-to-day social context needs to be taken into account. This implies that we need to pursue an image that is as complete as possible when our aim is to determine why certain teachers are more popular for data use activities.

Studies investigating teacher interactions have exposed a wide range of factors that influence teachers' interactive behaviour. In order to describe teachers' day-to-day social context, we need to take into account these different factors as good as possible. Four categories can be used to classify the diverse range of factors influencing teachers' interactive behaviour: (1) the formal school organization (e.g. Hopkins & Spillane, 2014), (2) homophily (McPherson et al., 2001), (3) structural elements in social relations, and (4) informal influences (e.g. Coburn & Russell, 2008). These will be explained further below.

2.2. Factors affecting who is consulted in interactions

2.2.1. The formal school organization

Within the formal school organization, two types of influences can be distinguished. The first one is the formal position of actors in the network, or their formal role. In this regard, the impact of formal leadership is often mentioned as influencing the position of actors in networks (Hopkins & Spillane, 2014; Spillane, 2005). For instance, it is likely that school leaders or teacher leaders are more often consulted by colleagues because they have more or greater formal responsibilities in the network. Also in the data use literature, leadership is often emphasized as an influencing factor (e.g. Chen, Heritage, & Lee, 2005; Datnow, Park, & Wohlstetter, 2007). However, the impact of (teacher) leadership as a formal characteristic on the informal network position of data users in teams has been hardly described. Nevertheless, depending on the culture formal leaders foster, they may be more or less popular to interact with on an informal basis (Daly, 2012). And this last aspect is highly determines which information or knowledge is (not) shared in data use teams.

The second aspect that comes to the front as influencing the extent to which educators are consulted in networks are formal groupings. Informal connections that are established often relate to being involved in the same formal groupings in the school (Daly, Moolenaar, Bolivar, & Burke, 2010; Meredith, Van den Noortgate, Struyve, Gielen, & Kyndt, 2017). A frequently recurring example is that of grade-level teams. Teachers are more likely to connect with colleagues with whom they share grade-level team membership (Coburn & Russell, 2008; Spillane, Kim, & Frank, 2012). Grade-level teams are not the only formal groupings that influence informal connections between teachers. Cross-grade teams, formed for example around a certain course or subject, can affect teachers' interactive behaviour outside of these groupings as well (Spillane & Hopkins, 2013). Although data use is often implemented through formal groupings or formal roles (e.g., Cosner, 2011; Schildkamp, Poortman & Handelzats, 2016), there remains a gap in the literature regarding to how formal groupings affect informal interactions between teachers. This knowledge is, however, vital in the context of data use. For example because the sustainability of (formal) data use interventions or the success of formal roles in data use depend on how teachers interact informally (Hubers, Moolenaar, Schildkamp, Daly, Handelzalts, & Pieters, 2017).

Despite that aspects of the formal school organization affect teachers' interactive behaviour, there is consensus in the literature that formal structures do not fully explain the patterns of interactions among teachers (Penuel, Riel, Joshi, Pearlman, Kim, & Frank, 2010; Spillane, 2005). For example, research by Spillane (2005) shows that other teachers can be more central players in networks than those who were given the formal 'expert' role. With regard to formal groupings, research has showed that the number of informal interactions between

grade-level team members may be quite limited (e.g., Van Gasse et al., 2017b). Therefore, other aspects might be even more important to explain why educators share ties; think of, for example, informal cultures (Penuel et al., 2010).

2.2.2. Homophily

The concept of homophily is built around the fact that people have a general tendency to connect to 'similar others': other people who are similar to them because they, for instance, share certain characteristics (McPherson et al., 2001; Moolenaar, Sleegers, Karsten, & Daly, 2012). Several researchers have found this tendency in teacher interactions as well (e.g., Penuel, Riel, Krause, & Frank, 2009; Spillane, Hopkins, & Sweet, 2015). In some cases, homophily relates to formal aspects of the school organization (Spillane et al., 2015). Teaching in the same grade or teaching the same course or subject, for example, are homophily aspects that pertain to how the school is structured or organized. Characteristics independent of the formal school organization may cause homophily relations between teachers as well. Spillane et al. (2012) concluded, for example, that teachers who are similar in terms of gender or race are more likely to interact with each other. In addition, non-visible characteristics such as shared beliefs, attitudes or identities have also been found to affect teacher interactions (McPherson et al., 2001; Penuel et al., 2009).

With regard to data use interactions, whether teachers are more likely to connect with similar others has hardly been investigated. To our knowledge, only one study has attempted to expose homophily connections in data use and explored homophily based on non-visible characteristics of teachers, namely their level of self-efficacy and attitude in data use (Van Gasse, 2019). The study did not find significant effects of homophily based on these data use related characteristics. However, homophily in data use interactions based on structural aspects of the school organization or based on other non-visible teacher characteristics has not yet been the subject of investigation. Given that teachers' data use interactions cannot be considered independent from their regular professional interactions (Farley-Ripple & Buttram, 2015), it is essential to take into account homophily when explaining data use interactions.

2.2.3. Structural elements

Another important factor that may explain why interactions between teachers do or do not occur are structural elements of the school environment. As opposed to formal roles or positions, structural elements are more tangible as they refer to situations that occur when the school organization is put into practice. Therefore, instead of being a priori organized, structural elements are consequences of how the school is organized.

Quite central in social relations is the concept of proximity. Proximity implies that people are more likely to be connected to others when they are physically or temporally close to them (Coburn & Russell, 2008). For example, Spillane et al. (2012) found that teaching in adjacent classrooms or moving between buildings between classes according to the same flow facilitate teacher interactions.

