Teaching and Teacher Education 89 (2020) 102989

Contents lists available at ScienceDirect

Teaching and Teacher Education

journal homepage: www.elsevier.com/locate/tate

Teacher interactions in taking action upon pupil learning outcome data: A matter of attitude and self-efficacy?

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HIGHLIGHTS

- The effects of attitude on data use interaction seeking is team-dependent.
- Higher self-efficacy positively affects data use interaction seeking.
- Teachers' self-efficacy does not explain the extent to which they are consulted.

ARTICLE INFO

Article history:
Received 23 February 2018
Received in revised form
15 January 2019
Accepted 30 November 2019
Available online 6 December 2019

Keywords:
Data use
Attitude
Self-efficacy
Teacher interactions

ABSTRACT

Teacher interactions are highly valued in data use. Essential preconditions for teacher interactions are teachers' attitude and self-efficacy. However, how these factors affect the formation of teachers interactions remains unclear. The present study uses social network analysis to reveal the impact of teachers' attitude and self-efficacy on their interactive behaviour. The results from seven teacher teams show that attitude and self-efficacy are explanatory for the extent to which teachers seek interaction with colleagues, but not for the extent to which teachers are being consulted for data use action. The use of social network analysis leads to deeper and more refined insights into how teacher interactions, with regard to data use action, are formed compared to regular research methods.

1. Introduction

Over the years, data use has become an important topic in educational research. Adequate analysis and interpretation of different types of data provides opportunities for teachers to learn about and improve their classroom practice (Campbell & Levin, 2008). For teachers, in particular pupil learning outcome data are highly informative in order to improve their practice and better facilitate pupil learning (Jimerson, 2014). As a result, a considerable amount of research has invested in describing and exploring data use at teacher level, and particularly teachers' use of pupil learning outcome data. Although the assumption rises that data use can provide important learning opportunities for teachers, research has drawn a rather pessimistic state of the art, both with regard to the quality of data use among teachers and to its contribution to teachers' professional learning and the improvement of their classroom practice (Van Gasse, Vanlommel, Vanhoof, & Van Petegem, 2016; Farrell & Marsh, 2016; Horn, Garner, Kane, & Brasel, 2017; Schildkamp, Visscher, & Luyten, 2009).

The current state of the literature describes two major problems in teachers' data use. The first problem is teachers' tendency to jump from data to improvement actions without in-depth consideration of potential causes and alternatives for the educational problems they are facing (Bryk, Gomez, Grunow, & LeMahieu, 2015; Schildkamp, Poortman, & Handelzalts, 2015, pp. 1–27). This can be addressed by paying attention to the different sub-processes that are involved in data use (Bertrand & Marsh, 2015; Ciampa & Gallagher, 2016; Marsh & Farrell, 2015). Similar to (policy) circles of inquiry, thorough data use has been considered as a cyclical process in which phases of discussion, interpretation, diagnosis and action are present (Verhaeghe, Vanhoof, Valcke, & Van Petegem, 2010). Each of these phases requires different knowledge and skills from teachers (Datnow & Hubbard, 2016). In particular, translating diagnoses on the basis of data into appropriate improvement actions proves to be not self-evident (Datnow & Hubbard, 2016). Yet, the action phase in data use is crucial

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https://doi.org/10.1016/j.tate.2019.102989
0742-051X/

because it inherits the potential of data use for classroom improvement. Whereas the first data use phases (i.e. discussion, interpretation and diagnosis) are a guide for teachers to interrupt their initial tendency to hasty decisions, the contribution of data use to classroom improvement largely depends on the quality of teachers' improvement actions.

The second problem found in the literature is that individual teachers do not always possess the knowledge and skills necessary to accomplish each of the data use phases (Datnow & Hubbard, 2016). Discussing and interpreting data require specific data use skills, but classroom improvement strongly depends on how effectively teachers are able to relate this data based knowledge to pedagogical and content knowledge (Mandinach & Gummer, 2016). Therefore, despite the thorough and adequate interpretation and diagnosis of data, the translation of data to effective improvement actions is not guaranteed (Datnow & Hubbard, 2016). Interactions with colleagues are generally assumed to improve the quality of teachers' data use in this regard (Hubbard, Datnow, & Pruyn, 2014). Grouping teachers' experiences, knowledge and skills is considered to be an effective strategy for coping with potential individual pitfalls in data use (e.g. inadequate interpreting or analysing skills) (Bertrand & Marsh, 2015; Hubbard et al., 2014). For example, interacting with colleagues challenges teachers to discuss their initial explanations for poor student results and reflect upon how these results can be attributed to their instruction (Bertrand & Marsh, 2015). The contribution of social relationships to both the quality of the different data use phases and teachers' individual capacities for data use has led to teacher interactions being considered as an essential building block for adequate data use.

Despite the value dedicated to data use interactions, relatively limited insights have been provided into how teachers engage in social relationships in their use of pupil learning outcome data. The difficulties for teachers to translate data-based knowledge into effective improvement actions, and the importance of this phase for instructional improvement, make it particularly necessary for gaining insight into how teachers apply their social environment for data use action. In this regard, it is crucial, both to take into account the power of formal structures within schools for one to one interactions, and the explanatory potential of individual characteristics within these formal structures (Meredith, Van Den Noortgate, Struyve, Gielen, & Kyndt, 2017; Spillane, Hopkins, & Sweet, 2015). When it comes to the use of pupil learning outcome data, teacher attitude and self-efficacy have been identified previously as prerequisites for teacher interactions more than other individual characteristics (Van Gasse, Vanlommel, Vanhoof, & Van Petegem, 2017a; Datnow, Park & Kennedy-Lewis, 2013; Hubbard et al., 2014). Therefore, the current state of the literature can be supplemented by in-depth insights into how teachers' attitude and self-efficacy guide their interactive behaviour in data use action.

