The drivers and dynamics of data use interactions

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Unpacking teacher collaboration

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The drivers and dynamics of data use interactions

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Bedankt!

Antwerpen, 3 juli 2011

> *Ik trek mijn stoute schoenen aan en begin een babbel met Jan. Dat ik dat onderzoek doen voor mijn masterproef toch heel erg leuk vond. En dat het toch fijn zou zijn moest ik nog zulke dingen kunnen doen in de toekomst. De juiste persoon op de juiste plek, zo bleek. "Dat treft. Ik zoek nog een jobstudent voor augustus…"*

Die maand werden er uiteindelijk drie, die werden gekwadrateerd en daarna ook vermenigvuldigd. En zo verschijnt er op 7 mei 2018 een boek waarop mijn naam prijkt. Al is het er niet gekomen zonder ruggensteun. Mijn boek zou zijn doel dus al voorbij schieten mocht ik als auteur nalaten de tijd te nemen om mijn netwerk te bedanken. Te beginnen met zij die rechtstreeks betrokken waren bij de realisatie van dit werk.

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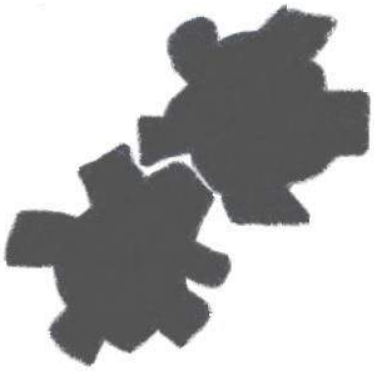
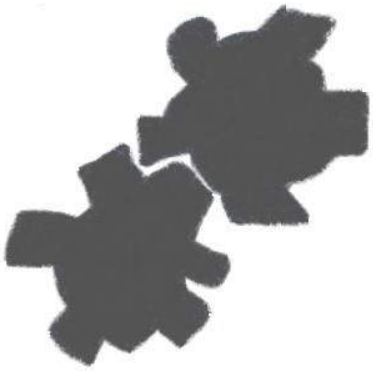


Introduction



The drivers and dynamics of data use interactions[1]

Data use originated in the context of standardized test data. In many countries, accountability expectations led to an increased emphasis on data use (Schildkamp, Ehren, & Lai, 2012). Schools and teachers were expected to use data and address weaknesses in teachers' instruction to improve learning among different types of students, which was then reflected in better results in standardized tests.

To date, the focus on data use has continued to expand. The current thinking is that different types of data can be used as guidance for educational decisions, process monitoring and problem-solving in schools. For example, teachers may assume that pupils' writing skills decline every year. A first reflex can be to test this assumption by means of data (e.g. by comparing results on writing assignments over the years). Subsequently, teachers think about why this would be. The hypothesis can, for instance, be that the curriculum provides less room for writing exercises, which can, again be tested with data (e.g. by comparing the number of writing assignments over the years). This example illustrates how different types of data can be used at different time points to fully understand current situations and practices in education. By using data, teachers build an objective framework around their gut-feelings or intuitive thoughts. As such, the use of data has been valued as a means by which to counter the potential biases of decisions solely based on intuitive thinking as it provides a reliable and valid framework for decision-making (Johnson, 1997; Kerr, Marsh, Ikemoto, Darilek, & Barney, 2006). Therefore, the appropriate use of data in teachers' day-to-day practice is assumed to contribute to teaching that is more effective and efficient, and enhances student achievement (Campbell & Levin, 2008; Carlson, Borman, & Robinson, 2011).

[1] This chapter is partly based on:

Van Gasse, R., Vanlommel, K., Vanhoof, J., & Van Petegem, P. (2016). Teacher collaboration on pupil learning outcome data: A rich environment for professional learning? *Teaching and Teacher Education, 60*, 387-397.

Van Gasse, R., Vanlommel, K., Vanhoof, J., & Van Petegem, P. (2017). Individual, co-operative and collaborative data use: A conceptual and empirical exploration. *British Educational Research Journal, 43*(3), 608-626.

Van Gasse, R., Vanlommel, K., Vanhoof, J. and Van Petegem, P. (2017). The impact of collaboration on teachers' individual data use. *School Effectiveness and School Improvement, 28*(3), 489-504.

Data use: state of the art and research gaps

Data use and the emphasis on collaboration

The rise of data use in educational settings introduced an increasing amount of data use research in the past decade. The earliest body of literature on data use was very descriptive. Numerous examples of good practices provided the basis for the way data use is conceptualized today.

Data use is a complex practice. The somewhat simplistic linguistic merger of 'data' and 'use' runs the risk of oversimplifying the actions underlying the concept. Research has shown that data use is not simply about 'data'. Data use involves the translation of data into information and information into knowledge (Marsh, 2012; Coburn & Turner, 2011). The implication is that data is imbued with meaning to become information. Combined with teachers' expertise, information can become actionable knowledge (Schildkamp, Poortman, & Handelzats, 2016). The transformation from raw data into information and actionable knowledge requires various types of knowledge and skills of the data user. Analytical and interpretation skills are needed to transform data into information, and a strong pedagogical knowledge base is crucial in creating knowledge and facilitating instructional improvement (Gummer & Mandinach, 2015; Marsh & Farrell, 2015). The transformation of data into knowledge and the diversity in knowledge and skills needed to do so, result in data use being a less straightforward activity than it seems. The complex inquiry process to fully understand current situations and improve educational problems implies a dynamic interplay between (intuitive or informed) hypothesis, data and teachers' knowledge and skills (Schildkamp et al., 2016).

Although individual data use is perfectly possible from a theoretical stance, data use research has invested in studies in which teacher teams use data to improve educational problems. The rationale behind this is that collaboration can improve data use, since it has the potential to reduce some of the biases that can occur when using data individually (e.g. a problematic interpretation of data) (Hubbard, Datnow, & Pruyn, 2014; Jimerson, 2014; Wayman, Midgley & Stingfield, 2007). 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, Poortman, Schildkamp, Pieters, & Handelzalts, 2016; Keuning, Van Geel, Visscher, Fox, & Moolenaar, 2016). As such, the value of collaboration has not only been assumed to lie in the presence of individual support in data use, but also in the construction of an environment within which teachers can learn (Vanhoof & Schildkamp, 2014).

Despite the great emphasis on collaboration in data use, the benefits of teacher collaboration in data use have remained an informed assumption rather than knowledge based on a large body of empirical literature. Only few studies specifically addressed teacher collaboration and its benefits for data use. These studies generally showed limited and quite superficial interactions in data use (Farley-Ripple & Buttram, 2015, Hubers et al., 2016; Keuning et al., 2016). However, when it comes to teacher collaboration, the dynamic character in data use has not been addressed sufficiently. Knowing that data use cannot be considered a straightforward activity (Schildkamp et al., 2016), research on data use collaboration requires a dynamic approach, in a sense that collaboration is considered as evolving throughout data use and can involve cross-overs to individual data use practices. Therefore, this dissertation will embrace potential *dynamics of data use interactions*.

The limited and superficial collaboration found in data use (Farley-Ripple & Buttram, 2015, Hubers et al., 2016; Keuning et al., 2016) raises a critical stance towards the benefits of teacher

collaboration in data use. The assumed benefits in terms of, for example, knowledge transfer and knowledge creation will largely depend on characteristics of this collaboration. Problematic in this regard are the difficulties to provide the concept of collaboration with sufficient meaning in order to understand such processes of mutual cognition building fully. As a result, the literature on data use is in vast need of in-depth investigation of (learning) activities in data use collaboration that potentially contribute to data use support, knowledge sharing or knowledge creation. Therefore, this dissertation aims at *unpacking teacher collaboration*.

The matter of teacher characteristics in data use

In order to understand teachers' data use, it is vital to acknowledge that it can be influenced in many ways. The interplay between the context in which teachers act, their personality and the type of data being used can affect the decisions they make or the behaviour they exhibit. For example, limited time may imply quick but less-considered (data-based) decisions and limited collegial consultation. Therefore, the first wave of descriptive research on data use has recently been followed by a wave of explanatory research. As a result, an extensive list of factors that are perceived to influence data use are now available, ranging from contextual factors to teacher and data characteristics (Datnow & Hubbard, 2016; Visscher, 2002; Visscher & Coe, 2003).

It has rather been teachers' perception of contextual factors and data characteristics than their 'true' being that are found to matter for teachers' data use. For example, *perceiving* a strong accountability focus or *estimating* data as non-relevant affect how data are used (Visscher, 2002; Vanhoof & Van Petegem, 2007). Together with the teacher characteristics of influence, this implies that teachers bear tremendous individual responsibility for the success of data use.

Several teacher characteristics have been found to influence teachers' data use and many of these factors are being further explored (e.g. data literacy, pedagogical orientation, trust) (Datnow & Hubbard, 2016). However, two specific teacher characteristics are recurring elements that affect how teachers behave in relation to data use: teachers' attitude and their self-efficacy (Datnow & Hubbard, 2016; Datnow, Park, & Kennedy-Lewis, 2013; Hubbard et al., 2014). Teachers' attitude refers to the extent to which they do or do not believe in the merit of data-informed decisions. Being more positive about the contribution of data to improve instructional practices facilitates data use (Datnow & Hubbard, 2016; Verhaeghe, Vanhoof, Valcke, & Van Petegem, 2010). Self-efficacy relates to teachers' confidence to use data. Teachers' perceptions about their own abilities to analyse and interpret data is crucial for teachers to engage in data use (Datnow & Hubbard, 2016). Therefore, a positive attitude and self-efficacy are considered prerequisites for data use (Datnow et al., 2013; Hubbard et al., 2014).

Despite the growing body of explanatory literature in data use and the identification of numerous factors of influence in data use, research has failed to generate clear insights into how teacher characteristics affect their data use collaboration. Therefore, limited knowledge is available into why data use collaboration does or does not come about. Bearing in mind that teachers' attitude and self-efficacy are generally put forward as two of the prime factors to explain data use, few studies have indicated potential interrelationships between those teacher characteristics and data use collaboration (Datnow et al., 2013; Hubbard et al., 2014). As a result, it is essential to gain more insight into how these so called prerequisites for data use also serve as prerequisites, or *drivers,* for collaboration in the context of data use.

Teacher collaboration and professional learning

Data use originated from the idea that using data bears power for school improvement and, in the end, increased pupil achievement. Over the years, the impact of data use has been hardly determined. Numerous factors of the learning context and the learner affect pupil learning outcomes, whereby the direct relation between practices of data use and learning effects at the level of the pupil is hard to demonstrate (Carlson et al., 2011).

However, up to now, the literature has showed some effects of data use that can be indirectly linked to pupil learning. Important effects in this regard are situated at the level of teacher cognition. For example, the use of data can result in deeper reflection upon educational practices and deeper insights into teaching and learning (Feldman & Tung, 2001; Schildkamp, Visscher, & Luyten, 2009; Wayman & Stringfield, 2006). Furthermore, data use can result in new ideas on schooling and instruction and the development of a more refined and sophisticated vision or on pupils' learning (Johnson, 1997; Schildkamp & Teddlie, 2008; Verhaeghe et al., 2010). Thus, major opportunities of data use lie in teachers' professional learning (Vanhoof & Schildkamp, 2014).

Although there are indications for the contribution of data use to teachers' professional learning, the literature on data use has insufficiently explicated the relation between the characteristics of data use activities and teachers' professional learning. Moreover, whether a collaborative data use environment is beneficial for teachers' professional learning, as is assumed, has been hardly addressed. And if such attempts were made (e.g. Hubers et al., 2016), systematic determination of *which* collaborative activities do or do not contribute to teachers' professional learning has been lacking. Therefore, the focus in this dissertation will also lie in the relation between collaborative data use activities and teacher' professional learning.

General research goals

Insights into data use collaboration are fairly limited. few research has invested in a detailed exploration of contributions collaboration can make to adequate data use. The general aim of this dissertation is to address this research gap. The state of the art in data use research and the remaining research gaps outlined above have led to four central research goals in this dissertation. Via these research goals, this dissertation aims at expanding and refining knowledge on teachers' data use in general, and teacher collaboration in the context of data use in particular. The following research goals will guide this dissertation:

1. *Exploring the nature of teachers' data use and its dynamics*

   When the aim is to address the research gap on teacher collaboration in data use, it is essential that such collaboration can be situated within the broader context of data use practices in Flanders. To reach understanding of (the value of) data use collaboration, it is needed to gain insight into which data use practices can be identified as 'collaboration' and how such collaborative practices distinguish from and relate to individual practices. In other words, the nature of data use needs to be explored. In this regard, it is essential to address the dynamics inherent to the practice of data use. Therefore, this goal aims to explore whether the nature of teachers' data use can be considered consistent and stable, or whether it exhibits a changing or dynamic character with cross-overs between individual and collaborative data use practices.

2. *Examining learning activities in teachers' data use interactions*

   The second challenge in this dissertation will lie in the in-depth investigation of teacher collaboration and how such activities are perceived valuable for, *inter alia*, support, knowledge transfer and knowledge building. In other words, understanding (the value of) teacher collaboration in data use needs insights into the learning potential of collaborative activities. The emphasis in this regard will lie on *how* collaborative activities may serve the learning of teachers. Therefore, the second goal involves an elaboration on the learning activities that underlying data use collaboration.