Different studies in data use show that informal data use interactions in teacher teams are few (Farley-Ripple & Buttram, 2015; Keuning et al., 2016). Moreover, diffusion of knowledge from formal groupings to other colleagues is limited (Hubers et al., 2017). Knowing that teachers' informal data use interactions often happen ad hoc (Van Gasse, Vanhoof, & Van Petegem, 2017a), implies that structural elements in the school may affect teachers' data use interactions. However, up to now it remains quite unclear to what extent this is the case.

2.2.4. Informal influences

To a certain extent, the occurrence or absence of interactions between teachers in schools can be explained by the factors already discussed. Nevertheless, only looking at these aspects does not do justice to the social reality in schools. A lot of what plays a role in teacher networks relates to implicit social processes of schooling (Penuel et al., 2010). The presence or absence of trust, for instance, plays a part in the decision whether or not to interact with a colleague (Coburn & Russell, 2008; Penuel et al., 2010). Moreover, being acquainted due to prior professional encounters, or sharing a history at the same school have been found to facilitate teacher interactions (Coburn & Russell, 2008). This illustrates that getting to know colleagues and creating collegial bonds is important in teacher interactions (Penuel et al., 2010).

Also in data use, it is likely that informal bonds between teachers play a role for their interactive behaviour. Connecting to colleagues in data use implies that teachers are willing to de-privatise their classroom practice by sharing, analysing and solving educational problems they experience. Therefore, when it comes to informal data use interactions, or the connections of formal data use groupings to colleagues, teachers' may be more likely to interact with the colleagues they feel safe with (Van Gasse, 2018). Also data use expertise of colleagues may be an important factor to interact with them. This implies that insight into the implicit social processes between teachers is needed in order to fully grasp why some teachers are more popular to interact with than others in data use.

2.2.5. Social network theory

The potential for data use in teacher teams depends on the combination of knowledge and expertise of all actors involved. Relations between teachers define the social capital of the network. To investigate why data use interactions do or do not occur, we draw on social network theory. The underlying assumption of this theory is that the position of actors within a network determines their access to, for example, (data use) knowledge, strategies or skills (Finnigan & Daly, 2012).

In social network theory, the basic idea is that inter-actions are shaped by the behaviour of the two actors involved. For example, teacher A may ask teacher B for advice. In this case, teacher A sends a connection (or a tie) to teacher B. This is what is called a sent tie. The total of sent ties per actor is reflected in the 'outdegree' measure. In reverse, teacher B may also ask advice from teacher A (or send him/her a connection). From teacher A's perspective, this is a received tie. The 'indegree' measure represents the total of received ties per actor. If both teachers ask each other advice, and both are therefore sending and receiving ties to and from each other, reciprocated ties are established (Borgatti, Everett, & Johnson, 2013). Although the characteristics are illustrated here by way of advice ties, social network studies report about a wide range of interaction topics (e.g., friendship ties, information ties, general professional ties) (Daly et al., 2010; Moolenaar, Sleegers, Karsten, & Daly, 2012).

Because this study aims to reveal what makes teachers popular to interact with in data use, we will be mainly focusing on the received ties in social networks. This implies that the indegree measure will be central to this study. In models that try to explain indegree measures (for example by examining formal roles), *receiver effects* are typically included (Sweet, 2016). However, in some cases characteristics of the receiver alone, do not provide the full image of a certain situation. This is due to the fact that people often connect to similar others (i.e., homophily). Thus, in some cases we will be looking for information on the (dis)similarity of teachers who interact with each other. This type of information can be provided by *homophily effects* (Sweet, 2016).

3. Method

This study will complement social network analysis with interview data in order to do justice to the complex reality of teachers' interactive behaviour in data use. We intend to pinpoint factors that influence teachers' positions in a network (i.e., the first research question). Subsequently, in-depth interview information exploring teachers' drivers to seek out (certain) colleagues will deepen our understanding of explanatory factors for data use interactions (i.e., the second research question). The combination of both methods is crucial to fully grasp why

teachers seek out certain colleagues in data use. Before elaborating on the combination of both methods, we will first briefly describe the research context of this study.

3.1. Research context

The study was carried out in Flanders, the Dutch speaking part of Belgium. In Flanders, schools have autonomy over how they achieve the required educational standards (Penninckx, Vanhoof, & Van Petegem, 2011). The government does not impose central exams (OECD, 2014). As a consequence, Flanders does not have a strong tradition in data use compared to countries that make more use of standardized testing (e.g., the Netherlands, United States, United Kingdom). In practice, Flemish schools and teachers often primarily rely on their own data sources (e.g., tests, assignments, observations or portfolios) for data use purposes.

In this study, we will report on teachers' networks for discussing pupil learning outcome data. These data are informative for teachers to improve their practices and to evaluate whether or not pupils meet the Flemish standards at the end of secondary education. Pupil learning outcome data include cognitive outcomes (i.e., linguistic and arithmetic skills) as well as non-cognitive outcomes (i.e., attitudes, and artistic and physical education). These data can be both quantitative (e.g., class tests) and qualitative (e.g., observations). This conceptualisation of 'data' is broader than often used definitions which refer solely to cognitive output indicators (Schildkamp, Ehren, & Lai, 2012).