In addition to the limited attempts to study teacher interactions in the context of data use, common methods used in data use research have approached teacher interactions with insufficient granularity (Daly, 2012). Inherent to the concept, an 'inter-action' is an action in which two people are involved. This implies that the characteristics of both actors may be explanatory for the interaction established. Therefore, to better understand teacher interaction in the context of data use, refined methods are needed in which the information of both actors can be combined. Social network analysis is a powerful method for exploring and explaining teacher interaction (related to data use). It provides opportunities to investigate how the individual characteristics of teachers (e.g., their attitude or self-efficacy) affect the extent to which teachers seek interaction, are consulted and interact with (dis)similar others for data use action. However, up to now, only few data use studies have drawn upon social network analysis. Therefore, the contribution of this study lies in both the theoretical and the methodological aim to investigate the impact of teachers' attitude and self-efficacy on how they engage in interactions with colleagues to take action upon pupil learning outcome data.

2. Conceptual framework

Teacher interactions are considered beneficial for data use (Bertrand & Marsh, 2015). Not only can interactions address individual difficulties when using data (e.g., problems with the interpretation of data or the diagnosis of problems), interactions amongst teachers create depth in the data inquiry process and provide opportunities for teachers to develop their individual data use capacities (Van Gasse et al., 2016; Ciampa & Gallagher, 2016; Hubbard et al., 2014). Therefore, establishing interactions amongst teachers is generally seen as of considerable importance to teachers' data use, particularly for the translation of data based knowledge into data use action, which requires a complex combination of data use skills with instructional knowledge and skills (Datnow & Hubbard, 2016; Gummer & Mandinach, 2015). For this reason, teachers' interactions, with regard to taking action upon pupil learning outcome data, will be the subject of investigation in this study.

2.1. Teacher interactions

Teacher interactions will be studied by means of social network analysis. This method is based upon social network theory, in which the central idea is that the position of actors within a network determines their access to resources (Finnigan & Daly, 2012). In the context of data use action, these resources can be, for example, teachers' past experiences of instructional interventions that worked or not worked for certain problems. Next to describing teachers' access to colleagues' knowledge and skills, social network analysis makes it possible to explain interactions by means of teacher characteristics.

Inter-actions can be considered as an action (e.g. thinking out an improvement action on the basis of pupil learning outcome data) between two teachers. Therefore, three general aspects of teacher interactions can be explained by means of teachers' individual characteristics (e.g. their attitude or self-efficacy): the extent to which teachers seek interaction (i.e. *sender effects*), the extent to which teachers are consulted by colleagues (i.e. *receiver effects*) and the extent to which teachers head to colleagues with similar characteristics (i.e. *homophily effects*) (Sweet, 2016).

Sender effects describe how teacher characteristics (e.g., their attitude or self-efficacy) affect the number of interactions they will seek (Sweet, 2016). The calculation of the sender effect is based upon the outdegree measure. This measure reflects the number of teachers' outgoing interactions or, in other words, the extent to which they seek interaction with colleagues (Borgatti, Mehra, Brass, & Labianca, 2009). For example, a positive sender effect for attitude in this study would mean that teachers with a more positive attitude are more likely (i.e., have a higher probability) to seek more interactions within the network (i.e., have a higher outdegree measure).

Receiver effects describe how teacher characteristics (e.g., their attitude or self-efficacy) affect the extent to which they are consulted by colleagues (Sweet, 2016). The indegree measure is the basis for the calculation of the receiver effect. This measure reflects teachers' incoming interactions or, in other words, the number of colleagues by whom they are consulted. Therefore, the indegree measure reflects the popularity of teachers within a network (Borgatti et al., 2009). For example, in this study, an example of a

positive receiver effect for self-efficacy would mean that teachers with a higher self-efficacy have a higher probability of being consulted by colleagues in the data use action phase (i.e., have a higher indegree measure).

The last effect that can affect interactions between actors in a network is the *homophily effect*, or the common phenomenon in educational networks in which actors engage in interactions with similar others (Mc Pherson, Smith-Levin, & Cook, 2001; Moolenaar, Sleegers, Karsten, & Daly, 2012). The homophily effect provides information on the (dis)similarity of teachers who interact with each other (Sweet, 2016). In homophily effects, a general distinction can be made between formal or structural homophily effects and effects of individual characteristics (Meredith et al., 2017). Spillane et al. (2015) concluded that formal structures in schools (e.g., grade level teams) are more important in explaining teacher interactions than some visible individual characteristics (e.g., gender or race). On the other hand, non-visible individual characteristics related to teachers' knowledge and beliefs (e.g., attitude, self-efficacy) have been found to affect teacher interactions as well (Mc Pherson et al., 2001). Therefore, teachers tend to interact with other teachers similar to themselves to a greater extent, whereby similarity can be expressed in formal structures, as well as visible or non-visible individual characteristics (Meredith et al., 2017). For example, in this study, a positive self-efficacy homophily effect would mean that teachers with a similar level of self-efficacy, with regard to the use of pupil learning outcome data, interact with each other in the data use action phase.

2.2. Individual characteristics for the explanation of teacher interactions

Few studies have focused on factors that can explain the formation of teacher interactions in the context of data use, in particular, by using refined methods such as social network analysis. What is currently known is that teachers' attitude and self-efficacy are indispensable prerequisites for teachers' data use, both for their individual data use and for their engagement in social interactions in the context of data use (Van Gasse et al., 2017a Datnow, Park, & Kennedy-Lewis, 2013; Hubbard et al., 2014). However, up to now, the impact of both characteristics on teacher interactions for data use action has remained unclear.