3. *Investigating the relations between data use collaboration and teacher characteristics influencing data use*

   Next to understanding how teachers behave in data use, a focus in this dissertation will lie in grasping *why* certain teacher behaviour occurs in data use collaboration. In this regard, it is essential to investigate factors influencing data use collaboration. Given the great focus on teachers' attitude and self-efficacy as prerequisites for data use, it is needed to examine how these teacher characteristics affect data use in relation to data use collaboration. Therefore, an emphasis in this dissertation will lie in investigating the interrelationship between teacher characteristics and data use collaboration.

4. *Determining the impact of data use collaboration on teachers' professional learning*

   When the aim is to understand teachers' collaborative behaviour, it is essential to get some insights into the results of this behaviour. As this dissertation aims to *unpack* teacher collaboration in terms of learning activities, these activities can be better understood by also examining the professional learning outcomes such activities produce. In other words, which impact does data use collaboration have on teachers' cognition or behaviour? With the aim to evaluate how valuable teacher collaboration in data use can be considered, the focus need to lie on both the characteristics of teacher collaboration (i.e. their learning activities) *and* their impact on teachers professional learning (i.e. their learning outcomes). Therefore, the last aim of this dissertation is to determine the impact of data use collaboration in terms of professional learning.

Conceptual approach in this dissertation

A conceptual framework was designed in order to address the four central research goals in this dissertation (Figure 1). In this framework, theories out of the research field of data use and the research field of professional learning are combined. This provides valuable opportunities for both research strands.

First, the added value of data use for school improvement is mainly situated at teacher level, because data use activities are carried out by teachers. Particularly when it comes to the emphasis on teacher collaboration, understanding teacher behaviour can only be achieved by examining the context of collaboration and how it relates to effects at teacher level. Theories on workplace learning are particularly useful in this regard. More specifically, they provide us with handles to capture learning behaviour in data use collaboration and how it relates to teacher learning in terms of cognition and behaviour. As such, the processes and effects of data use can be approached at teacher level and combined to better understand teacher

behaviour in data use in relation to its effects. Thus, the introduction of theories of professional learning in the context of data use can provide an innovative lens to achieve better understanding of teacher behaviour and learning within the field.

Second, data use provides a valuable context to examine professional learning in. The use of data is a way of systematic learning about teachers' teaching environment and the learning of pupils within it. Therefore, the context provides opportunities to reach better understandings on how teachers interact with their environment in order to learn about and improve their professional behaviour. As such, deeper insights in the learning behaviour of teachers can be generated by embedding theories of professional learning in the context of data use. Given the complex transformation of data into knowledge and decisions, the context provides opportunities for further theory building on, for example, the dynamic character and interrelation of learning activities in dynamic contexts such as data use and into the impact of such learning activities on professional learning in terms of cognition and behaviour. As a result, the context of data use provides interesting opportunities to enlarge and refine the knowledge on professional learning in the field of teaching.

The theoretical approach of this dissertation is shown in Figure 1. Theories of professional learning are embedded within the general framework of data use to achieve a better understanding of teacher behaviour in relation to collaboration in data use. In addition, teacher characteristics of influence to data use will be used to explain this teacher behaviour. In the next sections, this conceptual introduction will elaborate on the conceptualization of the central concepts of this dissertation.

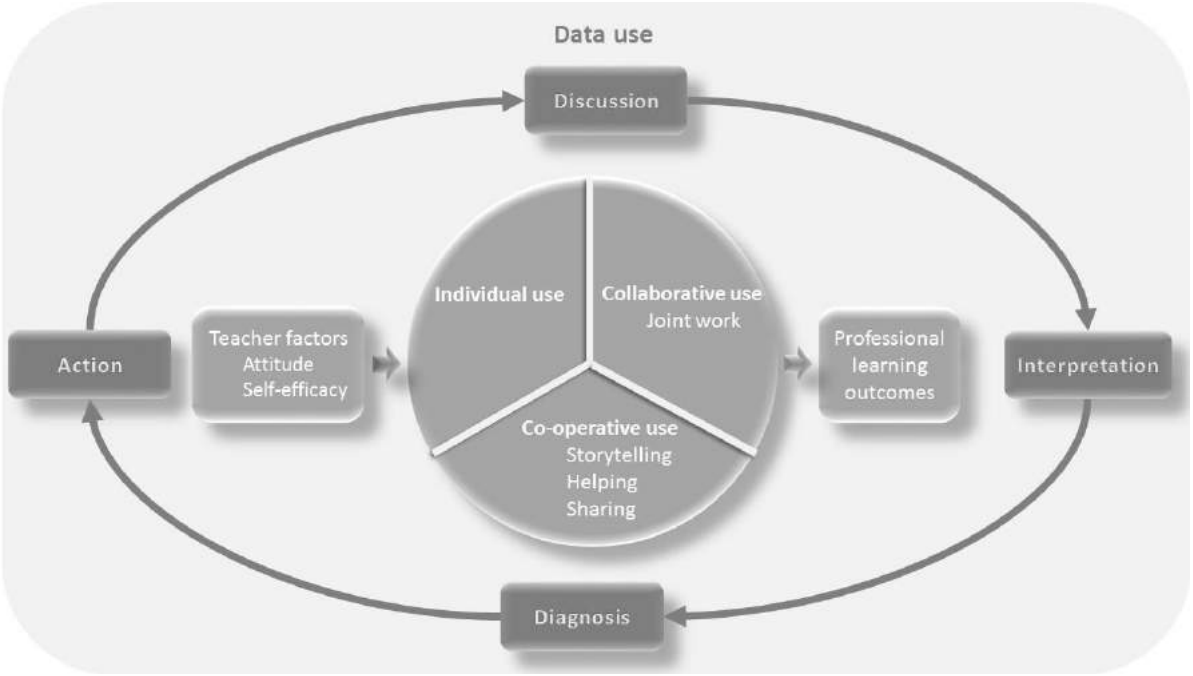


Figure 1. Conceptual framework of this dissertation

Data and data use

The concept of 'data' can refer to many different types of data on many different types of subjects and, therefore, requires clear boundaries. A common restriction to 'data' is its definition as standardized test data. However, such restriction does not do justice to the responsibility schools have to contribute to students' overall development (Schildkamp & Kuiper, 2010; Schildkamp, Rekers-Mombarg, & Harms, 2012). At the same time, for teachers,

data that reflect their students' functioning remain the most informative (Van Gasse et al., 2015).

In this dissertation, we will study 'pupil learning outcome data'. Pupils' learning is central to compulsory education. Moreover, although different types of data can be used to inform teachers, learning outcome data are the most important type of data teachers can use to evaluate whether their instructional goals have been achieved. Thus, pupil learning outcome data provide opportunities for teachers to learn about and improve their practice and enhance student achievement (Campbell & Levin, 2009; Carlson et al., 2011). Furthermore, our conceptualization of pupil learning outcome data is not restricted to cognitive indicators. In this dissertation, it will refer both to cognitive (e.g. linguistic and arithmetic skills) and non-cognitive learning outcomes (e.g. attitudes, art, and physical education). Such data can be distilled from quantitative (e.g. class tests) and qualitative (e.g. observations) sources.

The complexity underlying how data can be transformed into knowledge and decisions is often addressed by approaching data use through a circle of inquiry. Fixed data use phases guide teachers in the complex translation of data into meaningful decisions (Marsh et al., 2015). In so doing, teachers' tendency to quickly move from data to improvement actions without any in-depth consideration of potential causes and alternatives is halted (Schildkamp et al., 2016).

Although the merits of conceptualizing data use as an inquiry circle is emphasized in the field of data use, a remaining shortcoming of much research is that it often overlooks the conceptualization of different data use phases. Consequently, the process of data use remains a black box and people's behaviour is not specified in terms of the phases (Little, 2012). To elucidate teacher collaboration in detail, this dissertation will approach data use as an inquiry circle. As such, teacher behaviour can be evaluated in terms of the different knowledge and skills that define each data use phase.

An inquiry circle that is often drawn upon distinguishes the phases of data discussion, analysis, interpretation and action (Gummer & Mandinach, 2015; Marsh, 2012; Schildkamp et al., 2016). However, given teachers' difficulties with translating data into classroom interventions (Datnow & Hubbard, 2016; Gummer & Mandinach, 2015), we will use a conceptualization that is slightly different. This dissertation will distinguish the data use phases of discussion, interpretation, diagnosis and action (Verhaeghe et al., 2010). The rationale for this choice lies in the fact that teachers' often experience problems translating information into decisions or improvement actions, a translation that requires high-order pedagogical skills and thinking (Gummer & Mandinach, 2015). We believe that including a problem diagnosis phase provides teachers with extra guidance that will enable them to analyse data adequately and translate them into classroom interventions. Therefore, the phase of diagnosis is an important facilitator for data use action and is highly intertwined with analysis, whereby it broadens the scope of open-ended 'analysis' to more concrete determination of problems. Throughout this dissertation, the data use circle of inquiry begins with data initially being read and discussed. Subsequently, data are interpreted and transformed into information. Following this phase, potential causes and alternatives are deliberated upon in the diagnostic phase, culminating in the design and implementation of concrete improvement actions in teachers' practice (Verhaeghe et al., 2010).

Conceptual clarity in 'data use collaboration'

Although individual interpretation of data, data diagnosis and action are perfectly possible from a theoretical standpoint, individual performances in each of these phases are rarely described. More research focuses on how teams, or so called 'professional learning communities' engage

in data use discussion, interpretation, diagnosis and action. The main reason for this is that the conceptualization of data use as an inquiry circle is often used in research built around teams moving through the circle as a data use support intervention. Consequently, little knowledge is available on how teachers move through data use inquiry circles during their daily practice. Given that the first research goal is to explore the nature of teachers' data use, we will not focus our research on interventions designed to study data use. The aim is to explore individual teachers' daily practice regarding data use. A detailed description of everyday reality is needed to evaluate the potential data use has for teachers' decision-making and informed practices.

Thus far, a quite rigid distinction has been made between individual and collaborative data use. It is important, however, to emphasize that such a distinction is difficult to sustain when describing teachers' daily practice. Collaboration is often used as an umbrella term for data use activities that involve more than one actor. However, in its strictest sense, collaboration refers to long-term engagement between teachers, joint-goal setting and a shared responsibility for (collaborative) results (Hammick et al., 2009; Stoll et al., 2006; Seashore Louis, Dretzke, & Wahlstrom, 2010). Collaboration implies an intensive and ongoing involvement from the different actors. For example, a joint goal might be to improve pupils' writing skills. To this end, data can be used to collaboratively investigate which aspects of writing need to be better addressed. Subsequently, arrangements can be made among teachers regarding the strategies each will implement to improve their pupils' writing skills. However, some data use activities will involve numerous actors without being characterized by joint goals or any shared responsibility. Such activities will be constructed among teachers who are open and willing to work with each other, but who do not necessarily share common work-related goals (Hammick et al., 2009). In contrast to collaboration, these so-called co-operative activities have a 'loose' character as teachers work together on an occasional basis. Co-operative activities are individually steered, but involve (necessary) interactions to reach individual goals. For example, teachers might analyse pupils' mathematics exercises with the aim of improving their test scores. In so doing, they may find that a pupil makes similar mistakes every time. Consequently, colleagues can be consulted to discuss the appropriate remedy for this type of mistake.

Data use collaboration can involve many different types of activities steered from many different (individual or collective) goals. Therefore, the concept needs to be approached with sufficient granularity, which implies that it is necessary to eschew the strict distinction between individual and collaborative data use practices that has been used up until now. The strive towards conceptual clarity with regard to the concept of 'collaboration' implies that, during this dissertation, specific research questions and methodologies will affect the terminology used. The difficulty in this regard will be to create clear boundaries to the concept, depending on the questions under investigation, and to the types of 'collaboration' involved in this dissertation.

The first research goal in this dissertation implies that a large variety on data use practices will be described, ranging from individual to co-operative and collaborative data use. When the focus will come to lie on how teachers' interact in data use (i.e. research goals 2, 3 and 4), co-operative and collaborative data use practices will be described. As outlined above, the terminology used in this dissertation will not be fixed throughout the studies addressing the different research goals. Depending on the goal of the studies (e.g. more generic or specific examinations) and the unit of analysis (e.g. the population, individual teachers or interactions between teachers), the terminology will be different. In more generic cross-case descriptions of data use in which multiple teachers are involved, collaboration will be used as a container concept. For example, when the aim is to generate insights into the amount of individual data use compared to the amount of data use that involves multiple teachers, the specificity of

interactions is of less importance. In such cases, collaboration can be used as a container concept. However, more in-depth analyses on individuals' specific co-operative or collaborative activities, requires more accurate denominations of the concepts. For example, when the aim is to investigate how mutual activities among teachers change across the different data use phases (i.e. discussion, interpretation, diagnosis and action), more refined terminology is needed to address this question adequately. Therefore, in such sections throughout this dissertation, the use of 'interactions' becomes more appropriate to avoid conceptual haziness. Although a fixed terminology throughout this dissertation might be easier to follow, choosing to adapt terminology depending on the question examined does more justice to the complexity inherent in the concept of 'collaboration'.