The participating schools and teachers were selected in the context of a project on the assessment of competences (comproved.com). In each school, the target population were all teachers of the pupil group that participated in an assessment of writing competences in the aforementioned project, i.e., the fifth grade of a secondary academic track in economics and languages (16-to 17-year-olds). In Flanders, teachers teaching the same grade are required to discuss their pupils' progress at a formal team meeting two or three times during the school year. As such, they form temporary interdisciplinary groupings with a collective responsibility for pupils' learning. At the last team meeting of the year, the team members deliberate over whether or not pupils will successfully complete their year by passing the grade.

3.2. Social network data

3.2.1. Participants

Six out of ten participating teams in the larger project were selected to participate in this study. The main selection criterion was heterogeneity in the geographical location of the schools in Flanders. One of the teams did not achieve a sufficiently high response rate for the social network analysis (for social network analysis, an 80 % response rate is the minimum). For another team, information was missing about teacher leadership, which was crucial in light of the research questions. Both teams were excluded from the analysis. All other teams reached a 100 % response rate, which was optimal for the intended social network analyses. The high response rate in the teams allow for accurate conclusions to be drawn about how the social position of teachers can be explained within the team context.

All teams consisted of 11 teachers. Across the teams, 440 data points ensure that some general tendencies can be revealed regarding teachers' informal data use networks.

3.2.2. Instrument

Data were collected by means of an online survey. The survey started with some general questions (e.g., gender, subject taught) and continued with two types of questions regarding teachers' data use interactions.

The questionnaire distinguished between formal interactions (i.e., the team meetings to discuss and evaluate pupils' learning outcomes, as described above) and informal interactions. These informal interactions could include any interaction that did not occur in the context of formal team meetings; from superficial information exchange to in-depth analysis of pupil results. The analyses of the current study only concerned the informal interactions, which were mapped by social network questions. For each step in the data use procedure we used in this study (i.e., discuss, interpret, diagnose, take action), a social network question was included in the questionnaire (e.g., 'Which of the following colleagues do you consult in order to discuss pupil learning outcome data?'). Subsequently, all members of the teacher team were listed.

For this study, we analyzed the data discussion networks within teams. The Quadric Assignment Procedure (QAP) correlations revealed high similarity in teams' networks across the different steps in the data use procedure. Additional analyses already showed that teachers do not tend to consult different colleagues across the different data use phases, but rather consult a smaller number of colleagues more intensely (Van Gasse et al., 2017b). Therefore, we decided to focus on the most active networks (i.e., data discussion networks) as they bear the most potential for explaining why teachers are consulted in data use.

3.2.3. Analyses and model specification

As a preliminary step in the analyses we calculated descriptive network statistics at team level. First, we calculated teachers' indegree measures, or the extent of incoming relations, and aggregated them to average indegree per team. This shed light on how often teachers are consulted on average for data use discussion within the teams. Second, we calculated the indegree range per team in order to determine variation between teachers in the teams. Additionally, we calculated the overall centralization measure of the teams. Centralization reflects the extent to which relations in networks are directed to one or a few central teachers. The combination of these descriptive statistics provided insight into the differences between teachers within and across teams regarding the extent to which they are consulted for data use discussion. All descriptive statistics were calculated using the 'sna' package in R (Handcock, Hunter, Butts, Goodreau, & Morris, 2016).

The first research question was explored by using Exponential Random Graph Modelling (ERGM). ERGM enables researchers to analyse and explain specific relations in social networks. It predicts the presence of particular relations in the network and can, as such, be used to assess the predictive value of aspects of the formal school organization for teachers' informal data use interactions. ERGM takes into account that specific relations are always related to global network structures. Therefore, ERGM accounts for the multilevel effect that occurs when using the level of relationships (within teachers within teams) as the unit of analysis. We used Statnet's R-based ERGM package for the analyses (Handcock et al., 2016).

When using ERGM, models are specified per network. Therefore, we proposed an identical explanatory model to test across the four data discussion networks (i.e., one per team). In this model, three types of effects were included to evaluate the effects of formal aspects within schools on informal team behaviour. Two of those were receiver effects. Receiver effects mean that the model will analyse whether teachers with certain characteristics are more likely to receive relations in the network, or to *be consulted* by colleagues. The model we defined included receiver effects for teacher leadership (i.e., to what extent are teacher leaders likely to be consulted for data use discussion?) and for teachers' volume of appointment in the fifth grade of the economics and languages track in secondary education (i.e., to what extent are teachers who have more contact hours with the specific pupil group more likely to be consulted for data use discussion?). Teacher leaders were defined as the teacher carrying the end responsibility for the specific pupil group. For teachers' volume of appointment, two categories were distinguished: (1) teaching the pupil group less than three hours per week, or (2) more than three hours per week. This distinction was made because participants distinguished between less and more important subjects based on their volume in the curriculum (i.e., in which the benchmark was at three hours per week). Next to two receiver effects, we included one homophily effect in the model. Homophily effects propose that teachers with similar characteristics are more likely to

being connected to each other. In our model, we defined a homophily effect for categories of the subject taught, in which we analysed whether mathematics/sciences teachers, language teachers, or teachers teaching other subjects are more likely to be connected to each other.

For each ERGM analysis, the explanatory model was compared to the baseline model by means of the Akaike Information Criterion (AIC). This method was used to evaluate whether informal data use interactions were better explained by the proposed model than by chance. To evaluate overall effects across teams' discussion networks, a meta-analysis was conducted by using the 'metafor' package in R (Viechtbauer, 2010).

3.3. Qualitative data

3.3.1. Participants

Over the four teams that participated for the social network analyses, 10 teachers were interviewed in total. In every team, three teachers were randomly asked to participate. Due to drop-out in teams Riverbank and Melrose, only two teachers participated. The other teams were represented by three teachers. Participation of all teachers was voluntary. They were selected independent of their network position, in order to achieve sufficient heterogeneity in the motives for choosing (certain) colleagues to interact with in data use.