2.2.1. Teachers' attitude towards data use

Attitude is a complex interplay between personal characteristics, standards, values, feelings, ideas and opinions, which determines how a person behaves in a particular situation, (e.g. data use) (Krathwohl, Bloom, & Masia, 1971; Sanbonmatsu & Fazio, 1990). With regard to data use, in particular teachers' cognitive picture of data use, or their knowledge about the subject has been used to explain their data use (Datnow & Hubbard, 2016). The concept implies the beliefs, models, preferences and other aspects that determine what teachers think about data use and to what extent they believe that using data to improve their practice is valuable (Coburn & Talbert, 2006; Coburn & Turner, 2011; Farley-Ripple & Buttram, 2015). For example, teachers with a positive attitude towards data use are convinced that the use of data is valuable in improving teaching and learning in schools.

Teachers' attitude towards data use is seen as indispensable for teachers to engage in interactions in the context of data use (Datnow et al., 2013; Young, 2006). Interactions can be a means of moderating a lack of knowledge and skills with regard to interpreting data. However, according to Young (2006) and Datnow et al. (2013), only teachers with a positive attitude towards data use will engage in interactions for school improvement. A recent study (Van Gasse et al., 2017a) confirmed the positive impact of teachers' attitude on their collaboration in the context of data use by means of path analysis. However, this effect has not yet been unravelled in a refined way, for example by means of social network analysis.

Given that attitude is a prerequisite for engaging in data use (Datnow et al., 2013; Young, 2006), the general assumption is that teachers with a more positive attitude will have a higher chance of consulting team members or to be consulted in the context of data use (i.e., sender and receiver effects). However, given the tendency of teachers to engage in interactions with similar others in terms of knowledge and beliefs (Mc Pherson et al., 2001), also a positive attitude homophily effect can be hypothesized.

2.2.2. Teachers' self-efficacy with regard to data use

Self-efficacy with regard to data use is a concept that describes the way in which data users see themselves as being capable of handling data (Bandura, 1997; Deci & Ryan, 2000; Woolfolk, 2008). When teachers' self-efficacy is high, they will be more confident in using data to successfully achieve their goals. As a result, they will set more ambitious goals with regard to data use, and demonstrate more perseverance in achieving them (Bandura, 1997; Woolfolk, 2008).

According to Datnow et al. (2013), teachers' lack of self-efficacy in terms of using data is a hindrance when it comes to engaging in interactions in the context of data use. Believing that one is able to use data properly is particularly more important in persuading teachers to engage in interactions than teachers' actual knowledge and skills in handling data (Datnow et al., 2013; Farley-Ripple & Buttram, 2015). By means of interactions, disagreements can be overcome and teachers can achieve deeper insights, but a positive self-efficacy is needed to initiate these processes (Datnow et al., 2013). This may result in a positive sender effect of self-efficacy in the context of data use.

Additionally, self-efficacy is an individual characteristic that can be important in the explanation of why some teachers are more likely to be consulted for data use action than others because teachers often turn to colleagues who seem (more) confident (Farley-Ripple & Buttram, 2015). Therefore, next to support for self-efficacy as a variable that can explain teachers' interaction seeking behaviour (sender effect), the literature provides evidence for the assumption that teachers' higher self-efficacy can be a reason why some teachers in the team are more frequently consulted than others (receiver effect).

Generally, positive sender and receiver effects for self-efficacy are indicated. However, like attitude, self-efficacy is an individual characteristic that is part of teachers' knowledge and beliefs with regard to data use (Datnow & Hubbard, 2016). Therefore, additionally a homophily effect can be assumed. Farley-Ripple and Buttram (2015) state that teachers turn to colleagues who are more confident in data use. This would imply a negative homophily effect for self-efficacy, meaning that interactions occur more frequently between teachers who are dissimilar in terms of their self-efficacy with regard to the use of pupil learning outcome data.

2.3. Research questions

Four research questions will guide this study. Interactions among teachers are strongly dependent upon certain characteristics of the team (Datnow & Hubbard, 2016). Therefore, we will start by describing the attitude and self-efficacy in teacher teams. Afterwards, we will investigate how teacher interactions can be explained by their attitude and self-efficacy. This results in the following research questions:

1. How do teacher teams resemble or differ with regard to teachers' attitude and self-efficacy with regard to the use of pupil learning outcome data?
2. How do teachers' attitude and self-efficacy affect the extent to which they consult colleagues for taking action on the basis of pupil learning outcome data?
3. How do teachers' attitude and self-efficacy affects the extent to which they are consulted for taking action on the basis of pupil learning outcome data?
4. To what extent do teachers' interact with similar others in terms of attitude and self-efficacy with regard to taking action on the basis of pupil learning outcome data?

3. Method

3.1. Research context

The current study took place in secondary schools in Flanders. Compared to other countries, the Flemish government's perspective on data use is school improvement oriented. Standards are defined at the end of the second and sixth grade of secondary education and schools are autonomous in how they achieve these standards (Penninckx, Vanhoof, & Van Petegem, 2011). Central exams and the resulting public data bases or rankings of schools do not exist (OECD, 2014). Schools themselves have full responsibility for getting insight into attaining the Flemish standards at the end of secondary education.

The absence of standardized testing in Flanders implies that schools and teachers primarily rely on their own data sources in order to obtain insight into pupil learning outcomes. A wide range of data sources (e.g., tests, assignments, observations or portfolios) can be used. Given the critique of the narrow conceptualization of pupil learning outcome data as quantitative cognitive output indicators (Schildkamp, Rekers-Mombarg, & Harms, 2012), the context of this study provides opportunities to broaden the conceptualization since the Flemish system does not focus teachers' conceptualization of 'data' on cognitive output indicators. Therefore, pupil learning outcome data in this study includes cognitive outcomes (e.g., linguistic and arithmetic skills) as well as non-cognitive learning outcomes (e.g., attitudes, art and physical education).