Teachers' learning activities

This dissertation will draw on theories of workplace learning to provide insights into how teachers' data use activities contribute to professional learning. Specific to the concept of 'workplace learning' is that it is comprehensive and can be described from a variety of different angles (Bakkenes, Vermunt, & Wubbels, 2010; Hoekstra, Brekelmans, Beijaard, & Korthagen, 2009; Levine & Marcus, 2010; Meirinck et al., 2009a). However, a recurrent theme in the literature is that learning is situated within people's daily practice. Workplace learning generally includes informal activities in which people (in this case teachers) actively construct new knowledge, beliefs or behaviour (Kwakman, 2003; Roblin & Margalef, 2012; Meirink et al., 2009a). In this regard, two major foci can be distinguished in research: a focus on learning activities, or 'what people do to learn', and a focus on learning outcomes, or the results of learning activities.

The aim of this dissertation to gain in-depth understanding of teachers' collaborative activities in data use and their effect on learning, implies that a focus in this dissertation will lie on teachers' learning activities. This focus will address 'what teachers do' when using data that can be considered 'learning in the workplace'. The concern in this regard is to describe teacher behaviour without emphasizing the potential results of this behaviour. As such, in-depth insights into which collaborative data use activities can be considered learning activities will be generated.

Because teacher interactions will be studied in the context of teachers' daily practice a framework on learning activities was selected that clearly reflects teachers' social reality. Given that workplace learning occurs in the workplace, one cannot consider teachers' learning activities as strictly individual or collaborative. There are always potential relationships with colleagues to be formed, although this does not necessarily happen. Moreover, with certain colleagues deeper interactions may be established. Little (1990) developed a framework that is particularly useful to address this, because it includes both an individual and social perspective on learning. Depending on the level of interdependency, Little (1990) categorises four types of learning activities: storytelling, helping, sharing and joint work. Storytelling refers to daily conversations held by teachers in which rapid exchanges of information take place. Helping is about asking or giving help or advice to colleagues. Sharing includes the distribution of data, materials and methods. Joint work refers to collective purposes that result in truly collective action, such as work groups or agreements (Little, 1990). These collective purposes and action imply that only joint work can be considered as collaboration and storytelling, helping and sharing need to be classified as co-operative activities.

Little's (1990) framework is over 25 years old and has demonstrated its value in educational research over the years (Kwakman, 2003; Katz & Earl, 2010). Within the context of data use, the framework is useful because teachers' learning activities can vary depending on the data

use phase they are engaged in (discussion, interpretation, diagnosis or action). Discussing data can, for example, comprise different teacher interactions and learning activities than developing improvement actions based on pupil learning outcome data. Using a framework with interrelated learning activities is particularly useful in identifying small changes and variations in learning activities across the different data use phases. Moreover, Little's (1990) framework is particularly feasible to address the conceptual difficulties in the 'collaboration' concept, and, as such, provides appropriate handles to investigate the concept in-depth.

Attitude and self-efficacy as factors of influence

To increase the understanding of teacher behaviour in the context of data use, this dissertation will investigate the impact of teachers' attitude and self-efficacy on their use of pupil learning outcome data. The literature has shown that attitude and self-efficacy have a substantial influence on teacher behaviour in data use (Datnow & Hubbard, 2016; Datnow et al., 2013; Hubbard et al., 2014). Moreover, attitude and self-efficacy are explicitly important in terms of their interrelationship with teacher interactions. A positive attitude towards data use and self-efficacy are considered prerequisites for teacher interactions in the context of data use (Datnow et al., 2013; Hubbard et al., 2014).

In this dissertation, teachers' attitude towards data use refers to their conceptualization of data use. It encompasses the beliefs, models, preferences and other aspects that determine what teachers think about data use and its contribution to improving their practice (Vanhoof et al., 2014). Although attitudes also have an affective component, we will focus on the cognitive aspect of this concept. This is justifiable in that it has primarily been teachers' willingness to use data that is generally seen as a prerequisite for data use, and only to a lesser extent how they enjoy using data (Kowalski & Lasley, 2009; Van Gasse et al., 2015). A positive attitude is indispensable for teachers wishing to engage in interactions (Datnow et al., 2013; Young, 2006). With such an attitude, teachers will engage in conversational routines to enhance their knowledge and skills around data use, and are willing to face potential interpersonal conflicts for the sake of school improvement (Datnow et al., 2013; Young, 2006).

In combination with attitude, teachers' self-efficacy is an important factor explaining their data use. The concept of self-efficacy refers to the extent to which teachers consider themselves competent in a certain context (Bandura, 1997; Deci & Ryan, 2000; Woolfolk, 2008). In this dissertation, teachers' self-efficacy refers to how capable teachers consider themselves to be when using data. Feeling capable of using data bears tremendous importance for the data being used. Teachers are not likely to use data when they doubt their knowledge and skills around data use (Pierce & Chick, 2011). Therefore, positive self-efficacy is crucial for data use. This is especially the case for data use interactions, where teachers' beliefs about their own competence in using data is even more important than their actual knowledge and skills (Datnow et al., 2013).

Professional learning outcomes

To better understand the value of teacher collaboration, this dissertation will address how data use interactions contribute to teachers' professional learning. Thus, next to the focus on learning activities in teachers' data use, this dissertation incorporates the focus on learning outcomes, or the impact of data use activities on the cognition and behaviour of teachers.

At teacher level, learning outcomes have often been considered as a form of change, for example changes in thinking, in strategies or in behaviour (Bakkenes et al., 2010; Hoekstra et al., 2009; Katz et al., 2008; Levine & Marcus, 2010; Meirink et al., 2009b; Zwart, Wubbels,

Bergen, & Bolhuis, 2007). However, in the context of data use, describing teachers' learning outcomes as 'change' may represent a too narrow a view of reality. Much of what teachers learn by using data will be about instructional practices that are proceeding well. After all, we believe that teachers possess knowledge and skills that enable them to develop high-quality instructional practices after graduation. We do not expect data to persuade teachers that many instructional practices should be changed, but we do expect data to provide teachers with insights into what is working well and what can be improved. For example, when math teachers consult each other to select appropriate remedial exercises for pupils after a diagnostic test, it might not feel to them like 'learning something new'. However, such interactions may contribute to applying already internalized knowledge adequately. Therefore, in the context of data use, learning needs to be conceptualized broader than 'changes' in cognition and behaviour.

This dissertation has found merit in a framework that encompasses both changing and maintaining instructional practices. Zwart et al. (2008) included both the change- aspect and the confirmation-aspect in their list of professional learning results. They determined that change can occur by means of new ideas, conceptions or beliefs, which can then be translated in practice, changed ideas of the self, intention to change practices or a greater consciousness. On the other hand, confirmation can also be a learning result in the form of confirmed ideas, conceptions or beliefs that can also be translated into practice. As such, the framework is particularly useful for the conceptualization of learning outcomes in the context of data use.

The previous paragraphs have provided a broad introduction to the key frameworks that have informed this dissertation. We have explained our approach to data use, its influencing factors, and how we can investigate teacher learning in the context of data use. The introduction to these frameworks serves as a frame of reference to structure our thinking. In the following chapters, the frameworks will be further elaborated in terms of the different studies conducted in this dissertation. Each of the studies will draw deeply on one or more of these frameworks. The following sections will outline how this dissertation is built conceptually and methodologically, taking into account the four central research goals.

Approach to answer the central research goals

Five empirical studies were used to accomplish the central research goals. An overview of how the central research goals were translated into empirical studies is presented in Table 1. The five empirical studies create a funnel regarding the unit of analysis in this dissertation. This funnel is the result of conceptual considerations. On the one hand, generic insights are needed in order to broaden knowledge on how teachers use data in Flanders and the role of collaboration in this data use. This implies that generic insights across schools and teachers are generated, which is achieved via the first two studies. On the other hand, the aim in this dissertation is to create conceptual clarity with regard to data use collaboration and to unpack activities and evaluate them depending on their level of interdependence. To this end, a closer view is needed on interactions in teams, so that the focus will come to lie on examining how teacher interactions are formed within teams. In addition, greater understanding of such data use interactions are formed when it becomes clear in which effects they result. Therefore, the last study takes the individual within the team as the unit of analysis. This study aims to provide insights into the effects of teachers' data use interactions at teacher level. The combination of different units of analysis provides opportunities to gain deep comprehension of teachers' data use interactions, as more generic insights are needed to get to know common practices across schools and teachers and specific insights at team and teacher level are essential to understand teacher and team behaviour.

Three of the four research goals will be addressed by using multiple foci. For example, the first research goal (i.e. on the nature of teachers' data use and its dynamics), will be addressed by studies with a general focus and a study with a team focus. Research goals 2 and 3 are addressed similarly, in a sense that generic analysis will be combined with specific analysis at team or individual level for more in-depth understanding. The fourth research goal will only use individual teachers as the unit of analysis given its specific teacher-level formulation. The combination of different units of analysis in the approach to answer the research goals ensures triangulation and cross-validation of the research results.

Table 1. The different studies and foci in relation to the research goals

	Study 1: The impact of collaboration on teachers' individual data use	Study 2: Individual, co-operative and collaborative data use: a conceptual and empirical exploration	Study 3: Unravelling data use in teacher teams: How network patterns and interactive learning activities change across different data use phases	Study 4: Teacher interactions in taking action upon pupil learning outcome data: A matter of attitude and self-efficacy?	Study 5: Teacher collaboration on pupil learning outcome data: A rich environment for professional learning?
	General focus		**Team focus**		**Individual focus**
1. Explore the nature of teachers' data use and its dynamics.	X	X	X		
2. Examine learning activities in teachers' data use.		X	X		X
3. Investigate the relations between collaboration and teacher characteristics that influence data use.	X			X	
4. Explore the impact of collaboration on teachers' professional learning.					X

The funnel regarding the unit of analysis in this dissertation has implications for the methodologies used to approach the research goals. Various methodological approaches will be used in this dissertation to address these different research aims. The goal is to construct a more objective investigation by means of triangulation of different types of self-report data. Therefore, different research designs were employed depending on the research goal (Table 2).

The first research goal ('explore the nature of teachers' data use and its dynamics) was investigated using a combination of quantitative research, qualitative research and social network analysis. Descriptive statistics (quantitative research) provide a substantial overview on the nature of data use by teachers. Later in the dissertation, further insight will be provided

into the meaning of these statistics through the analysis of in-depth interviews (qualitative research). Additionally, the quantitative research findings will be refined by means of social network analysis. Social network analysis is a method that maps and investigates interactions (so called 'ties') between individuals (actors or 'nodes') (Borgatti, Everett, & Johnson, 2013). It obtains information from both actors in an interaction. As such, social network analysis provides opportunities for highly detailed insights into interactions.

The second ('examine learning activities in teachers' data use') and fourth research goals ('explore the impact of collaboration on teachers' professional learning') include a cross-over between the field of data use and the field of professional learning. These goals require a description of process characteristics (i.e. learning activities) and outcomes (i.e. professional learning) of teachers' learning within the context of data use collaboration. The unit of analysis in these research goals is that of individual teachers. To provide an in-depth investigation of professional learning, one-to-one interviews were conducted (qualitative research).

To achieve the third research goal ('investigate the relations between collaboration and teacher characteristics that influence data use'), a combination of quantitative research and social network analysis were conducted. In line with the other approaches in this dissertation, a large-scale quantitative analysis forms the basis upon which to investigate how teacher characteristics influence collaborations in data use. This knowledge is refined further in the dissertation by means of social network analysis.

Thus, from a methodological viewpoint, this dissertation strives to achieve a balance between generic and in-depth research. Approaches that aim to generalize findings (i.e. quantitative approaches) are used to inform further in-depth methods of investigation (i.e. qualitative analysis and social network analysis).

Table 2. Methodologies used for the different research goals

		Quantitative research	**Qualitative research**	**Social Network Analysis**
1.	Explore the nature of teachers' data use and its dynamics.	X	X	X
2.	Examine learning activities in teachers' data use.		X	
3.	Investigate the relations between collaboration and teacher characteristics that influence data use.	X		X
4.	Explore the impact of collaboration on teachers' professional learning.		X	

General focus in this dissertation

In the first part of this dissertation, a general focus guides the first two studies. These studies address the first three research goals from a bird's eye view as they explore the nature of teachers' data use in a general way, across schools and teachers. The aim is to examine whether there is an interactive component in teachers' data use, how this component is related to teachers' individual data use and the individual characteristics that influence data use, and

which learning activities are embedded in the way teachers use data interactively. Therefore, the first part of this dissertation is built around the following studies:

Study 1 addresses the importance of collaboration. Using large scale survey data, it provides insights into the impact of collaboration on teachers' individual data use and the extent to which attitude and self-efficacy serve as prerequisites for individual and collaborative data use practices. To this end, a path model, using Structural Equation Modeling (SEM) was conducted.

Study 2 adds clarity to the conceptualization of 'collaboration'. Using in-depth qualitative interviews, different types of interactions are investigated in a data use context and categorized according to the level of interdependence between teachers. The level of interdependence in teachers' data use interactions then serves as a framework through which to examine their learning activities.

Team focus in this dissertation

In the second part of this dissertation, the general focus on teacher interactions as the unit of investigation transfers to teacher teams. In this part of the dissertation, the aim is to explore and explain different types of data use interactions within teacher teams. Insights that were generated in the first two studies will be further elaborated and complemented by social network analyses to deepen our knowledge of interactions in these teams. Two studies comprise the second part of this dissertation:

Study 3 focuses on how networks of teacher teams change across different phases of data use, both in terms of structural interaction patterns and the interactive learning activities that are undertaken. In this study, social network analysis is combined with qualitative data to explore the dynamics in data use interaction, both from a structural point of view and in terms of learning activities. A Stochastic Actor Oriented Model is designed to evaluate changes in interactions in teams during data discussion, interpretation, diagnosis and action. Complementary, teachers' learning activities during these phases are analysed using qualitative analysis to capture the stories behind changing patterns.