The 10 teachers varied in gender (five were male, five were female), teaching experience (ranging from 6 to 23 years) and subject taught in the fifth grade of the economics and languages track in secondary education (Dutch, English, German, French and history). Table 1 provides an overview of the teachers that participated in the interviews.

3.3.2. Interviews and coding

The semi-structured interviews were used to investigate the second research question (i.e., How do the formal school organization, homophily, informal influences and structural elements affect teachers' interactive data use behaviour?). Participants' answers to the social network questions described earlier, formed the starting point of our interviews. We provided the teachers with an overview of the colleagues they indicated they consulted. Then we asked them why they were closer to these colleagues than to others when it came to data use. The interviews also included questions about teachers' learning activities and professional learning outcomes based on their data use interactions. However, our analysis in this study is focused on why teachers consult certain colleagues for data use interactions.

The interviews had an average duration of 45 min and were transcribed ad verbatim. These transcriptions were coded using Nvivo 12 software.

The coding process consisted of several steps. First, teachers' motives to consult colleagues for data use were coded by keeping close to the narratives (open coding) (Pandit, 1996). Subsequently, if possible, these codes were attributed to the four categories of potential influencers of teacher interactions that were found in the literature (axial coding) (Strauss & Corbin, 2008): aspects of the formal school organization, homophily, informal influences and structural elements in the school environment. During the axial coding process the need arose to create an additional axial code because the open coding revealed that some teachers mentioned aspects of heterophily (e.g., teaching a different grade or having a different perspective on teaching). Table 2 provides an overview of the axial coding scheme, with a description on how the different codes were conceptualized for the investigation of the inter-rater reliability. Additionally, this table provides some examples of coded fragments.

To ensure the quality of the coding, a second researcher was involved in the axial coding. Two interviews were randomly selected and coded by both researchers. The researchers agreed on double coding when quotations could be related to multiple axial codes as the coding process revealed interrelations between some of the codes. Subsequently, the inter-rater reliability was calculated at the level of the axial codes. This resulted in a substantial Cohen's kappa of 0.75 (Sim & Wright, 2005). The main recurring differences in the coding of both researchers was due to overlap between the 'aspects of the formal school organization' and 'homophily' in the second researcher's coding. The first researcher finished the coding of the eight remaining interviews independently.

3.3.3. Analyses

In the network analyses, we analysed all relations in the networks statistically (i.e., whole network approach). The analyses of the interviews go deeper into the specific interactions of certain actors within these networks, what is called an ego network approach. The combination of both types of analyses provides insight into teacher interactions from different angles of incidence. In the interview analyses, we binarized the qualitative data coding for each participant. Score 1 was given to a participant if the code was present in the interview, score

Table 1
Interview participants.

Team	Participant	Gender	Teaching experience (in years)	Subject(s) taught
Riverbank	Peter	Male	13	Dutch
	John	Male	13	German
Northvale	Kristen	Female	6	History
	Chandler	Male	–	Dutch
	Monica	Female	–	French
Melrose	Ross	Male	16	History
	Joey	Male	8	English
Colby	Rachel	Female	23	English
	Phoebe	Female	18	Dutch
	Susan	Female	15	German

Table 2
Axial coding and conceptual description.

Axial Code	Conceptual description
Aspects of the formal school organization	Formal aspects of schooling that affect teachers' interaction seeking: e.g., knowing colleagues from subject groupings, teaching the same grade, or formal roles (Coburn & Russell, 2008; Hopkins & Spillane, 2014; Spillane et al., 2015). *Coded example* *Kevin teaches English languages parallel in another pupil group in the same grade. So we often talk about specific pupils or problems.*
Homophily	A phenomenon that people interact with similar others: e.g., race or gender, but also similar ideas, attitude or identity (Penuel et al., 2009). *Coded example* *John is my colleague for German languages. But he is a completely different person actually. With him I have little… He does different things and is very demanding for his pupils. He does come over often to tell me something about a pupil, but it's not that I can have a decent conversation with him.*
Informal influences	Non-organizational nor homophily reasons for interacting: e.g., personal bonds, shared responsibilities or knowing someone from the past (Coburn & Russell, 2008; Penuel et al., 2010). *Coded example:* *Those are people I feel comfortable with, who I will go and visit when they have given birth or something.*
Structural elements	Mainly proximity: e.g., teaching in classes next to each other, meeting in the hallways or the staff room, … *Coded example:* *I see Mary often in between hours. And often we have a conversation about certain pupils. Definitely.*
Heterophily	Being different to certain colleagues *Coded example:* *When filling in the survey, I realised I interact less with younger or newer colleagues. Honestly, I don't know why.*

0 if not. Binarization is a robust technique to obtain insight into the appearance of phenomena across or within participants (Onwuegbuzie, 2003). The advantage of binarizing relative to counting citations is that it neutralizes the personal differences between participants (e.g., talkative versus introverted participants). Subsequently, we conducted a cross-case analysis of the interviews.

4. Results

4.1. Explaining teachers' popularity in data use

To explain teachers' popularity in data use networks, we will first take a closer look at the descriptive statistics of the four teacher networks that were studied. These can be found in Table 3.