The study took place in the context of a project concerning the assessment of competences (d-pac.be). All ten schools involved in the project were asked to participate in this study. In each school, the target population were all teachers teaching the pupil group that participated in an assessment of writing competences in the aforementioned project; the fifth grade of an academic track in economics and languages (16- to 17-years-olds). In Flanders, these types of teacher teams are temporary and interdisciplinary and collectively responsible for the learning of pupils. Two to three times a year, the teams are obliged to discuss the pupils' learning outcomes in a formal team meeting. During the school year, these meetings serve to discuss pupils' learning progress. In the last team meeting of the year, team members deliberate as to whether or not pupils will successfully complete their year.

In order to answer the present research questions, different types of data were collected. For the first research question (i.e., how teachers' attitude and self-efficacy with regard to the use of pupil learning outcome data resemble or differ across teams), quantitative data of an online survey were analysed. The other research questions were investigated by means of social network analysis of data collected in the same online survey.

In five of the seven teams that are included in this study, the data use networks (data discussion, interpretation, diagnosis and action) were also investigated in a prior study (Van Gasse, Vanlommel, Vanhoof, & Van Petegem, 2017b). In this study, the analysis validated that the depth teachers' learning activities could be related to the structural interaction patterns within the networks across the five teams. Moreover, the interactions in the action networks of teacher teams appeared the greatest depth across the process of data use. Therefore, within the participating teacher teams, the most promising data use interactions for teacher learning are investigated in the current study.

3.2. Participants

Due to the required response rate of 80% in social network analysis, the data of three teams were excluded for this study. The response rates of the teams that were involved in the social network analysis are shown in Table 1. Response rates above 80% are reached in all teams and maximum response rates (100%) in four out of seven teams. Apart from team McKinley (13 teachers) and team Eppingswood (8 teachers), the teams generally include eleven teachers.

Due to the high response rates in seven teams, accurate conclusions can be drawn on how teachers' attitude and self-efficacy affect their interactive behaviour. Across the teams, 690 data points ensure that some general tendencies can be revealed.

3.3. Instrument

The online survey included scales on teachers' attitude and self-efficacy with regard to the use of pupil learning outcome data that were validated in previous research (Van Gasse et al., 2017a,b). The scale questions were answered on a Likert scale, going from 1 (totally disagree) to 5 (totally agree). The attitude scale included three items (e.g. '*I am convinced that the use of pupil learning outcome data in schools is valuable*'). The self-efficacy scale consisted of five items (e.g. '*I see myself as able to handle pupil learning outcome data appropriately*'). Cronbach's alpha values of 0.83 and 0.82 indicated a good internal consistency of the attitude and self-efficacy scale respectively.

In order to get an insight into teachers' interactions in the context of data use, two types of questions were included. The questionnaire distinguished between formal, obliged interactions (i.e., the team meetings to discuss and evaluate pupils' learning outcomes) and informal interactions. This study focuses on the informal interactions in taking action upon pupil learning outcome data. To this aim, colleagues of the participants were listed guided by the question '*Which of the following colleagues do you consult to take action upon pupil learning outcome data?*'. Subsequently, participants ticked the checkbox next to colleagues' name. The internal validity of these responses was confirmed by means of member-checking via 12 interviews with participants on which is not reported in this study.

Table 1
Teams' response rates (social network analysis).

Team	N	Response rate (%)
Riverbank	11	100
Northvale	11	100
Melrose	11	83
McKinley	13	100
Colby	11	100
Easton	11	91
Eppingswood	8	88

3.4. Analyses

The first research question was answered by means of descriptive statistics (i.e. average and standard deviation) across the total number of participants, using SPSS 22 software. Although these descriptive statistics were sufficient to answer the first research question, we aimed to add insights into (variation in) these statistics across the teams that were included in the social network analysis. For each team, we calculated the team average so that strong differences in attitude and self-efficacy across teams would become clear. Additionally, participants were divided into four groups for attitude and self-efficacy separately on the basis of the quartiles in the scale scores of the study sample (i.e., ranging from the lowest to the highest scale scores, Q1 indicates percentiles 0 to 25; Q2 percentiles 26 to 50; Q3 percentiles 51 to 75 and Q4 percentiles 76 to 100). This allowed us to get deeper insights into the types of teachers per team and it was essential to include homophily effects in the social network analysis. The division into quartiles was approached flexibly, which means that teachers with equal scale scores were classified into the same group. This led to the groups slightly differing in terms of the number of teachers. The division into quartiles provided a good explanation for the variance in both the attitude and the self-efficacy scale (i.e. eta^2 of 0.88 and 0.91 respectively). Post-hoc analysis showed significant differences between each of the quartiles in both the attitude and the self-efficacy scale.

To investigate the impact of attitude and self-efficacy on teacher interactions (i.e., research questions 2, 3 and 4), a theoretical model was designed and tested for the networks of the different teams using Exponential Random Graph Modeling (ERGM) with the 'ergm' package of Statnet in R (Handcock, Hunter, Butts, Goodreau, & Morris, 2016). ERGM analyses the chance to which interactions occur within a certain network (e.g. teacher team). The analysing technique can detect (1) which teachers search interaction with colleagues, (2) which teachers are popular to interact with and (3) which teachers are connected to each other. ERGM provides opportunities to explain these relations by means of teacher characteristics (e.g. attitude or self-efficacy). As such, the analysis provides insight into how teachers' attitude and self-efficacy affect the probability they are involved in different types of interactions with colleagues.