Study 4 scrutinizes the data use action network of teacher teams and explains teachers' interactions in terms of their attitude towards data use and their self-efficacy. Exponential Random Graph Models (ERGMs) are used to explore how attitude and self-efficacy affect the way interactions are conducted in teams. The merit of this social network approach, compared to a purely quantitative analysis, is that the social network approach takes interaction as the unit of analysis. The ERGM refines and complements the SEM analysis in study 1 by providing insight into how attitude and self-efficacy affect teachers' tendency to consult colleagues, their tendency to be consulted by colleagues and their tendency to engage in interactions with similar others. The distinction between these three aspects can never be determined using a purely quantitative approach (SEM analysis).

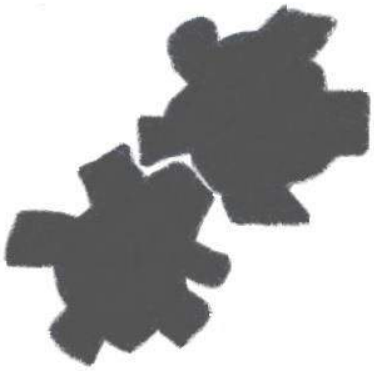
Individual focus in this dissertation

In the final part of this dissertation, the focus lies on the individual within the team. The central research goal in this study is to investigate the impact of teacher interactions on professional learning. Insights into the network activities of teachers will be combined with self-reported gains in professional learning. To this end, study 5 concludes the empirical part of this dissertation.

Study 5 examines teachers' interactive activities and professional learning gains. In-depth qualitative interviews provide insight into the interdependence in teachers' network activities and self-reported learning at cognitive, attitudinal and practical levels. As such, the study provides insights into the effects of current data use interactions on teachers' professional learning.

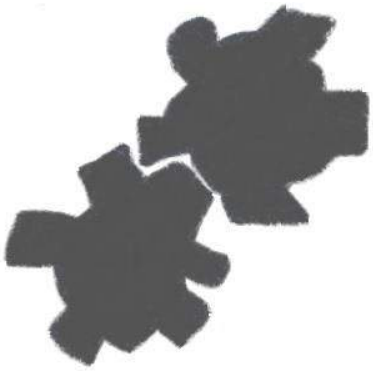
Each empirical study forms a self-contained chapter within this dissertation. This implies that every chapter (or study) can be read as a separate story. Consequently, a degree of overlap in conceptual and methodological approaches may occur across the chapters.

To conclude this dissertation, the final chapter will provide an overview of the main findings and how these have addressed the general research goals. The chapter then moves on to discuss the central lessons to be learnt from this dissertation as well as implications for research, policy and practice.



Study 1:

The impact of collaboration on teachers' individual data use



Abstract[2]

Research considers collaboration to be a significant factor in terms of how teachers use data to improve their practice. Nevertheless, the effects of teacher collaboration with regard to teachers' individual data use has remained largely underexplored. Moreover, little attention has been paid to the interplay between collaboration and the personal factors that influence teachers' data use. This paper addresses this research gap by defining factors that affect collaboration, and by investigating the impact of collaboration on teachers' individual data use. The resulting research questions were answered by drawing on questionnaire data from 1,472 primary and secondary school teachers in Flanders. The findings indicate that collaboration is the main explanatory factor for teachers' individual data use compared to teachers' self-efficacy and attitude. Therefore, this study demonstrates the value of collaboration for future research and for creating a supportive environment for teachers' individual data use.

Introduction

Over the years, there has been increased interest in teachers' data use because of its potential benefits for student achievement (Campbell & Levin, 2009; Carlson, Borman, & Robinson, 2011). Cognitive and non-cognitive learning outcome data are generally seen as informative for teachers in terms of developing and improving their practice. Therefore, the amount of literature on this topic has expanded recently (Jimerson, 2014). To date, international researchers have demonstrated a rather pessimistic state of the art regarding teachers' use of data in general, and of teachers' use of pupil learning outcome data in particular (Schildkamp, Visscher, & Luyten, 2009; Vanlommel, Vanhoof & Van Petegem, 2016; Verhaeghe, Vanhoof, Valcke, & Van Petegem, 2010).

Recently, a change of direction from descriptive to explanatory research with regard to teachers' data use has been introduced. In the literature, we find two main pathways to explain teachers' (non-) use of data. First, the authors generally point to personal factors as influences for the (non-) use of data. For example, teachers' limited confidence in their capacity to use data appropriately (self-efficacy) can result in data remaining untouched (Pierce & Chick, 2011; Schildkamp, Ehren, & Lai, 2012). Second, school-wide collaboration on data use has often been considered to be influential for teachers' data use (Daly, 2012; Marsh, 2012; Young,

[2] This chapter is based on:

Van Gasse, R., Vanlommel, K., Vanhoof, J. and Van Petegem, P. (2017). The impact of collaboration on teachers' individual data use. *School Effectiveness and School Improvement, 28*(3), 489-504. doi: 10.1080/09243453.2017.1321555.

2006). Collaboration involves internal support among teachers, alignment in terms of norms and agendas, and a shared responsibility with regard to data use (Datnow, Park, & Kennedy-Lewis, 2013; Farley-Ripple & Buttram, 2014; Hubbard, Datnow, & Pruyn, 2014; Jimerson, 2014). Therefore, collaboration is considered an important factor in terms of overcoming barriers deriving from personal factors that influence teachers' data use. Moreover, collaboration is assumed to shape fundamental conditions for teachers' data use, since collaboration on data use requires a high degree of teacher involvement and more perseverance in terms of implementing improvement actions (Blink, 2007; Jimerson, 2014; Verhaeghe, Vanhoof, Valcke, & Van Petegem, 2011; Wayman, Jimerson & Cho, 2012).

Although the aforementioned pathways are suggested in explanatory research, the interrelationship between each of them has not been sufficiently explored. Despite the attention attached to teachers' personal factors in terms of data use, little is known about the interplay of these factors with regard to collaboration. Yet literature has suggested that there are two specific personal factors that can be related to teacher collaboration in the context of data use. More than other personal factors, a positive attitude towards, and self-efficacy in terms of data use are identified as prerequisites for teacher collaboration in the context of data use (Datnow et al., 2013; Hubbard et al., 2014). Therefore, knowledge is needed on how teachers' attitude and self-efficacy and their collaboration in terms of data use are interrelated, in order to provide a deeper understanding of the importance of collaboration in creating a supportive data use environment. Furthermore, despite the interest attached to collaboration in the data use literature, researchers have not specifically focused on the effect of collaboration on teachers' individual data use. Nevertheless, it is necessary to examine the assumption that collaboration creates a supportive and stimulating environment for teachers in their use of data (Daly, 2012; Marsh, 2012; Young, 2006). Therefore, insight into the impact of collaboration on teachers' individual data use is essential. Moreover, this knowledge would expand our understanding of the potential sustainability of interventions that are built on collaboration, in order to create a supportive data use environment in schools.

The present study addresses the aforementioned research gaps by investigating the extent to which teachers collaborate in the context of data use, the impact of teachers' collaboration on their individual data use and the explanatory value of self-efficacy and attitude for teachers' collaboration. Given the impact of attitude and self-efficacy on teachers' data use, we hypothesize that differences in teachers' collaboration with regard to data use can be the result of variety in these factors (Datnow et al., 2013; Datnow & Hubbard, 2016). That is why we will examine the impact of attitude and self-efficacy on (1) collaboration and (2) teachers' individual data use.

These main research objectives lead to the following research questions:

1. To which extent does collaboration take place among teachers in the context of data use?
2. To which extent does collaboration affect teachers' individual data use?
3. To which extent do teachers' self-efficacy and attitude affect (a) collaboration and (b) teachers' individual data use?

In the next sections, we will first clarify the central concepts and hypotheses associated with this study. Then, we will describe the research approach we adopted. Subsequently, we will provide insights into teachers' collaboration on data use and how it is affected by self-efficacy and attitude, and into the effects of teachers' collaboration on their individual use of data. Conclusions will be drawn from the research results. We will also consider the limitations of the research and implications for further research.

Theoretical framework

In this section we will provide an overview of the literature with regard to what is known about collaboration in the context of data use, and on how collaboration can affect teachers' individual data use. Finally, we will describe the concepts of self-efficacy and attitude in the context of data use, and formulate hypotheses on how these factors can affect collaboration and teachers' individual data use. Figure 1 visualises the theoretical approach of this study.

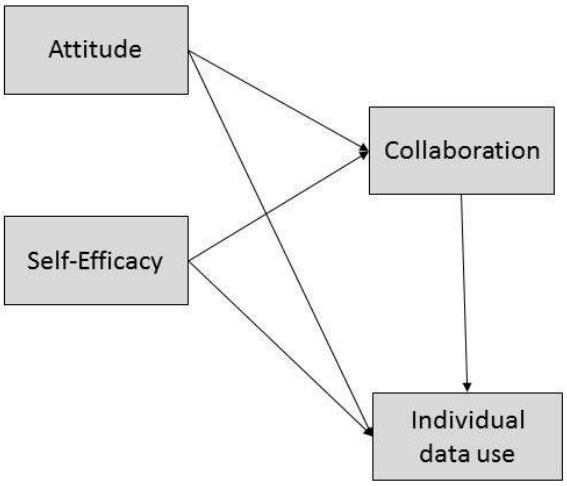


Figure 1. Theoretical framework.

Teachers' individual data use

Data use has been described as a cyclical process, in which the phases of discussing, interpreting and diagnosing data and taking action follow on from each other (Verhaeghe et al., 2010b). Data use can involve the use of several types of data - both qualitative and quantitative - that are informative for schools and teachers (Hulpia, Valcke, & Verhaeghe, 2004; Schildkamp & Kuiper, 2010).

With regard to teachers' individual data use, this study focuses on a type of data that is generally seen as being highly informative to teachers: pupil learning outcome data. Given the potential of this type of data for improving teachers' practice and eventually pupils' achievement (Campbell & Levin, 2009; Carlson et al., 2011), several studies have investigated teachers' use of learning outcome data (Jimerson, 2014). Research often delimits this concept to cognitive output indicators, which is criticized because these indicators in themselves fail to provide a complete picture of a pupil's learning (Schildkamp et al., 2012; Schildkamp & Kuiper, 2010). Therefore, we include cognitive outcomes (i.e. linguistic and arithmetic skills) as well as non-cognitive learning outcomes (i.e. attitudes, art and physical education) in our conceptualization of teachers' individual data use. Additionally, learning outcomes are not narrowed down to quantitative data (e.g. class tests). In addition, qualitative data (e.g. observations) fit into our conceptualization.

Collaboration

Collaboration is a concept that is strongly dependent on the context in which it is embedded (Datnow et al., 2013; Kelchtermans, 2006; Little, 2012; Spillane, 2012; Stoll, Bolam, McMahon, Wallace & Thomas, 2006). Therefore, a universal definition of the concept is not readily available.

The idea of collaboration in the context of data use is that a group of individuals initiates and undertakes data use processes, with the specific aim of problem solving or sharing expertise (Hammick, Freeth, Copperman, & Goodsmith, 2009). In the context of data use, this means that the initiation of data use inherits a shared responsibility (Stoll et al., 2006). Among teachers, the shared responsibility for data use generally lies in student learning (Louis, Dretzke, & Wahlstrom, 2010; Wahlstrom & Louis , 2008).

Next, collectively undertaking processes involving data use (collaboration) implies that more dense connections are present among teachers. Teachers build constructive relationships through conversations with colleagues (Louis et al., 2010; Stoll et al., 2006). These relationships allow them to better apply one-another's strengths with regard to data use (Datnow et al., 2013; Jimerson, 2014; Young, 2006) and to engage in processes of knowledge creation and knowledge sharing (Datnow et al., 2013; Farley-Ripple & Buttram, 2014; Hubbard et al., 2014; Louis et al., 2010; Stoll et al., 2006). Furthermore, collaborative processes in the context of data use provide teachers with help or support. Colleagues work with one-another in processes of analysing and interpreting data or introducing improvement actions (Datnow et al., 2013; Farley-Ripple & Buttram, 2014; Hubbard et al., 2014; Jimerson, 2014).

Many forms of collaboration are possible in the context of data use (Wayman & Jimerson, 2014). Transcending the differences between several forms of collaboration, it can be seen as a way of structural support for data use. Collaboration allows teachers how to learn to engage in data use and use it as a source of support when needed (Farley-Ripple & Buttram, 2014; Jimerson, 2014; Young, 2006). Several studies have attributed teachers' individual data use to the existence of collaboration (Datnow et al., 2013; Hubbard et al., 2014; Jimerson, 2014). Engaging in collaboration in the context of data use motivates teachers to use data in order to improve their instruction (Young, 2006). That is why we assume that collaboration affects teachers' individual data use in a positive manner.

Attitude and self-efficacy

This study focuses on the interplay between collaboration and person-related factors in the context of data use. Although the data use literature suggests an extensive list of influential person-related factors with regard to individual data use (Datnow & Hubbard, 2016; Vanlommel et al., 2016), few studies indicate a relationship between person-related factors and collaboration with regard to data use.