Each teacher team consists of 11 teachers, which implies that the maximum of incoming relations or ties per teacher is 10. The number of established incoming relations is reflected in the indegree measure. In other words, higher indegree measures indicate more popular teachers for data use interactions. Normalized indegree statistics reflect the raw indegree and potential indegree ratio. These scores range between 0 (when not a single incoming connection is received) and 1 (when a teacher is consulted by all of his colleagues for data use). Therefore, the normalized statistic 'indegree range' tells us something about the distribution of indegree measures within the teams.

The average indegree per team indicates that, overall, less than half of the potential incoming relations are realized per teacher. In addition, across the teams, there is quite some indegree variation among teachers. In team Riverbank, for example, the average indegree is the highest, with four to five incoming relations per teacher. Nevertheless, the indegree range indicates that some teachers do not receive any incoming relation from their colleagues, while others receive up to 7 (or 70 % of the possible ties).

A similar – and even more pronounced – picture is found in the descriptive statistics of teams Northvale and Colby. In those teams, the average indegree measures are lower than in Riverbank (i.e., Av. = 3.09 in team Northvale and Av. = 3.64 in team Colby). Teachers in those teams generally receive about three incoming relations of colleagues for data use. At the same time, the indegree range is large (i.e., normalized indegree ranging from 0.1 to 0.7 in team Northvale and from 0.1 to 0.8 in team Colby). This implies that there is larger variation in indegree measures in these teams. Or, in other words, that some teachers are clearly more popular colleagues to interact with in data use than others.

Team Melrose somewhat distinguishes itself from the other teams when it comes to the network statistics. First, the average indegree is the lowest (Av. = 2.00). Teachers are generally consulted by only two of their colleagues for data use. In addition to that, the normalized indegree range is the smallest (range from 0 to 0.4). This implies that there is limited variation between teachers' indegree in team Melrose.

Next to the average indegree and indegree range, Table 3 provides two general network statistics: density and centralization. Density is the ratio of the number of interactions and the number of possible interactions in teams. When, for example, 10 interactions are possible and 8 interactions are present, the density measure is 0.80, which indicates that 80 % of the possible interactions are accomplished. Overall, Table 3 shows rather low density measures across the teams, ranging from 0.20 (team Melrose), to 0.45 (team Riverbank).

Centralization reflects the extent to which teachers in networks all turn to one or a few colleagues. For example, if all interactions in a team are directed to one teacher (e.g., an expert in data use), the centralization value will be 1 (i.e., 100 % of the interactions are directed to one teacher). Table 3 reveals that particularly the data discussion network of team Northvale is highly centralized (with a centralization measure of 0.84), which implies that a few actors are particularly popular in this network. In the other teams, the centralization measure ranges between 0.41 (team Colby) and 0.49 (team Melrose). This indicates that less than half of the established relations are directed at one or a few teachers.

Table 4 shows the results of the ERGM analyses. In these analyses, the indegree measures of teachers are explained by their teacher leadership status and their volume of appointment in the specific pupil group. In addition, a homophily effect of subject taught is included, which indicates whether teachers are more likely to be connected to colleagues teaching similar subjects.

The AIC measures of the ERGM analyses show that the baseline model is a better fit for the networks of team Northvale and team Melrose than the model including the aforementioned effects (Northvale: AIC of 138 in the baseline model and 139.1 in the explanatory model. Melrose: AIC of 112.1 in the baselinemodel and 114.3 in the explanatory model). This implies that data use interactions in those teams can be better explained by chance than by the proposed theory. In teams Riverbank and Colby the AIC measure of the explanatory model is better than the baseline model.

The ERGM analyses reveal that the formal school organization (i.e., teacher leadership, the volume of appointment or subject homophily) has a limited effect on informal data use interactions in some teams. The only significant effects found are situated in team Riverbank and team Colby. In team Riverbank, teachers' incoming relations (or indegree measures) in data use can be explained to a certain extent by their volume of appointment in the pupil group. Here, teachers who have a larger number of teaching hours in the specific pupil group under study are more likely to receive ties from colleagues. In none of the other teams was this effect significant. In team Colby, teacher leadership is explanatory for teachers' indegree. In this team, the teacher leader is more likely to be consulted for data use. However, this effect was again not significant in the other teams. Finally, teaching similar subjects does not explain the established relations in any of the teams.

Although scarce significant effects of the formal school organization on teachers' data use interactions are found, two effects in the meta-analysis are on the verge of being significant. Across the teams, being a teacher leader is related to higher indegree measures. Also, having more teaching hours in the pupil group appears to be related to being consulted more often with regard to data use. Therefore, although the ERGM analyses within teams do not clearly confirm the effect of aspects of the formal school organization on teachers' popularity in data use, the meta-analysis does not reject these relations either on a general level. We conclude that, aside from aspects of the formal school organization, there might be other, potentially more important factors that explain

Table 3
Descriptive statistics of the four teacher networks.

	Riverbank	Northvale	Melrose	Colby
Average Indegree	4.45	3.09	2.00	3.64
Indegree range (normalized)	0–0.7	0.1–0.7	0–0.4	0.1–0.8
Density	0.45	0.31	0.20	0.36
Centralization	0.43	0.84	0.49	0.41

Table 4
Results of the ERGM-analysis.

	Intercept	Teacher leadership status	Volume of appointment	Subject homophily
	Est. (s.e.)	Est. (s.e.)	Est. (s.e.)	Est. (s.e.)
Riverbank	−2.03 (0.71)**	0.41 (0.57)	1.16 (0.45)**	−0.31(0.46)
Northvale	−0.91 (0.72)	0.18 (0.74)	0.25 (0.45)	−0.92 (0.49)
Melrose	−1.88 (0.44)***	0.73 (0.76)	0.37 (0.32)	0.01 (0.63)
Colby	−1.81 (0.74)*	1.80 (0.84)*	0.74 (0.44)	−0.23 (0.46)
Meta-analysis		0.72 (0.42)	0.61 (0.32)	−0.38 (0.35)

*p < 0.05, **p < 0.01, ***p < 0.001.

why some teachers are more popular for data use discussion than others.