An ERGM was specified, including sender effects (i.e., RQ 2), receiver effects (i.e., RQ 3) and homophily effects (i.e., RQ 4) of attitude and self-efficacy. For each team, this model was compared with the baseline model by means of the Akaike Information Criterion (AIC) in order to evaluate whether our conceptual model explained the teacher interactions better than the baseline model. AIC is a relative estimate for the quality of the measurement model. Comparing AIC estimates between different models (e.g. baseline model and model with predictive variables) informs us on which of the models is best. In this regard, a better explanation of the baseline model (i.e., AIC in the explanatory model is higher than in the baseline model) indicates that interactions in the network can be better explained by chance than by the relationships our model hypothesizes. Meta-analysis was conducted using the 'metafor' package in R to evaluate overall effects in data use action networks across the seven teams.

4. Results

The result section is structured following the research questions. Therefore, we will first describe the attitude and self-efficacy of teachers within the teacher teams. Next, we will present the results of the ERGM analysis to clarify how teachers' attitude and self-efficacy affect their interactions in taking action upon pupil learning outcome data.

4.1. Attitude and self-efficacy in teacher teams

Table 2 provides an overview of the descriptive statistics for interactions, attitude and self-efficacy in each of the teams. The average degree per team provides an indication for the average number of interactions of teachers in the teams. In other words, average degree tells us something about teachers' average activity with regard to interacting with colleagues to take action upon pupil learning outcome data. Knowing that teachers can be connected up to seven colleagues (in team Eppingswood), up to twelve colleagues (in team McKinley) and up to ten teachers in all the other teams, we find that teachers' interactions with colleagues remain low across the teams. This means that teachers do not generally engage in a lot of interactions with colleagues to take action upon pupil learning outcome data. However, there are differences between the teams. For example, in team Eppingswood, teachers use on average about half of their possible connections with their colleagues, which indicates that teachers in Eppingswood are more active than their colleagues in other teams. In team Riverbank, teachers use on average a third of their possible connections to other teachers in the team. The average degree in all other teams, ranging from 1.09 in team Northvale to 2.00 in team McKinley, indicates less activity of teachers. Therefore, particularly in teams Melrose, McKinley, Colby and Easton, teachers engage in few interactions with colleagues to take action upon pupil learning outcome data.

With regard to teachers' attitude, the scale scores indicate that teachers are on average positive towards the use of pupil learning outcomes. This means that teachers perceive that using pupil learning outcome data is valuable to improve their instruction and achieve better pupil results. However, the data show some differences in average scale scores across the teams. For example, in teams Colby (av = 3.84) and Eppingswood (av = 3.88), teachers are on average less positive about the contribution of using pupil learning outcome data for school improvement than teachers in the other teams. This is also indicated by where teachers of those teams are situated across the quartiles of the attitude scale. In teams Colby and Eppingswood, the majority of teachers (n = 9 in team Colby and n = 4 in team Eppingswood) have attitude scores that are situated in the lowest 50% of the teacher sample in this study. Although the average scores on the attitude scale cannot be considered as low, it is noticeable that teams Colby and Eppingswood differ from all the other teams in the average scale scores for attitude. In all other teams, teachers are on average firmly positive (i.e., average scores above 4 on a 5 point Likert-scale) about the value of the use of pupil learning outcome data for better teaching and learning. In particular in teams McKinley and Easton, the scale scores of the majority of teachers (n = 9 in team McKinley and n = 8 in team Easton) are situated in the upper 50% of the attitude scale.

Looking at the self-efficacy scale, the average team scores indicate on average firmly positive results, ranging from 4.00 in team Eppingswood to 4.57 in team Easton on a 5 point Likert scale. This means that teachers feel competent in using pupil learning outcome data across the teams. However, when we look at the quartiles within the self-efficacy scale, we find some differences between the teams. For example, in teams McKinley and Easton, the self-efficacy score of the majority of teachers (n = 9 in team McKinley and n = 8 in team Easton) is situated in the highest 50% in the self-efficacy scale. This means that, in these teams, more teachers are involved who feel themselves more capable in using pupil learning outcome data compared to other teachers in the sample. On the other hand, we find that in team Northvale, the scale score of the majority of teachers (n = 7) is situated in the lowest 50% of the self-efficacy scale. This implies that teachers in team Northvale feel less competent in using pupil learning outcome data than other teachers in the sample of this study.

Table 2
Descriptive statistics per team.

		Team						
		Riverbank (N = 11)	Melrose (N = 11)	McKinley (N = 13)	Colby (N = 11)	Easton (N = 11)	Eppingswood (N = 8)	Northvale (N = 11)
Average degree		3.27	1.18	2.00	1.82	1.27	3.63	1.09
Attitude	Av	4.30	4.33	4.48	3.84	4.69	3.88	4.36
	SD	0.76	0.62	0.70	0.72	0.34	1.06	0.66
Attitude Quartile								
1: 0–25% (lowest)	n	2	1	2	3	0	3	2
2: 25%–50%	n	3	4	2	6	3	1	4
3: 50%–75%	n	2	2	4	2	3	1	1
4: 75%–100% (highest)	n	3	2	5	0	5	1	4
Self-Efficacy	Av	4.34	4.24	4.40	4.23	4.57	4.00	4.21
	SD	0.53	0.53	0.36	0.57	0.42	0.69	0.40
Self-Efficacy Quartile								
1: 0–25% (lowest)	n	1	2	0	3	0	3	2
2: 25%–50%	n	2	3	4	2	3	0	5
3: 50%–75%	n	5	2	5	3	3	3	3
4: 75%–100% (highest)	n	2	2	4	3	5	1	1

4.2. Explaining teacher interactions

The research questions regarding the impact of teachers' attitude and self-efficacy on their interactions with regard to taking action upon pupil learning outcome data (RQ 2, 3 and 4) are answered by means of ERGM analysis on the action networks of the different teams in this study. The results of these ERGMs are shown in Table 3.