Two factors are explicitly mentioned as influencing collaboration in the context of data use: attitude and self-efficacy (Datnow et al., 2013; Hubbard et al., 2014; Kelchtermans, 2006). A positive attitude towards data use is seen as indispensible for teachers for them to engage in collaboration (Datnow et al., 2013; Young, 2006). Lack of knowledge and skills with regard to interpreting data can be moderated in collaborative settings through conversational routines. However, only teachers with a positive attitude towards data use will engage in such conversations, and will be willing to face interpersonal conflicts for school improvement (Datnow et al., 2013; Young, 2006). Also positive self-efficacy is crucial for collaboration in the context of data use. According to Datnow et al. (2013), believing that data can be used properly is particularly more important for persuading teachers to engage in collaboration than teachers'

actual knowledge and skills in handling data. By means of discussion, 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).

Attitude

Attitude is generally seen as an important factor in terms of influencing teachers' data use (Datnow & Hubbard, 2016; Schildkamp & Kuiper, 2010; Verhaeghe et al., 2010). Attitude denotes the teacher's cognitive picture of data use, which can be described as his or her knowledge about this subject. It 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 (Vanhoof, Vanlommel, Thijs, & Vanderlocht, 2014).

A negative attitude towards data use is generally seen as one of the main barriers to teachers' data use (Datnow & Hubbard, 2016; Vanhoof et al., 2014; Verhaeghe et al., 2010). Empirical research suggests that data use is hindered when teachers, for example, do not believe in fair data for (some types of) students (e.g. learning outcome data of low SES students), do not believe that some aspects of schooling are measurable (e.g. learning progression of students) or are not convinced that data use can improve teaching and learning within the school. A negative attitude therefore causes such data to remain unused (Kowalski & Lasley, 2009; Schildkamp et al., 2012). The general assumption is that a positive attitude is an important precondition for teachers' data use (Datnow & Hubbard, 2016; Schildkamp & Kuiper, 2010; Verhaeghe et al., 2010). Little is known about how attitude impacts various data use processes differently (e.g. individual or collaborative data use). Therefore, following the assumption that a positive attitude is a necessary condition for teachers to engage in any type of data use, we hypothesize that a positive attitude on the part of teachers with regard to data use will affect various kinds of data use they engage in (i.e. both individual and collaborative data use).

Self-efficacy

Next to the attitude of teachers, self-efficacy impacts on teachers' use of data (Datnow & Hubbard, 2016). Self-efficacy denotes the way in which data users see themselves as 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). From this point of view, we hypothesize that teachers' self-efficacy impacts on their data use positively (Vanhoof et al., 2014). The positive impact of teachers' self-efficacy on data use has been found (or documented), both in studies on individual data use (Vanhoof et al., 2014) and on collaborative data use (Datnow et al., 2013). Therefore, similarly to teachers' attitude, their self-efficacy can be seen as a precondition for different types of data use. Following the assumption that teachers' self-efficacy affects engagement in any type of data use, we hypothesize that self-efficacy both impacts individual and collaborative data use of teachers.

Method

Context of the study

This study took place in Flanders, which has, compared to the surrounding countries, a specific context in which to study data use. The Flemish government wields a rather school improvement oriented perspective with regard to data use. Whereas standards are defined at the end of secondary education, schools are autonomous as to how to achieve these standards (the curriculum) (Penninckx, Vanhoof, & Van Petegem, 2011). In addition, central exams do not exist. Therefore, no public databases or rankings of schools are available (Organisation for Economic Co-operation and Development (OECD), 2014). Schools themselves are responsible for obtaining insight as to whether or not they have achieved the Flemish standards at the end of secondary education. Thus, government expectations with regard to data use are rather implicit, and the responsibility for using data and the support for data use lies with individual schools and teachers.

Participants

In this study, we made use of a quantitative research approach, involving an online survey. Questions were included on teachers' individual data use, collaboration in the context of data use, and teachers' attitude and self-efficacy with regard to data use.

The target population consisted of Flemish teachers in primary and secondary education. In order to generate a representative sample, we stratified for the school's network (i.e. schools providing a Catholic education, schools from Flemish cities and provinces, and GO! education of the Flemish community), school size and school type (i.e., schools offering academic or vocational education). A total of 1,472 teachers, from 63 primary schools and 54 secondary schools, participated in the study. A response rate of at least 50% was required for schools to be included in the analyses of this study. In the majority of the schools (68%), a participation ratio of at least 70% was achieved. Our sample consisted of 22.2% male and 77.8% female participants: 77% of the participants hold a bachelor's degree and 22% participants a master's degree, 26% are beginning teachers (less than 5 years of teaching experience) and 74% are experienced teachers (more than 5 years of teaching experience). Generally, a representative sample for Flanders was achieved despite a slight oversizing of the share of beginning teachers.

Instrument

Most of the scales in the questionnaire were derived using existing and validated survey instruments (Vanhoof et al., 2014; Vanhoof, Van Petegem, Verhoeven, & Buvens, 2009). Only the scale regarding teachers' individual data use was developed and validated during this study. For all scales a 5 point Likert scale was used (1- entirely disagree, 2 - disagree, 3 - partly disagree/partly agree, 4 - agree, 5 - entirely agree) with an additional category 'don't know/inapplicable'.

The construct validity of the instrument was tested through a confirmatory factor analysis. For all items, the cutoff factor loading on the latent concept was set at 0.50. Fit indices that were taken into account to evaluate the validity of the instrument were the Comparative Fit Index (CFI), the Tucker Lewis Index (TLI) and the Root Mean Square Error of Approximation (RMSEA). Chi^2 was not included given the potential bias due to the sample size (Barrett, 2007). For the CFI and TLI a cutoff of 0.95 was used (Schumacker & Lomax, 2004), which was

exceeded for both indices (CFI: 0.98 and TLI: 0.97). For the RMSEA, a cutoff of 0.05 was taken into account (Chen, Curran, Bollen, Kirby, & Paxton, 2008). The RMSEA-value of 0.04 thus indicates a good fit. In sum, the confirmatory factor analysis confirmed the validity of the instrument.

Additionally, we calculated the Cronbach's alpha values in order to evaluate the reliability of the instrument (see Table 1). The Cronbach's alpha value of 0.65 indicates a reasonable reliability for the scale 'teachers' individual data use', given the small number of items (2) (Sijtsma, 2009; Tavakol & Dennick, 2011). The reliability of the other scales can be evaluated as good to very good, given the range of the Cronbach's alpha values, ranging from 0.89 to 0.93 (DeVellis, 2012). Table 1 provides an overview of the scales that were included in the questionnaire with an indication of their Cronbach's alpha values.

Table 1: Psychometric characteristics and descriptive statistics of the different scales

	items	n	Ave	SD	Cronbach's alpha
Individual data use *I use data about the cognitive results of pupils to shape my practice.*	2	1417	3.77	0.79	0.65
Collaboration *In our school, we make good use of the expertise of others to analyse data.*	6	1257	3.41	0.88	0.93
Self-efficacy *I see myself as able to handle data appropriately*.	5	1396	4.02	0.57	0.93
Attitude *I am convinced that the use of data in schools is valuable.*	3	1421	4.28	0.61	0.89

Analyses

In order to answer the first research question, we looked at the descriptive statistics of the different scales. The second and third research question were analysed using Structural Equation Modeling (SEM). Given the fact that we were analysing teachers within schools, the nested structure of the data was taken into account (TYPE = COMPLEX in Mplus). A path model was built, including the five relationships that resulted from the theoretical framework (Figure 1). In the analysis, the measurement model behind each variable (several manifest items measuring a latent variable) was modelled to become a veracious conceptual representation of reality, and to account for error in the different scales used. Taking into account the fit indices, the path model was found to fit well to the empirical data (RMSEA = 0.02; CFI = 0.97 and TLI = 0.97).

Results

We will begin by presenting the descriptive results for the different variables. The descriptive results on collaboration in the context of data use provide an answer to our first research question. We will then go on to the explanatory results, which will provide insight into the answers regarding the second and third research question.

Descriptive results

An overview of the descriptive results is provided in Table 1. With regard to teachers' individual data use, we find a moderately positive average scale score (ave = 3.77). Thus, teachers

indicate that they use cognitive (i.e. linguistic and arithmetic skills) and non-cognitive learning outcome data (i.e. attitudes, art and physical education) to a certain extent. Taking into account the frequencies, close to 64% of the teachers surveyed largely/entirely agree with the statements included about their use of data to shape their practice. This result indicates that there is also a fairly large number of teachers who reacted neutrally or negatively to these items (36%). Hence, teachers use learning outcome data to shape their practice to some extent, but we cannot call it a standard practice.

Overall, teachers respond neutrally to moderately positively to the subject of collaboration in the context of data use. The average of 3.41 implies that teachers neither agree nor disagree that support is provided with regard to analysing and interpreting data, that data use is a responsibility of the whole school team, or that teachers collaborate intensively with regard to data use. The frequency measures underpin this result. Only 32.7% of the surveyed teachers largely/entirely agree with the items on collaboration with regard to data use. This means that the average score of 63.7% of the participants is neutral to negative for this variable. We thus find that collaboration among teachers is relatively uncommon.

Teachers respond positively to questions related to person-related factors that might influence data use. We find that teachers generally believe that data use is valuable and that they usually perceive themselves as capable of handling it, as indicated by the averages of the attitude scale (ave = 4.28) and the self-efficacy scale (ave = 4.02).

In sum, these results indicate that teachers take a fairly positive stance towards data use. However, this positive stance towards data use does not lead to data use being a common practice among teachers. Also, with regard to our first research question, teachers do not appear to collaborate extensively in the context of data use. Thus, in Flemish schools, a stimulating and supporting environment in the form of collaboration with regard to data use is not common among teachers.

Explanatory results

The path model is summarised in Figure 2. The direct effect of attitude on teachers' use of learning outcomes was excluded from the model because of the statistical insignificance of this effect ($p > 0.05$).

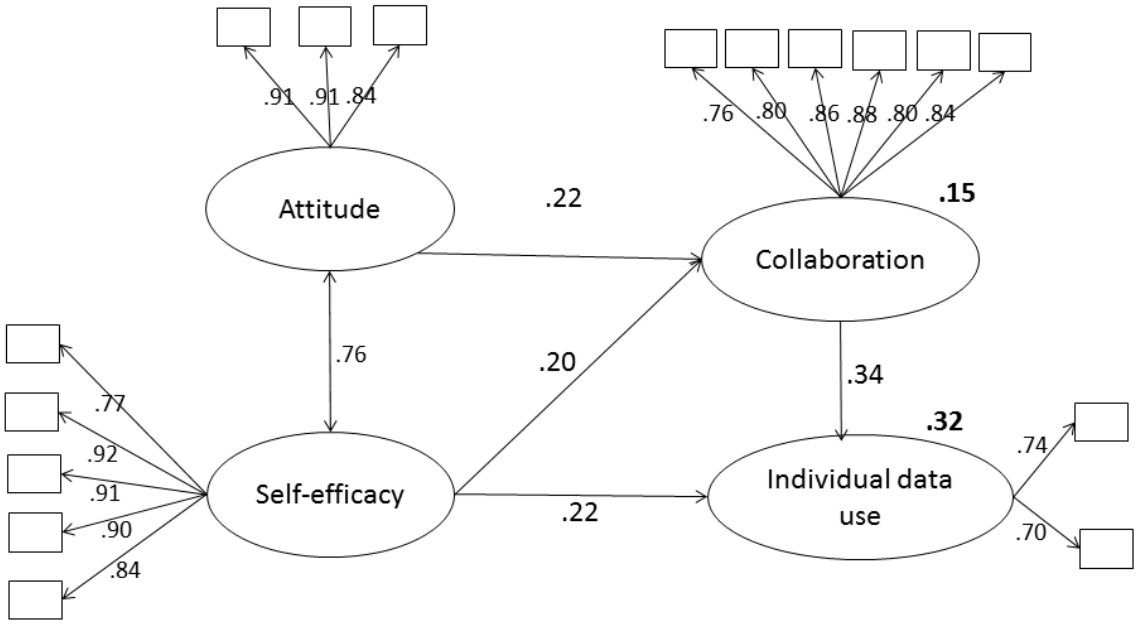


Figure 2. Explanatory results.

The path model first confirms our assumption that collaboration in the context of data use affects teachers' individual data use. More specifically, we find that collaboration bears a statistically significant positive relationship to teachers' individual data use. Teachers who collaborate to a greater extent in the context of data use also make more use of data to inform their individual practice. This relationship is characterized by a medium effect size. The regression coefficient of 0.34 indicates that close to 11% of the variance in teachers' individual data use can be explained by collaboration.

A second finding is that attitude does not affect teachers' individual data use directly. However, it does affect it indirectly. This effect runs through collaboration. The path model shows a statistically significant positive relationship between attitude and collaboration. In other words, the more teachers perceive data use to be valuable, the more collaboration on data use they report, and the more they say that they use data to inform their individual practice. The effect of attitude on collaboration on data use is small (β = 0.22). Only 5% of the differences in the extent of teacher collaboration can be explained by teachers' attitude towards data use. It is remarkable to find that the effect of attitude on teachers' individual data use is small in our sample, and that this effect only results from collaboration instead of affecting teachers' individual data use directly.