4.2. Why teachers interact with colleagues in data use

In what is next, we will present the results regarding research question 2, i.e., why teachers interact with colleagues in data use. In order to answer this research question, we conducted cross-case analysis on the interview data. First, we will describe the results of the cross-case analysis as a general overview of important and less important drivers for teachers' data use interactions.

4.3. Cross-case analysis

Table 5 provides an overview of the binarization of the interview coding. We only included codes for elements that were mentioned by more than one teacher. A first finding is that all categories that were theoretically distinguished (i.e., aspects of the formal school organization, homophily, informal influences and structural elements) were reported by the interview participants. Moreover, an extra category was added due to participants naming aspects of heterophily as causes for why they seek out colleagues in data use.

When teachers attributed their data use interactions to *formal aspects of the school organization*, the formal position of colleagues was the most frequently recurring reason for connecting to colleagues. Most of these interview fragments were about addressing the teacher leader of the specific pupil group about poor pupil results for their class. The participating teachers see the teacher leader as the most important person to inform about issues with pupils. Therefore, according to them, teacher leaders are the first in line to get involved in interactions regarding the use of pupil learning outcome data.

> "*Automatically you have more contact with teacher leaders of the pupil groups. That's evident." (Phoebe about the influence of formal roles*)
> *"Chandler is the first person I will talk to in case of problems. He is the teacher leader of this pupil group." (Monica about the influence of formal roles)*

Additionally, being part of the same formal groupings appeared to be an incentive for teachers to connect with those colleagues over data use. A common example of such formal groupings that facilitated informal data use interactions were subject-based groupings (e.g., all teachers who teach foreign languages). Other examples were scarce. With regard to formal aspects of the school organization, a few teachers (i.e., three) also mentioned that the volume of appointment of colleagues in the specific pupil group influenced the extent to which they consulted them for data use interactions. In these examples, colleagues teaching subjects involving more teaching hours per week (e.g., mathematics or economics) were more popular to discuss pupil learning outcome data with.

The interview data also show that teachers tend to flock together with colleagues who are similar to them. Aspects of *homophily* were mentioned by nine out of ten participants as reasons why they head to particular colleagues for data use. Homophily was reported in terms of grade (i.e., teaching in the same grades as the specific colleague) and in terms of a shared perspective on teaching and learning (e.g., wanting to be an "emphatic" teacher versus a very "severe" one or valuing traditional "cognitive" education versus believing in "learner-centred" education). Nevertheless, the most common homophily aspect that was brought up, was subject homophily). Language teachers in particular mentioned that they often head to other language teachers in order to discuss their pupils' learning outcomes. However, from the narratives of participants we can deduce that subject homophily is important, though not necessarily decisive for data use interactions. The following citations of Peter and Monica illustrate that differences in perspectives on teaching and learning, personal bonds and structural elements in the school can be more important to establish data use interactions than subject homophily.

> *"John is my colleague for German. But he is a completely different person actually. With him I have little… He does different things and is very demanding for his pupils. He does come over often to tell me something about a pupil, but it's not that I can have a decent conversation with him." (Peter about homophily in terms of perspectives on teaching)*
> *"It's a subject-related thing. It's language-related, because, yeah, they all teach languages. […] Now with Tom it can be a structural issue. He teaches German, but I almost don't see him apart from the team meetings to discuss learning outcomes. […] And Walter teaches English. But that's a personal issue." (Monica about homophily in terms of subject)*

Informal influences take up a reasonable share in the reasons teachers report to consult certain colleagues for data use interactions. The most reported facilitator for data use interactions are collegial bonds. In most of the narratives, this implies that teachers have a certain sympathy for the colleague they consult. For example, some participants view the closest colleagues in their data use networks as "friends". Those are the colleagues with whom they are willing to grab a drink with when school is out or whom they will visit at special occasions (e.g., a new baby). For example, Joey indicated how personal bonds are important to create a safe environment for feedback and the citation of Peter illustrates that personal conversations may end in conversations about pupil-related problems as well.

> *"I get more often in touch with people I feel comfortable with, someone who knows me well enough to give me relevant feedback."* (Joey about collegial bonds)

Table 5
Results of the cross-case analysis (binarization).

	Peter	John	Kristen	Chandler	Monica	Ross	Joey	Rachel	Phoebe	Susan
Formal school organization										
Position	1	1	0	1	1	1	1	1	1	1
Grouping	1	1	0	1	1	0	1	1	1	0
Volume of appointment	0	1	0	0	0	0	0	0	1	1
Homophily										
Subject	1	1	1	1	1	0	1	1	1	1
Perspective	0	1	1	1	0	0	0	0	0	0
Grade	0	0	0	0	0	0	0	1	1	0
Informal influences										
Collegial bond	1	1	1	1	0	1	0	1	1	1
Experience alter	0	0	1	1	0	1	0	0	1	1
Behaviour alter	1	0	0	0	0	0	0	0	1	1
Structural elements										
Teacher's room	1	1	1	0	1	1	0	1	0	1
Proximity in time and space	1	0	1	0	0	1	0	0	1	1
Heterophily										
Grade	0	0	1	1	0	0	1	0	1	0