The ERGMs consist of an intercept, which reflects the probability that teachers in the different teams interact with any of their colleagues for taking action upon pupil learning outcome data. Furthermore, sender effects, receiver effects and homophily effects for attitude and self-efficacy are included.

For each of the ERGMs, the final model was compared to the baseline model in terms of AIC. For teams Easton and Northvale, this led to the conclusion that the AIC of the baseline model was better (i.e., lower). This means that, for these teams, we cannot conclude that attitude and self-efficacy explain teachers' interactions significantly better than explaining them by chance. In all other teams, the AIC of the final ERGM improved, compared to the baseline model.

4.2.1. The effect of attitude and self-efficacy on consulting colleagues

In the ERGMs, sender effects were included to investigate the effect of attitude and self-efficacy on the extent to which teachers consult colleagues for data use action. This is measured by means of the outdegree or the number of sent interactions. Sender effects explain teachers' outdegree measures by means of individual characteristics. In other words, sender effects reflect whether or not deciding to consult colleagues depends on individual characteristics. In this study, the effects of teachers' attitude and self-efficacy on their interaction seeking behaviour in the action phase of data use are investigated.

We find significant sender effects of teachers' attitude in teams Riverbank, Melrose, McKinley, Easton and Eppingswood. This means that, accept in teams Colby and Northvale, teachers' attitude affect their consultation of colleagues for data use action. However, the sender effects found for attitude across the schools are not coherent. In teams Riverbank, McKinley and Eppingswood, the ERGMs show significantly positive sender effects for attitude. This means that, teachers' probability to consult colleagues for data use action increases when they score higher on the attitude scale. Thus, being more positive about the value of the use of pupil learning outcome data to improve teaching and learning, increases the chance to connect with colleagues for data use action in teams Riverbank, Eppingswood and McKinley. The opposite tendency is noticeable in teams Melrose and Easton. In these teams, the ERGMs show significantly negative sender effects for attitude. In other words, explicating a more positive attitude towards the use of pupil learning outcomes, decreases the probability of teachers to be connected to colleagues for data use action in teams Melrose and

Table 3
Results of the ERGM per team.

	Intercept	Sender Effects		Receiver effects		Homophily Effects	
		Attitude	Self-Efficacy	Attitude	Self-Efficacy	Self-Efficacy	Attitude
	Est. (s.e.)	Est. (s.e.)	Est. (s.e.)	Est. (s.e.)	Est. (s.e.)	Est. (s.e.)	Est. (s.e.)
Riverbank	−16.65 (4.95)**	0.81 (0.40)*	1.79 (0.57)**	0.26 (0.34)	0.74 (0.49)	0.29 (0.50)	0.05 (0.62)
Melrose	- 2.26 (4.98)	−3.78 (1.25)**	4.21 (1.73)*	0.79 (1.06)	−1.22 (1.19)	−0.42 (1.26)	−0.61 (1.15)
McKinley	−15.64 (5.45)**	1.87 (0.73)*	0.44 (0.59)	0.07 (0.38)	0.71 (0.65)	−0.06 (0.46)	0.13 (0.50)
Colby	1.26 (4.49)	0.10 (0.40)	0.19 (0.52)	0.55 (0.41)	−1.48 (0.59)*	−0.28 (0.76)	−0.07 (0.64)
Easton	0.75 (8.89)	−1.95 (0.88)*	0.73 (0.88)	−0.66 (0.88)	1.39 (0.95)	−0.55 (0.83)	−0.90 (0.83)
Eppingswood	−23.51 (7.79)**	1.62 (0.60)**	2.95 (0.98)**	0.80 (0.48)	0.42 (0.62)	1.31 (0.95)	3.47 (1.58) *
Northvale	- 2.15 (5.96)	0.00 (0.61)	−0.36 (0.99)	1.12 (0.65)	−0.83 (1.01)	0.67 (0.68)	−1.64 (1.19)
Meta-analysis		0.19 (0.29)	1.11 (0.33)***	0.41 (0.27)	0.03 (0.31)	0.14 (0.31)	−0.06 (0.33)

*Significant at p < .05.
**Significant at p < .01.
***Significant at p < .001.

Easton. Although the sender effect for attitude is significant in five of the seven teams, the meta-analysis does not confirm a cross-team effect of attitude on consulting colleagues for data use action because of the disparity of the effects across teams. This implies that a positive or negative effect of attitude on teachers' interaction seeking behaviour cannot be generalized across the teams, but that any effect remains team-specific.

For self-efficacy, significant sender effects are found in teams Riverbank, Melrose and Eppingswood. This means that teachers who score higher on the self-efficacy scale, have a higher probability of engaging in interactions in the networks of Riverbank, Melrose and Eppingswood. In other words, teachers out of these teams who indicate being more confident about their capabilities for using pupil learning outcome data appropriately, are more likely to seek interaction with colleagues for data use action. The positive sender effect of self-efficacy is confirmed by the meta-analysis. This means that, across the teams in this study, it is likely that sender effects for self-efficacy are positive. Thus, overall, the teachers in this study with higher levels of self-efficacy have a higher probability of consulting colleagues in order to take action upon pupil learning outcome data.

4.2.2. The effect of attitude and self-efficacy on being consulted by colleagues

Investigating effects on 'being consulted', or on how many colleagues turn to a certain teacher for data use action, is done by analysis of receiver effects. Such effects explain the number of incoming interactions (i.e. the extent to which they are consulted) by means of certain teacher characteristics. In this study, the receiver effects of teachers' attitude and self-efficacy were included in the ERGMs.

For attitude, no significant receiver effects were found in and across the different teams. This implies that teachers' attitude does not explain the extent to which teachers are consulted for data use action by colleagues. In other words, believing that the use of pupil learning outcome data is valuable to improve (teaching) practice does not necessarily increase the probability of being consulted for data use action.