Thirdly, the results confirm both of our hypotheses regarding self-efficacy. We find that self-efficacy affects teachers' individual data use directly as well as indirectly. Both are statistically significant relationships. Teachers who are more confident about their capacities to use data, appear to use data more extensively (direct effect). Furthermore, an indirect impact of self-efficacy on teachers' individual data use runs through collaboration. Teachers who report a higher degree of self-efficacy tend to collaborate more, and subsequently appear to use data to a greater extent (indirect effect). Given the interest dedicated to self-efficacy in data use, it is notable that the effect sizes of both the direct and indirect effects of self-efficacy are relatively small. The regression coefficient of 0.20 indicates approximately 4% of the explained variance

in collaboration (indirect effect), whereas the regression coefficient of 0.22 corresponds to an amount of 5% of the explained variance in teachers' individual data use (direct effect).

The model as a whole provides a reasonable explanation for teachers' individual data use. The R^2 value denotes that 32% of variance in this variable can be explained by means of the model. Additionally, the model explains variation in collaboration in the context of data use to a smaller extent. The R^2 value shows a percentage of 15% of explained variance in teachers' collaboration in the context of data use.

Conclusion and discussion

Although researchers widely agree upon the important role of collaboration in teachers' data use, little was known as to whether or not collaboration moderates two main personal factors of influence on teachers' individual data use: attitude and self-efficacy. In order to contribute to this gap in the current knowledge base on data use, the following research questions were proposed:

1. To which extent does collaboration take place among teachers with regard to data use?
2. How does collaboration affect teachers' individual data use?
3. How do teachers' self-efficacy and attitude affect (a) collaboration and (b) teachers' individual data use?

To address the aforementioned research questions, we used questionnaire data of 1,472 teachers, from 63 primary schools and 54 secondary schools in Flanders. Descriptive statistics were calculated and Structural Equation Modelling (SEM) was conducted.

We first found that teachers' collaboration in the context of data use is rather limited in Flanders. According to teachers, they do not collaborate extensively to address team members' competences in order to analyse and interpret data, or to create alignment and a shared responsibility around data use within the school team. Thus, in the context of data use, collaboration among Flemish teachers is not standard practice. Internal support, constructive relationships and knowledge sharing are not readily available. An explanation for this finding can be that Flemish teachers sense a great deal of individual instead of collective responsibility for qualitative teaching and learning in school. Hence, data use might be perceived as an individual responsibility of teachers. Consequently, teachers may not tend to initiate collaborative activities with regard to data use. Yet, teachers' individual data use remains low as well.

The finding of limited collaboration among teachers is not uncommon given the educational context in which the study took place. International comparative research (OECD, 2014) has shown that Flemish teachers do not generally engage in collaborative activities, which can be explained by the limited resources available for professional development in Flanders. Resources for structured time for collaboration in teachers' lesson schedule may encourage Flemish teachers to engage in data use collaboration so that data use becomes a shared responsibility in schools. An additional explanation for the amount of collaboration found in this study, is that, overall, data use is limited in the Flemish educational context (Vanlommel et al., 2016; Verhaeghe et al., 2010). Thus, the result of limited collaboration in the context of data use is in line with what we would have expected on the basis of previous research on collaboration and on data use in Flanders.

Second, this study shows that collaboration is an important factor for teachers' individual data use. With a medium effect size, the path model indicates that teachers who report a higher amount of collaboration, also report more personal data use. It is likely that the key features of collaboration (i.e. internal support, constructive relationships, collective responsibility, knowledge creation/sharing) provide valuable handles for teachers' individual data use. For teachers who, for example, struggle with the interpretation of their pupils' test results, collaboration provides a safe environment for learning how to do so, which eventually can lead to an increased individual data use.

The finding that collaboration has an impact on teachers' individual data use is consistent with what has been found in previous research. In the context of data use, involvement in collaborative activities is found to impact on teachers' individual data use (Datnow et al., 2013; Young, 2006). Collaboration has been emphasized as a way of providing structural support, since collaborating teachers are continuously provided with learning opportunities and mutual support (Farley-Ripple & Buttram, 2014; Jimerson, 2014; Young, 2006). In this way, teachers are motivated to persevere with regard to engaging in data use to inform their individual practice.

The last major finding is that collaboration is the main explanatory factor for teachers' individual data use, compared to teachers' attitude and self-efficacy. Taking into account teacher collaboration, no direct effect of attitude and only a small direct effect of self-efficacy on individual data use are found. Moreover, this study shows that attitude and self-efficacy (also) affect collaboration. The indirect effects of attitude and self-efficacy can be explained by how collaboration is shaped in schools. In the context of data use, it is likely that teachers will engage in collaboration with colleagues who are convinced that data are valuable (attitude) and who feel confident in using data (self-efficacy). Subsequently, collaboration is a way to achieve a data culture in schools with clear expectations with regard to data use. Therefore, the involvement of teachers in collaboration in the context of data use is reflected in their individual data use.

The findings of indirect effects of teachers' attitude and self-efficacy on their individual data use through collaboration are in line with prior knowledge. Consistent with previous research, the expectation grew that personal barriers such as a lack of self-efficacy and a negative attitude also explain why teachers do (not) collaborate in the context of data use (Datnow et al., 2013; Hubbard et al., 2014). This is confirmed by our study. Moreover, collaboration turns out to be a reinforcing factor in data use. Teachers with a greater self-efficacy or a more positive attitude towards data use are more likely to engage in collaboration, which eventually can lead to an increased degree of individual data use.

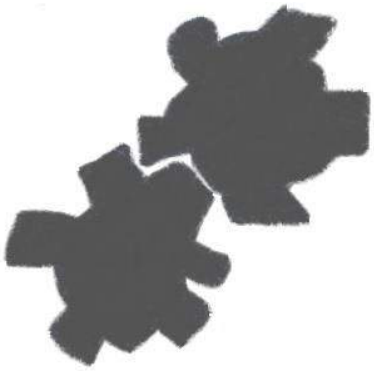
Despite the broad understandings this study provides regarding the role of collaboration in teachers' data use, some methodological limitations must be noted. First, given the context in which the study is conducted, the question arises whether (future) cross-contextual generalizations of the research findings are needed. In the context of data use, Flanders stand out from other educational systems given its limited amount of standardized data sources available. Schools and teachers primarily depend on their own data sources, such as self-composed tests and their own observations. Therefore, attempts to establish a data rich culture in Flanders and interventions to increase schools' and teachers' data use capabilities are still growing. Thus, on the one hand, choosing Flanders as a context in which to study data use has been an opportunity to address knowledge gaps on how teachers use data in rather school improvement oriented contexts. On the other hand, due to the specificity of this context, it remains unclear as to whether or not conclusions are applicable to other educational contexts. Replications of this study in other educational contexts or cross-contextual investigations are necessary to strengthen the findings of this study. Second, we conceptualized 'collaboration'

in this study in a broad sense, including general characteristics of collaboration found in data use literature. The strength of this approach is that, particularly in the context of Flanders, in which schools are not systematically supported in data use collaboration, different types of collaborations that are embedded in existing social structures are included in the concept. However, in this way, collaboration remains the container concept it is in a lot of studies and the granularity of the concept needs to be better addressed. Therefore, more in-depth methodological approaches are needed in order to explore the wide range of collaborative forms of data use that lie in between individual data use and more strict types of collaboration (e.g. a datateam or work group).

Altogether, this study confirms the importance of collaboration with regard to teachers' data use. Even when controlled for significant personal factors (self-efficacy, attitude), collaboration appears to be the main explanatory factor in teachers' individual data use. Therefore, the need arises to dig deeper into teachers' collaboration in the context of data use. First, an exploration of the concept 'collaboration' is essential in this context. Up to now, great variance exists in how the concept is approached in different studies, ranging from team work to professional learning communities (Datnow et al., 2013; Hubbard et al., 2014; Schildkamp, Poortman, & Handelzalts, 2016). Conceptual clarification is needed in order to enhance the comparability of (cross-contextual) research. Furthermore, more micro-level research on teacher collaboration in the context of data use is essential. This type of research would not only provide opportunities for further unravelling the interplay between collaboration and personal influences on data use, but would also have the potential to reveal how collaboration within these processes does or does not contribute to teachers' professional learning. Since research suggests that collaboration is a type of structural support with regard to individual data use (Farley-Ripple & Buttram, 2014; Jimerson, 2014), it is necessary to invest in research on the outcomes of collaboration in the context of data use for teachers' professional learning in general and for learning with regard to data use in particular.

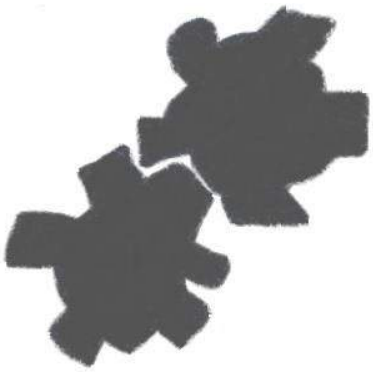
The results of this study imply that collaboration in the context of data use should be a major focus among practitioners for the development of teachers' individual data use. Even more than investing in teachers' attitudes and feelings of self-efficacy with regard to data use, the need arises for collaboration to become the focus in schools. The initiation of collaboration activities in the context of data use is the basis for working on a stimulating environment in which individual data use can flourish. In such collaboration initiatives, the involvement of all teachers is a point of focus. Our results indicate that teachers with a greater self-efficacy and a more positive attitude towards data use are more likely to engage in collaboration. Thereby, collaboration reinforces the data use of teachers who already take a more positive stance towards data use. Thus, it will be challenging for practitioners to involve teachers with a lower self-efficacy and less positive attitudes towards data use in collaboration initiatives without imposing these initiatives. Nevertheless, this balancing act will have to be made in order to stimulate the individual data use of all teachers in schools.

Given the increasing emphasis on data use for instructional improvement, it is necessary to think about how policy and research will accompany teachers in data use processes. This study has shown that next to addressing individual barriers, attempts will have to be made to facilitate data use at the team level. Despite differences between teachers in their attitude and self-efficacy with regard to data use, collaboration can be a powerful key to further develop and improve data use in schools.



Study 2:

Individual, co-operative and collaborative data use: A conceptual and empirical exploration



Abstract[3]

In recent decades, the belief has originated that data use contributes to more thought-out decisions in schools. The literature has suggested that fruitful data use is often the result of interactions among team members. However, up until now, most of the available research on data use has used 'collaboration' as an umbrella concept to describe very different types of interactions, without specifying the nature of collaboration nor the degree of interdependency that takes place in interactions. Therefore, the current study investigates and describes Flemish teachers' individual, co-operative and collaborative data use. In doing so, the level of interdependency of teachers' interactive activities (storytelling, helping, sharing, joint work) is taken into account. The results of a qualitative study with semi-structured interviews show that teachers' data use is predominantly of individual nature and that felt interdependencies among teachers are few. The study enhances knowledge and opens the conceptual debate about teachers' interactions in the context of data use.

Introduction

In the past few decades, the belief has originated that data use contributes to more thought-out decisions in schools. Hence, the amount of research on data use has recently expanded. Significant differences have been found in how practitioners use data to inform their policy and practice and in the extent to which data use serves as an accelerant for educational reform and school improvement (Schildkamp & Kuyper, 2010; Verhaeghe, Vanhoof, Valcke & Van Petegem, 2010, 2010; Wayman, 2005; Wayman, Midgley & Stringfield, 2007).

The literature has suggested that fruitful data use is often the result of interactions among team members (Copland, 2003; Hubbard, Datnow & Pruyn, 2014; Wayman, Midgley & Stringfield, 2006). Interactions are assumed to shape fundamental conditions for data use. Although researchers expect that teachers' individual data use might fail due to lack of knowledge and skills with regard to how to use data, capacity issues of data users can be overcome by interacting with colleagues (Hubbard et al., 2014; Mason, 2003; Wayman et al., 2006).

[3] This chapter is based on:

Van Gasse, R., Vanlommel, K., Vanhoof, J. and Van Petegem, P. (2017). Individual, co-operative and collaborative data use: A conceptual and empirical exploration. *British Educational Research Journal, 43*, 608–626. doi:10.1002/berj.3277

Moreover, interactions can shape fundamental conditions for thorough data use, since interactions require teachers to be more involved in the process and to persevere in implementing improvement actions (Blink, 2007; Jimerson, 2014; Verhaeghe, Vanhoof, Valcke & Van Petegem, 2010; Wayman, Jimerson & Cho, 2012).

However, up until now, the body of literature that thoroughly investigates and describes interactions in the context of data use remains rather limited. Most available research on data use employs 'collaboration' as an umbrella concept. The concept is generally used to describe very different types of interactions, without specifying the nature of collaboration nor the degree of interdependency that takes place in interactions (Bertrand & Marsh, 2015). A lot of literature only gives surface attention to what exactly happens when teachers use data for school improvement. Hence, there is a growing need for studies that dig deep into teachers' data use processes (Little, 2012). Given the crucial role of interactions in teachers' data use, the literature would benefit from studies that examine how interactions among teachers are shaped in the context of data use.