"Kevin is a colleague in foreign languages, but he's also a good friend of mine. And because we often talk to each other, student-related problems come to surface more often; how you deal with certain problems or your didactic approach." (Peter about collegial bonds)

Other informal influences that were reported by teachers were related to the experience and the behaviour of the colleagues they interacted with. For example, the stories of five teachers showed that they head to colleagues to discuss pupil learning outcome data when they considered these colleagues as being particularly skilled or experienced. The examples participants gave of such valued experience are diverse: didactic expertise, knowing the pupils well, general experience on "what works" in class or general pedagogical skills. The participants that reported these types of knowledge and skills all considered them as helpful for their use of pupil learning outcome data. Remarkable in this regard was that data use expertise was not explicitly mentioned by the teachers. Next to experience, three teachers indicated that colleagues' behaviour influenced whether or not others involved them in data use interactions. According to these teachers, they connect more with colleagues who take initiatives to interact themselves than to colleagues who seem more solitary.

The interview data also shows that *structural elements* in the school do facilitate data use interactions. The main elements in this regard are the common room and proximity in time and space. The majority of the participants indicated that the teacher's room is the main place in which informal data use interactions take place. Therefore, in the case of colleagues whom they do not meet in the teacher's room, this can be a hindrance for their interaction on data use. But proximity in time and space is also brought up. According to teachers, free periods together, meeting each other in the hallways or teaching consecutive hours in the same classroom lead to informal contacts. And these contacts can also involve (quick) discussions of pupil learning outcome data. Although teachers mention these structural elements as facilitating data use interactions, the interview data do not make entirely clear how decisive these elements are for data use interactions. For example, in the following citation John indicates that his data use interactions do not depend on them.

"Those differences in whom you consult, can they sometimes be attributed to structural elements within the school? For example teaching in the classroom next door or something like that?
No, for me absolutely not. No, because yesterday I had a question for Mathilda. I didn't see her yesterday so I just called her in the evening. And she told me that she couldn't answer my call, but that she would call me back at ten o'clock. I can call her quite late in the evening actually…" (John about structural elements)

Finally, the cross-case analysis reveals that teachers report an extra category in their drivers to consult colleagues for data use interactions than those that were derived from theory. Although homophily aspects are reported by the majority of interview participants, some of them indicate that they consult colleagues because they differ (i.e., heterophily). The main recurring aspect here is grade heterophily. Particularly in the use of pupil learning outcome data, teachers say they sometimes want to consult the perspective of teachers knowing the pupils from previous school years. In these cases, they head to colleagues who are similar in the subject they taught to the pupils (e.g., language teachers head to other language teachers), but who teach in different grades.

5. Discussion and conclusion

The importance of data use interactions is often stressed because of their potential for teachers' professional development. These interactions are seen as a means for teachers to tackle a lack of competences and skills to use data adequately for instructional improvement (Means et al., 2011). However, up to now research has drawn up a rather pessimistic state of the art regarding teacher learning in data use interactions (Van Gasse et al., 2016). Therefore, it is crucial we gain more insight into teachers' drivers to consult certain colleagues in data use. Social network analysis (i.e., ERGM-modelling) within four teacher teams and interview data of 10 teachers part of those teams provided insight into the following research questions:

1 Which factors do or do not explain the extent to which teachers are consulted by colleagues for data use purposes?
2 How do these factors affect teachers' interactive data use behaviour?

Both the ERGM-analysis and the interview data show that it is difficult to attribute the extent to which teachers are consulted in data use solely to formal aspects of the school organization. While most interviewed teachers attribute their data use connections to such formal aspects (e.g., being a teacher leader), the ERGM-analysis shows that in only one team the teacher leader is addressed significantly more often. Also, the volume of appointment only plays a significant role in one team. Therefore, other processes may play a more important role.

Considering those 'other' potential influences, the informal processes within teams might be an important factor in teachers' data use interactions. Although all theoretically distinguished influences were identified in the interview data (i.e., homophily, structural elements in the school and informal influences), informal influences were infiltrating in most of the interviews. Subject homophily was, for example, often mentioned in the interviews but turned out not to be a significant factor in the ERGM-analysis. Structural elements (e.g., teaching consecutive hours) were mentioned, but in none of the interviews were they the most prominent influence. In contrast, informal influences, such as collegial bonds, were mentioned in most of the interviews. Moreover, these influences sometimes subverted the rationale of teachers for (not) consulting colleagues. Thus, according to the interviewed teachers, informal bonds need to be present for formal aspects of the school organization and aspects of homophily to affect data use interactions.

That informal influences are emphasized for influencing how data use interactions are established does not automatically imply that interactions might not be effective. The interview data showed that informal influences also covered consulting colleagues for their expertise and experience. Thus, teachers might seek to interact with someone they consider as an 'expert' in data use rather than with, for example, the (formally appointed) teacher leader. Nevertheless, the data in this study showed that the experience of colleagues was only named as an influencing factor in five of the interviews. And, data use expertise was not explicitly mentioned in this regard. In contrast, collegial bonds, which appeared to relate to friendship ties, were mentioned as an influencing factor in eight of the interviews. Thus, the teachers in this study said to interact for data use with colleagues based on their friendship rather than based on the experience their colleagues have to offer. This might be similar in regular professional interactions because these are not that different from data use interactions (Farley-Ripple & Buttram, 2015). Moreover, it is not clear whether sufficient data use expertise was present in the teams nor the extent to which teachers were aware of colleagues' data use knowledge and skills. All these aspects make it questionable whether the teachers in this study purposefully selected colleagues to interact with in order to establish data use goals.