For self-efficacy, only the ERGM in team Colby shows a significant receiver effect. This effect is negative, which indicates that higher scores on the self-efficacy scale decrease the probability of incoming interactions. This means that teachers being more confident about their capabilities to use pupil learning outcome data appropriately, are less likely to be consulted for data use action in team Colby. Given that the receiver effect for self-efficacy is only significant in team Colby and there is disparity in other (non-significant) effects across the teams, the meta-analysis does not confirm a positive or negative receiver effect for self-efficacy. This means that the effect found in team Colby can be considered team dependent.

4.2.3. Teachers' interactions with similar others

The extent to which interactions generally occur among teachers who are similar to each other can be analysed by means of homophily effects. Therefore, to answer the fourth research question, homophily effects for attitude and self-efficacy were included in the ERGMs of all teams. The homophily effects indicate whether or not teachers who are connected are situated in the same quartile on the attitude or self-efficacy scale and thus can be considered as similar in terms of attitude or self-efficacy.

With regard to self-efficacy, we do not find significant homophily effects. This implies that connections between teachers for action upon pupil learning outcome data are not dependent of their (non-) similarity in terms of self-efficacy. Thus, for the present data set, no conclusions about heading to (dis)similar colleagues in terms of self-efficacy can be formulated for taking action upon pupil learning outcome data.

The homophily effect for attitude is only significant in team Colby. In this team, a positive homophily effect is determined. This means that, in team Colby, teachers whose scores on the attitude scale are situated in the same quartile are more likely to have a connection for action based upon pupil learning outcome data. Therefore, for data use action, there is a higher probability for connections amongst teachers with similar opinions on the use of pupil learning outcome data. Given that (non-) significant homophily effects of attitude are different in other teams, the meta-analysis does not confirm any overall attitude homophily effect across the teacher teams. Therefore, the effect in team Colby is team dependent and no conclusions can be drawn about teachers generally interacting with similar others in terms of attitude across the teams.

5. Discussion and conclusion

Teacher interactions are highly valued in the context of data use. Particularly in the action phase of data use, which involves the complex translation from data based knowledge to instructional actions, interactions are considered essential to achieve school- and classroom improvement (Bertrand & Marsh, 2015; Datnow & Hubbard, 2016). Up to now, limited efforts have been taken to describe and explain teacher interactions in taking action upon pupil learning outcome data. And if so, the methodologies used generally did not address the granularity of interactions in a sufficiently refined way. In this study, interactions in teacher teams were explained by two main individual characteristics that are generally assumed to affect teacher interactions: teachers' attitude and self-efficacy related to data use. To do so, we used social network analysis, a method that combines information of multiple teachers to generate refined insights into interactions. More specifically, we investigated by means of Exponential Random Graph Models (ERGMs) how teachers' attitude and self-efficacy affect the extent to which they consult colleagues (i.e., sender effect) or are consulted by colleagues (i.e., receiver effect) for data use action. Additionally, we investigated the tendency that teachers interact with similar others in terms of attitude and self-efficacy (i.e., homophily effect).

We first found that the participating teachers do not consult a lot of colleagues for action upon pupil learning outcome data (average degree of 2 connections across the teams), but that they are generally positive about the value of using pupil learning outcome data for school improvement and their own capabilities in doing so. The limited network activity found in this study is in line with what is known from the few network studies that are available in the context of data use (Farley-Ripple & Buttram, 2015; Hubers et al., 2017). A possible explanation for the limited interactions despite the positive values for attitude and self-efficacy, can be that teachers in the teams predominantly perceive data use for student learning as an individual responsibility. Therefore, action upon pupil learning outcome data may not be the result of interaction amongst (a significant number of) colleagues. This explanation does also find support in previous research, stating that data use is an activity that is primarily carried out individually and that only a limited number of colleagues is consulted when teachers experience the need for it (Cosner, 2011; Datnow & Hubbard, 2016).

A second finding is that, in the participating teams, teachers' attitude and self-efficacy with regard to data use influence their interactive behaviour. Although teachers' attitude clearly affects the number of colleagues they consult for data use action in five out of the seven participating teams, the direction for this relationship remains ambiguous and strongly team-dependent. Whereas in

some teams, being more positive about the value of data use for school improvement is related to a higher probability of engaging in interactions for data use action, in other teams the tendency is that teachers with lower scores on the attitude scale are more involved in interactions for data use action. This finding seems inconsequent with previous research, emphasizing the need for a positive attitude towards data use to engage in data use interactions (Van Gasse et al., 2017a,b; Datnow et al., 2013; Young, 2006). This finding is important for reflection on the approach to attitude as 'the higher the better' for teacher interactions in the context of data use. Given that a completely negative attitude towards data use was almost absent amongst teachers in the participating teams, this study does not reveal the impact of a negative attitude on teachers interactions in data use action. The diverse attitude effects found were determined in a modest sample of teachers with generally moderately to positive scale scores for attitude. Therefore, it is likely that teachers' attitude needs to be positive to a certain extent (Van Gasse et al., 2017a,b; Datnow et al., 2013; Young, 2006), but from that point on, a higher attitude might not necessarily imply a higher engagement in interactions with colleagues. In other words, teachers might need a baseline attitude to consult colleagues for data use action, but it is not a matter of course that they will consult more colleagues when this baseline level for attitude is exceeded.