Nuance is needed in the distinction that has been made between teachers' individual and collaborative data use. Conceptually, data use can be distinguished between individual, co-operative and collaborative (Hammick, Freeth, Copperman & Goodsmith, 2009; Roschelle & Teasley, 1995). Individual data use can be referred to as data use that is initiated and completely undertaken by individuals, without any type of interaction taking place. Co-operation indicates a loose and spontaneous relationship between team members, wherein joint goal setting and a long-term engagement remain absent (e.g. asking a colleague for help while interpreting test results). Collaboration is used for interactions that result from a common goal and imply a long-term engagement (e.g. introducing a work team to improve the school's test results on mathematics) (Hammick et al., 1995). In the context of data use, both co-operation and collaboration incorporate essential features for overcomming individual struggles with data use for school improvement, such as support, knowledge sharing and shared decision making (Hubbard et al., 2014; Mason, 2003; Wayman et al., 2006). However, in terms of exploring the nature of data use interactions, the distinction between individual, co-operative and collaborative data use has not been well examined.

Individual, co-operative and collaborative data use imply differences depending on the degree of interdependency that is inherent in the data use process. Therefore, it is crucial to gain insight into the degree of interdependency of teachers' interactive activities in the context of data use. Although researchers into data use have attempted to study various forms of interactions, such as team work or communities (Bertrand & Marsh, 2015; Hubbard et al., 2014; Wayman et al., 2006), limited evidence is available on what actually happens in these interactions. This type of in-depth insight is needed in order to generate a better comprehension of teachers' data use in general and of the importance of teacher interactions for their data use in particular.

Teachers' data use comprises processes that can vary over a spectrum of different interaction types, ranging between individual and collaborative (inter)actions. In order to address this complexity, we use the Little (1990) framework, which incorporates an individual as well as a social perspective on teachers' interactions. The framework distinguishes interactions by their level of interdependency. We will investigate four types of interactions in the context of data use: daily conversations on data (storytelling), asking for help or giving advice with regard to the use of data (helping), sharing materials or strategies to use data (sharing) and making arrangements or creating work groups with regard to data use (joint work) (Little, 1990; Kwakman, 2003).

Given the above considerations, the aims of the present study are twofold. First of all, we examine the nature of teachers' data use. We therefore investigate whether data use occurs at individual level or through co-operation or collaboration. Additionally, we focus on the degree of interdependency in teachers' co-operative and collaborative data use. Therefore, the present study addresses the following research questions:

1. What is the nature of teachers' data use (i.e. individual, co-operative, collaborative data use)?
2. What is the degree of interdependency of teachers' interactive activities in the context of data use (i.e. storytelling, helping, sharing, joint work)?

Theoretical framework

The theoretical framework of this study has three main parts. Since data use is a broad concept, which might include several processes and a wide spectrum of types of data, we start by describing the concept 'data use' and narrow down the concept 'data'. Next, we provide an overview of the existing literature on the individual, co-operative and collaborative nature of data use. Lastly, we describe the Little (1990) framework, which will be used to describe the interdependency of teachers' interactions in the context of data use.

Data use and data

Data use is a way to manage processes within the school. The aim is to map school processes, to ensure that these processes are in line with school-wide goals and to use data to improve these processes (Barrezeele, 2012; Schildkamp & Kuyper, 2010). Therefore, many types of qualitative and quantitative data can be used (Hulpia, Valcke & Verhaeghe, 2004; Schildkamp & Kuyper, 2010). In view of respecting the value of different data sources and in view of exploring the individual, co-operative and collaborative nature of various data use settings, we start this study from a broad interpretation of the concept 'data' by using the CIPO framework (Kellaghan & Stufflebeam, 2003; Scheerens, 1990). The name of this framework is an acronym for 'context', 'input', 'process' and 'output'. 'Context'-data includes contextual factors of the school, such as demographical data on the school environment. 'Input'-data covers characteristics, capabilities and competences of people within the school, for instance pupils, teachers or parents. 'Process'-data indicates the way in which results are achieved and might be, for instance, data on decision-making processes or pupils' learning processes. 'Output'-data includes the school's results, such as pupil learning outcomes. We further define the concept 'data' by only studying context-, input-, process- and output-data that can be related to core processes of teachers and (1) is (in)directly related to pupils' learning, or (2) has the potential to contribute to internal quality control. Although this definition of data is broad, it provides an exclusion of those types of data that we do not consider valuable for data use in schools, such as teachers' yearly number of parking tickets or a quick chat with parents about the next excursion.

Individual, co-operative and collaborative data use

We distinguish between individual, co-operative and collaborative data use. Although an implicit dual distinction between individual and interactive forms of data use is often supposed, the literature shows that this dual distinction between individual and collaborative activities is difficult to make. The transition from individual to collaborative activities incorporates a wide

spectrum in between (Hammick, Freeth, Copperman & Goodsmith, 2009; Roschelle & Teasley, 1995). Therefore, a conceptual clarification is needed.

Data use can be undertaken merely by individuals. Individual data use denotes data use processes that are initiated and completely undertaken by individuals, without any form of interaction taking place. For example, a teacher can analyse pupils' mistakes on certain exercises in order to gain insight into pupils' pitfalls that he or she needs to address.

Besides individual data use, more interactive forms of data use can take place in schools. Interactions between teachers can result in collaborative data use. In collaborative data use, a group of individuals initiates and undertakes data use. Specific to collaboration are the aims of problem solving or sharing expertise and an active and ongoing partnership (Hammick et al., 2009). This implies that collaborative data use is not a one-off. It is a continuous process in which joint goals are set and the responsibility for reaching these goals is shared (Stoll, Bolam, McMahon, Wallace & Thomas, 2006; Seashore, Louis, Dretzke & Wahlstrom, 2010). For example, a school-wide goal might be to improve pupils' writing skills. To this end, data can be used to collaboratively investigate which aspects of writing need to be better addressed. Subsequently, arrangements can be made among teachers for strategies they will implement to improve their pupils' writing skills.

On a continuum from a small to a large interactive component within data use, co-operative data use can be situated in between individual data use and collaboration. Co-operation is less elaborate and less ambitious than collaboration, but it still incorporates an interactive component. The concept of co-operation is used to describe people who are open, willing and able to work with others, but who do not necessarily share common goals to work on (Hammick et al., 2009). Co-operation is thus different from collaboration because of its 'loose' character. Whereas collaborating people have a long-term engagement with each other, co-operating people work together on an occasional basis. In co-operation the pith of the matter lies with the individual, but this individual might interact with others in order to reach his/her own (data use) goals. For example, a teacher might analyse a pupil's maths exercises with the aim of improving this pupil's test scores. In doing this, the teacher may find that the pupil makes similar mistakes every time. Subsequently, the teacher might consult a colleague to discuss the appropriate remedy for this type of mistake.

Storytelling, helping, sharing and joint work

In order to describe the level of interdependency of teachers' interactions in the context of data use, we use the Little (1990) framework. This framework addresses the complexity in the nature of teachers' data use, which can range from individual to collaborative. By categorizing types of interactions depending on their level of interdependency, Little (1990) embeds both an individual and a social perspective in her framework, which is particularly useful in the context of data use and is helpful in describing teachers' data use as a part of their daily practice. Little (1990) distinguishes between four types of interactions: storytelling, helping, sharing and joint work.

Storytelling is a type of interaction in which teachers are nearly completely independent of each other. Due to daily conversations with colleagues, a quick exchange of information takes place. Subsequently, teachers are completely independent in their use of this information in practice (Little, 1990).

Storytelling provides a good illustration of the daily life in schools (Katz & Earl, 2010; Meirink, Meijer, Verloop & Bergen, 2009; Bakkenes, Vermunt & Wubbels, 2010). Daily conversations occur also in the context of data use (Datnow, Park, & Kennedy-Lewis, 2013; Bolhuis,

Schildkamp, & Voogt, 2016). These storytelling activities can range from general conversations about data use to conversations about a specific data use topic within the school.

Helping refers to giving or asking for help or advice and incorporates a high level of independence (Little, 1990; Kwakman, 2003). Helping activities derive from a question that is asked by an individual teacher, who – subsequently – decides independently to follow or ignore the help or advice that is offered (Little, 1990). Due to the underlying purpose of help-seeking, this type of activity is less open-ended for the help-seeker than storytelling activities.

Helping activities are one of the main reasons why emphasis has been laid on interactions in the context of data use (Datnow et al., 2013; Hubbard et al., 2014). The presence of helping activities in data use settings can be crucial in order to tackle personal barriers with regard to data use, such as difficulties with analysing and interpreting data or setting improvement actions (Datnow et al., 2013; Hubbard et al., 2014; Jimerson, 2014).

A third type of interaction is *sharing*, which implies the distribution of data, materials and methods, or the open exchange of ideas and opinions (Little, 1990). The underlying goal of teachers is to make aspects of their work accessible and expose their ideas and intentions (Katz & Earl, 2010). Thus, teachers create a kind of 'open access environment' of materials, choices and rationales that have been made. Therefore, sharing is seen as a learning activity that incorporates a higher level of interdependence, compared with storytelling and helping (Little, 1990). Sharing activities do not imply that teachers are bound to shared strategies or materials with regard to how they shape their daily practice (Little, 1990).

Empirical evidence has validated sharing activities, also in the context of data use. However, there is little insight into their frequency of use, since the extent to which sharing activities are reported differs across studies (Kwakman, 2003; Katz & Earl, 2010; Hubers, Poortman, Schildkamp, Pieters & Handelzalts, 2016; Bolhuis et al., 2016).

The last type of interaction in Little's (1990) framework is *joint work*, or "*encounters among teachers that rest on shared responsibility for the work of teaching*". This implies a high level of interdependency - collective purposes that result in truly collective action, such as work groups and agreements (Little, 1990). Felt interdependencies among teachers are few, which is why joint work is rarely found among teachers (Kwakman, 2003; Katz & Earl, 2010). Within the context of data use, indications for joint work are found, but mainly in the context of intervention studies (Hubers et al., 2016; Schildkamp, Poortman & Handelzats, 2015; Cosner, 2011).

For reasons of conceptual clarity, we have strictly distinguished between storytelling, helping, sharing and joint work in this conceptual framework. However, we assume that in real-life situations more than one type of interaction can appear at a time (for example, situations in which storytelling as well as sharing materials appear).

The level of interdependency of teachers' interactions can be conceptually related to the nature of interactions (i.e. co-operative and collaborative data use). In storytelling, helping and sharing interactions, teachers do not set common goals or share responsibility for the outcomes of these interactions. Instead, teachers undertake these interactions out of personal goals and remain individually responsible for how these interactions change or do not change the outcomes of their individual data use. Therefore, we categorize storytelling, helping and sharing as co-operative data use and joint work as collaborative data use. This is visualized in Figure 1.

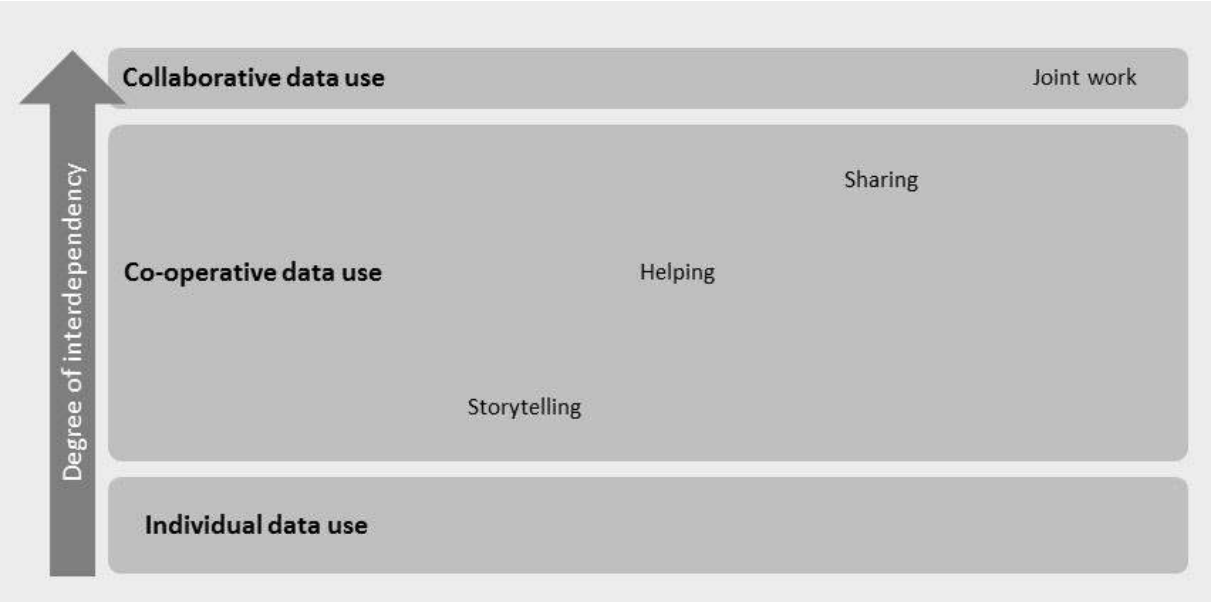


Figure 2. Level of interdependency for different types of interactions.

Method

With the aim of generating in-depth insights into teachers' interactions in the context of data use, we used a qualitative research design including semi-structured in-depth interviews. This approach was conducted in order to gain rich knowledge of teachers' individual, co-operative and collaborative data use and of the level of interdependency that is inherent in teacher interactions in the context of data use.