Some of the findings in this study confirm previous research findings, particularly because they are common to the Flemish research context of this study. For example, data use interactions are often limited and not systematically or planned in Flanders (e.g., Van Gasse et al., 2017b). And, Flemish teachers do not tend to collaborate often in general (OECD, 2014). Therefore, the fact that the teachers in this study do not purposefully choose who they consult for certain data use goals is not quite surprising. Similar to other, international, studies, it is more likely that the data use interactions investigated in this study are related to teachers' regular professional interactions (Farley-Ripple & Buttram, 2015). Teachers are not likely to seek contact in data use with colleagues

with whom they normally do not interact. Nevertheless, despite the specific Flemish research context, the frequency of data use interactions found does not differ strongly from those in other, international studies (e.g., Farley-Ripple & Buttram, 2015; Keuning et al., 2016).

The four categories that were distinguished based on the literature all were useful to gather more insight in data use interactions. Like other professional interactions among educators, who is consulted for data use can be explained by formal aspects of the school organization, homophily, structural elements in the school and informal influences (Coburn & Russell, 2008; Hopkins & Spillane, 2014; Penuel et al., 2009, 2010; Spillane, 2005). The existing literature does not provide a clear picture of how the different influencing factors are interrelated. Whereas Moolenaar et al. (2012) concluded that friendship ties were not a necessary condition for work-related interactions, for the participants in this study such collegial bonds appear to be an important precondition for data use interactions. An explanation for this might be that processes of data use require sharing, analysing and solving educational problems. It is likely that teachers will only do this with colleagues in safe and non-judgemental environments.

Notwithstanding that this study has produced a number of in-depth results, there remain some limitations. A first one is the sample size of teams. Because social network analysis is a very time-consuming method due to the high response rates needed, the number of teacher teams involved was small. Although this provided opportunities for gathering additional in-depth qualitative information, the results of this study remain team-specific. For example, the meta-analysis showed that the receiver effects of teacher leadership and volume of appointment in the specific pupil group were not significant. Nevertheless, the (mainly non-significant) effects of those variables all appeared to go in the same direction. Therefore, a greater sample size might have provided more significant results in the meta-analysis. A second limitation relates to how we were able to weigh up the different categories of influencing factors. An interesting path for future research would be to try and weigh them up to each other statistically in the ERGM-analysis. While this exploratory study was needed to define which informal influences and structural elements are important to establish data use interactions, future research should explore alternative ways to involve these elements in the statistical analysis (e.g., by also collecting structured information on friendship ties, and including questions regarding structural elements in the survey).

Our findings suggest that the participants involved do not choose the colleagues they interact with for data use purposefully. This implies that the potential of these interactions for teachers' professional development for data use (or their support in data literacy) is under scrutiny. Future research should invest in examining the drivers for teachers to interact with colleagues in data use in more detail. Are teachers, for example, conscious of the knowledge and skills of their colleagues in data use (i.e., know-who)? And when they are, how do they use this information to establish their data use interactions? Being aware of colleagues knowledge and skills and involving appropriately might be essential in order to establish high-quality data use interactions.

This study shows that combining different methodological approaches (e.g., social network analysis and interview data) both triangulate the results found *and* provides opportunities to increase the depth in educational research (Creswell & Garrett, 2008). Leaving out one of the both methods used in this study would have led to quite different results. Because what teachers *say they do* is not always consistent with what *they actually do*, future research on (data use) interactions should carefully think about how to tackle this issue through the methodological design. For example by trying to combine traditional methods with non-self report measures, such as observational (video) data.

Furthermore, the link of how data use interactions are formed on the one hand and the development and transfer of data literacy within teams on the other hand is an important area for further research as well. After all, the potential of data use for data literacy support and development depends greatly on who is involved in data use interactions. Consulting colleagues for data use, just because of personal bonds, may not necessarily provide the knowledge and skills needed for learning how to use data appropriately. Following the principles of social network theory, who teachers consult might be more important than interacting with a lot of colleagues that do not have the data use knowledge and skills they need (Daly, 2012). Up to now, the limited social network studies in data use have resulted in scarce evidence on how effective data use interactions look like, for example in terms of the development of data literacy. Therefore, a future focus on the results of data use interactions is essential to strengthen the field in which data use interactions to expect or to pursue.

It remains uncertain whether the manner in which the relationships were established in this study, provides sufficient opportunities for teachers to learn from each other and develop data literacy. After all, the competences of colleagues were only a minor reason for why teachers interact with each other. In order for teacher teams to develop data literacy, they need to develop strategies for engaging in more conscious interactions based on the knowledge and skills their colleagues have to offer. Formal roles can be a stimulator in this regard, although the current analyses also showed that being on a friends-base with each other may still be a prerequisite for interactions. A help in this regard may be to assure that data use starts from joint goals among teachers. Those goals might introduce task-interdependence between colleagues. As such, teachers may get more familiar with the data use related competences of colleagues they do not necessarily share friendship bonds with. This might stimulate more purposefully chosen data use interactions, that can enhance the potential and quality of those interactions for professional learning and data literacy development in teacher teams.

The current state of the art on data use interactions does not provide a very optimistic image of how these interactions contribute to teachers' professional learning and development. Particularly for teachers' lacking data literacy, which includes a wide range of knowledge and skills to expect from a single teacher, it is essential that interactions are established in order to boost teachers' existing knowledge and skills. To this end, colleagues' competences and skills need to become more central in connecting to colleagues rather than just liking each other or being friends. Knowing-who becomes essential in taking the next step to effective data use interactions.

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