For self-efficacy, ERGMs in the networks of the participating teams show that teachers who are more confident about their capabilities to use pupil learning outcome data consult a greater number of colleagues for data use action. This finding can be generalized across the teams and confirms previous research with similar findings (Datnow et al., 2013; Farley-Ripple & Buttram, 2015; Van Gasse et al., 2017a,b). On the other hand, a higher self-efficacy does not necessarily make teachers in the participating teams more popular to interact with for data use action, given that no significant receiver effects were found for self-efficacy. This does not confirm the previous finding that teachers who seem confident in using data are more likely to be consulted for data use interaction (Farley-Ripple & Buttram, 2015). An explanation for the effects of self-efficacy can lie in the fact that interacting with colleagues on pupil learning outcome data implies that teachers expose their data use practices and aspects of their teaching. Therefore, self-confident teachers (i.e. teachers with a higher self-efficacy) might be less reserved to do so compared to colleagues with a lower self-efficacy. However, when it comes to being consulted, colleagues with a higher self-efficacy might not necessarily be teachers' first choice because this relationship might be perceived as less safe. Nevertheless, it is remarkable that teachers interact more with colleagues when they are more confident in using data, whereas it might be the teachers being less confident who would benefit the most. This is a tendency that is also noticeable in help-seeking literature (Dawson, Meadows, & Haffie, 2010). This raises questions on how to make teachers who need data use support engage in interactions with regard to data use, or, in other words, how the proper teachers can be reached in data use networks.

The social network approach used in this study provides valuable opportunities to unpack and explain teacher interactions. However, the study has some limitations. A first limitation is the limited number of teams that was included in this study. Despite its advantages over survey research, the response ratio needed for the type of analysis in this study is quite high (80%). Therefore, the data collection is intensive and a great sample of teams is difficult to reach. Given the specific characteristics of each team, general conclusions across teams prove to be not straightforward. Illustrative in this regard is the disparity in the attitude effects across teams. A larger team sample might have revealed some more alignment in the effects, whereas in the current sample, the effects remain very team dependent which may be due to other interacting characteristics of the teams or teachers. In addition, in two teams (team Northvale and team Easton), interactions were better explained by chance than by our model. This might be due to the combination of the sparse network constellation of the networks and complex model. For the limited information on teacher interactions, six effects included in the model might have been too much, considering the limited statistical power of the networks in teams Northvale and Easton. Therefore, greater team sample sizes are needed in future research to gain statistical power in complex model testing and to result in more straightforward findings. Secondly, we used a whole network approach for the analysis. This means that we needed information on all team members' interactions within the boundaries of a specific (formal) team. However, it is not said that the boundaries in our studies were the right ones for all the participating teachers. For example, we used the criterion 'teaching a specific pupil group', which implies that the team involved teachers who teach different subject areas. However, for data use action, some teachers might prefer to consult colleagues who teach the same or related subjects and thus consult colleagues out of the boundaries of this specific team. A network approach in which the teacher is central instead of the team could address this issue in further research.

This study unravels the impact of self-efficacy and attitude on teacher interactions to some extent. Given that professional development in data use is becoming more central to the research agenda (Vanhoof & Schildkamp, 2014), it is necessary that future research goes further into depth on the learning potential of teacher interactions and teacher networks. It is necessary to further explore why some teams are denser than others in the context of data use and whether or not interactions with colleagues are deliberately chosen to increase the quality of data use or teachers' own data use competences. Therefore, the concept of data literacy and how it is related to teachers' attitude and self-efficacy needs to come higher on the research agenda. Up to now, data literacy has generally been approached as an individual characteristic. However, given the specific knowledge and skills required to accomplish each of the phases in the data use cycle and the value of interactions to achieve this, it is valuable to translate the concept into a team characteristic (Bertrand & Marsh, 2015; Datnow & Hubbard, 2016; Mandinach & Gummer, 2016; Means, Chen, DeBarger, & Padilla, 2011). How team members complement each other in terms of data literacy and how interactions make aspects of data literacy available to colleagues are paths that need exploration. Adequate methodologies, beyond self-perception, are needed to describe and explore how the learning potential of teacher teams in terms of data literacy is developed and improved.

The general contribution of this study can be found in complementing theory and methodology in studying teacher interactions in the context of data use. For the literature of data use, this study provides deeper insights into how teacher interactions with regard to data use action are formed. The use of social network analysis led to refined knowledge on the role of teachers' attitude and self-efficacy in their interactive behaviour. For example, the conclusion that attitude and self-efficacy are explanatory for the extent to which teachers turn to colleagues for data use action, but not for the extent to which teachers are consulted by colleagues, could not have been drawn from survey research. Therefore, the methodology in the current study has proved useful for further refinement in data use theory. At the same time, this study shows how a theoretical base can deepen the research results of social network analysis as a methodology. A lot of research into social network analysis aims to explain social structures by, for example, formal or informal positions of teachers. Therefore, the theoretical outcomes remain quite descriptive. This study shows that using individual characteristics (e.g., attitude or self-efficacy) can deepen

knowledge on teachers' position within a network. In other words, a strong conceptual base for hypothesized relations can add meaning to social network analysis as a methodology.

This study has addressed the value that is dedicated to teacher interactions in the context of data use by investigating the impact of attitude and self-efficacy in data use interactions. The method of social network analysis provided us with opportunities to distinguish different types of effects of teachers' attitude on their interactive behaviour. Whereas we found some effects of attitude and self-efficacy on the extent to which teachers consult colleagues for data use action, it remains unclear why certain teachers are more popular to consult than others. In order to establish rich interactions in terms of knowledge sharing and creation, colleagues' knowledge and skills should be more important than liking colleagues for turning to people. For data use, it is essential to acknowledge the power of teacher networks and to use them deliberately and adequately. In other words, 'knowing who' might be an important key when it comes to translating data based knowledge into instructional practices that have an impact upon the learning of students.

Acknowledgement

This work was supported by Flanders Innovation & Entrepreneurship and the Research Foundation Flanders (grant number 130043).

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