Context of the study

This study took place in Flanders, the Dutch-speaking region of Belgium. Flanders has a specific context in which to study data use. Compared with other countries appearing in the literature, the Flemish government tends to wield a perspective on data use that is oriented towards school improvement. Whereas attainment targets are set at the end of primary education and the second and sixth grades of secondary education, schools are autonomous in how these standards are reached (i.e. they have autonomy and control over the curriculum) (De Volder, 2012; Penninckx, Vanhoof, & Van Petegem, 2011). In addition, central exams are absent and no public databases or rankings of schools are available (OECD, 2013; De Volder, 2012). Schools themselves are responsible for investigating and assessing whether or not their pupils reach the Flemish standards at the end of primary and after the second and sixth grades of secondary education (De Volder, 2012). Thus, governmental expectations towards data use are implicit and the responsibility for using data and support for data use lies with individual schools and teachers.

Participants and interviews

Interviews were performed with 12 teachers in six primary and six secondary Flemish schools, taking into account the point of saturation and sufficient heterogeneity among participants (Guest, Bunce & Johnson, 2006; Morrow, 2005). All teachers participated voluntarily. The

participants varied in gender (four male; eight female) and in teaching experience (ranging from 6 to 32 years).

Table 1. Participant characteristics

School	Participant	Gender	Teaching experience	School type
1	Chrissy	F	20-25	Primary
2	Kelly	F	20-25	Primary
3	Martha	F	30+	Primary
4	Kristen	F	30+	Primary
5	Karen	F	5-10	Primary
6	Peter	M	5-10	Primary
7	Lizzy	F	30+	Secondary
8	John	M	30+	Secondary
9	Frank	M	10-15	Secondary
10	Kim	F	15-20	Secondary
11	Susan	F	10-15	Secondary
12	Joey	M	10-15	Secondary

For the interviews, a semi-structured guidance was used, which was based on the concepts of the theoretical framework. The in-depth interviews, with an average duration of one hour, were conducted by a single researcher and subsequently transcribed ad verbatim.

Coding and analysing procedure

Starting from the theoretical framework, a mainly deductive coding process took place using Nvivo 10 software. A coding scheme was developed by the main researcher and a colleague researcher with expertise in the field of study. General codes, such as ‘nature of data use’, were distracted from the theoretical framework (headcodes) and were specified through several subcodes, such as ‘individual data use’ or ‘co-operative data use’. In order to assure the validity of the study, agreements were made on when text fragments do (not) belong to the different codes in the coding scheme. Table 2 provides insight into the coding scheme of this study, characteristics of codes and data exemplars.

To test the construct validity of the coding, a second researcher coded four interviews independently. The inter-rater reliability (Miles & Huberman, 1994) – the ratio of the total amount of agreement in the coding and the total amount of coded text excerpts – was 85.7%.

Table 2: Conceptual characteristics of axial codes

Headcode	Subcode	Conceptual characteristics and example data
Nature of data use	Individual data use	Individually initiated and completed data use processes No interaction "For example, in my course you have a share grammar. You have distributed a piece of paper with certain grammatical rules that you explained and so on. Next, if you finished these lessons, pupils make a test. Well, this test is relevant for me to question myself whether my pupils understand what I taught."
	Co-operative data use	Individual purposes for data use Loose interactions Individual responsibility for data use "I give you an example. This year, I get a dossier of a pupil. This dossier tells me that there should be kept an eye on this boy. He bullied last year. But in my class, I see this boy as normal and well-behaved. So I went to his head teacher of last year to know which incidents happened. So I know this and for me, the case is closed."
	Collaborative data use / Joint work	Joint purposes for data use Active and ongoing interactions Collective responsibility for data use High interdependency: joint work is reflected in individual practice "Together with the school leader, I followed a seminar on child interviews. And afterwards, we had a team meeting about it. And at this team meeting, we made agreements on whether we would start with child interviews in the class and how we would organise these interviews."
Type of co-operative interaction (Little, 1990)	Storytelling	Asking/talking about data Individually driven: gathering information for own practice Quasi no interdependency "The moment I get some important information about a pupil, for example about a divorce, I go talk to the pupil's teacher to share this information."
	Helping	Advice related to data Individually driven: derives from a need/question Little interdependency: need of the advice-seeker "With the toddlers, we did a test on language proficiency. So I try to indicate which information my colleagues win with this test, how to interpret these scores and so on."
	Sharing	Intentional distribution of materials, strategies, data Driven from a collective perspective: serving the school Little interdependency: individual responsibility of teachers No examples available in the present data set.

Additional to the researcher triangulation, the coding and analysing procedure was peer debriefed at several time points by two members of the research team that were not involved in the development of the coding scheme (Newman & Benz, 1998). Furthermore, an audit trail was left, including raw data, quantitative summaries of findings, reflexive journals and instrument development information.

In the analyses, we searched for similarities and differences from theory as well as from the input of participants in the interviews to deduce cross-case interview results (Miles & Huberman, 1994). Thereby, we followed the principles of framework analysis (Maso & Smaling, 1998).

Additionally, we binarized the qualitative data on the level of subcodes for each participant. Score 1 was given to a participant if a subcode was present in the interview, score 0 if this was not the case. Binarization is a robust technique to gain insight into the appearance of phenomena across or within participants (Onwuegbuzie, 2003). Since all conceptual topics were questioned in all semi-structured interviews, this technique was suitable for the present data set. The advantage of binarizing relative to counting citations is that it purges personal differences of participants (e.g., talkative versus introverted participants).

The binarized data were used to generate insight into the occurrence of subcodes across participants via the calculation of the relative frequencies (Onwuegbuzie, 2003). For example, 'individual data use' occurred in 10 out of 12 interviews. This means that the relative frequency of 'individual data use' is 0.48 (10 of a total of 21 spread over individual data use, co-operative data use and collaborative data use). In theory, this relative frequency is a value between 0 and 1, ranging from not occurring (0) to being the only occurring code (1). Counting the relative frequencies of all learning activities together ends with a total of 1. Thus, the extent of occurrence of individual, co-operative and collaborative data use compared with each other is reflected by the values (Onwuegbuzie, 2003).

Results

In line with the present research questions, we start with the results on individual data use, co-operative data use and collaborative data use. The results regarding the second research question on the interdependency of teachers' data use interactions are posted within the sections on co-operative and collaborative data use.

Table 3. Binary results for the nature of teachers' data use.

	Participant ID												**Total**	**Relative frequency**
	Chrissy	Kelly	Martha	Kirsten	Karen	Peter	Lizzy	John	Frank	Kim	Susan	Joey		
Individual data use	1	1	1	1	1	1	0	1	1	1	0	1	10	0.46
Co-operative data use	1	1	1	1	1	0	0	1	1	1	0	0	8	0.36
Collaborative data use	0	1	0	0	1	1	0	0	0	1	0	0	4	0.18
													22	**1**

Individual data use

Two teachers, who both work in secondary education (i.e. Lizzy and Susan), do not report any type of data use. Within the transcriptions of their interviews, no indications are found that

context-, input-, process- or output data are used in any way (individually, co-operatively or collaboratively) to monitor or improve their classroom practice.

For all other teachers, who do report some kind of data use, we find that data use is to a great extent of individual nature. With 10 out of 12 interviewed teachers reporting individual data use, the interview data shows that data use generally is initiated and undertaken individually, which is reflected by a relative frequency of 0.46 within the present data set (Table 3).

The 10 teachers report data use activities that are similar as it comes to the absence of interaction in initiating and carrying out data use. Nevertheless, differences can be determined with regard to the extent of (individual) data use activities that are found in the interviews and the purposes that teachers report for (individual) data use. For example, regarding the extent of data use, a teacher in secondary education (i.e. Joey) indicates that he may undertake less activities than colleagues of him because he teaches 20 pupils one hour of geography each week, 250 in total, and does not believe that he is able to improve his education for every pupil.

We find that, in most cases, pupils are the mainspring for teachers' data use. Many of the citations that show individual initiation and use of data are about the use of pupil dossiers, which involve, *inter alia*, test scores, information about learning disorders and classroom observations. The main purpose for teachers to use pupil dossiers individually is to enhance their understanding of learning results, attitudes or learning progress of pupils. Additionally, four participants (i.e. Martha, Karen, Peter and Frank) indicate that they use data out of pupil dossiers individually with the purpose of initiating actions that can lead to improvement in their daily practice.

Illustration of how teachers' individual data use is shaped can be found in the interviews with Kirsten and Peter. Kirsten is a pupil care teacher in primary education who is responsible for the follow up of pupils with special needs and learning problems. How she says to use LVS tests [type of standardized test] is illustrative for how teachers generally use data out of pupil dossiers. The test scores are helpful for Kirsten to obtain a better understanding of whether her practice is oriented at the right pupils. Therefore, Kirsten's citation illustrates clearly the kind of individual data use that many teachers in the present data set report: using data to monitor and understand (the learning processes of) pupils. Peter, on the other hand, is one of the teachers who's purposes in data use are (also) in defining actions to improve his practice. Peter is also employed in primary education. In his interview, he confirms that LVS tests are helpful to understand pupils learning, but also indicates that they are an information source that is helpful to initiate differentiation. This way, the text fragment out of Peter's interview provides a good illustration on what our interviews show on how the same types of data can be used individually for different purposes.

> *"In February, the teachers give a LVS test, but only a part of it. The spelling test is given completely, but mathematics is limited to mental arithmetic. And I also get this information and then I monitor if the pupils that fall out, if these are the same pupils that are taken out of class for extra care. Now I know that this is not a perfect mirror, that these are all snapshots. But nevertheless I check whether or not there are some fluctuations." (Kirsten, care teacher in primary education)*

> *"Here at school, we have the habit to give LVS tests two times a year. Those LVS tests are used… Well, this is always the discussion here at school… or the question, how we are going to use these results. Because those tests always happen during class time, two times a year, two to three mornings. [thinks] Well, take two mornings that are necessary to give those tests. That is valuable class time that is lost. Well, lost, this time is not lost when you use the results in a meaningful way. And that is the discussion*

here at school how we can do this in the best way. And then mostly, in my experience, we use the results of those LVS tests primarily to get more insight into pupils' understanding of the curriculum and maybe to communicate this to parents in a certain situation if this is important for the child. The second thing is to differentiate in the class. If we notice that some children fall out for certain aspects we will look if it is possible to make smaller groups to remediate pupils. If for example appears that some children have difficulties with mathematical questions, we will focus on this topic with those pupils." (Peter, teacher in primary education)

Co-operative data use

Compared to individual data use, a smaller share of teachers reports involvement in co-operation in the context of data use. Eight out of the 12 interviewed teachers report co-operative data use. This is reflected in a relative frequency of 0.36. Thus, a moderate number of teachers engages in loose relationships and are willing to work together in order to achieve personal data use goals (Table 3).

Table 4 shows the binary results for the interdependency in teachers' co-operative data use activities. We did not find evidence for sharing activities in the context of data use among teachers. The absence of sharing activities that fit into the conceptualization in this study (cf. Table 2), was checked by the colleague researcher that was involved in developing the coding scheme. None of the teachers' activities for data use purposes involved the intentional distribution of materials, strategies or data from a school or team oriented perspective.

Table 4. Binary results for the level of interdependency of teachers' co-operative data use.

	Participant ID												**Total**	**Relative frequency**
	Chrissy	Kelly	Martha	Kirsten	Karen	Peter	Lizzy	John	Frank	Kim	Susan	Joey		
Storytelling	1	1	1	1	1	0	0	1	1	1	0	0	8	0.73
Helping	0	1	0	0	1	0	0	0	0	1	0	0	3	0.27
Sharing	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
													11	**1**

Storytelling

All eight participants who use data co-operatively indicate that these co-operative activities involve storytelling. Therefore, daily conversations of teachers in the context of data use are by far the most common type of co-operation that is reported by teachers in the context of data use. This is reflected in a relative frequency of 0.73 (Table 4).

In line with teachers' individual data use, their interactions in the context of data use are generally pupil (learning) oriented. Seven teachers in the present data set (i.e. Chrissy, Kelly, Martha, Kristen, John, Frank and Kim) engage in storytelling activities that are related to pupil

(learning) data. These teachers indicate that they find it important to try to understand pupils' learning process. That is why data about pupils' achievements, learning motivation or learning behaviour are discussed among colleagues. Most of these data are bundled in pupil dossiers. Thus, the main purpose for teachers' storytelling activities in the context of data use is in line with what we know about teachers' individual data use. Teachers use data in order to enhance their understanding of their pupils' learning process. Additionally, some teachers (i.e. Kristen and Karen) aim to use data to improve their practice. To this end, these teachers indicate that data are discussed among colleagues in order to align visions on certain topics.

To illustrate how teachers engage in storytelling activities, we provide interview fragments of Chrissy and Karen. Chrissy teaches toddlers. Her most common used data comes from classroom observations. Chrissy's citation is highly illustrative for how storytelling activities among teachers within the current data set are initiated and carried out. As the text fragment makes clear, achieving a better understanding of what is going on with pupils is the main purpose for teachers. Storytelling activities create opportunities to get insight into whether what they notice out of data is prevailing for (their type of) pupils. And to do so, they lean on experiences of colleague teachers. Additionally, the interview fragment of Karen shows how few teachers move beyond increasing their understanding via storytelling activities. Karen is a care teacher in primary education. Her interview indicates that storytelling in the context of data use can take the form of discussing and brainstorming about future improvement priorities. A footnote to make in this citation is that the level of interdependency increases by the end of the text fragment. With the team, they move from discussing the report to a more collaborative type of data use (i.e. prioritising improvement goals to work on).

> *"This is a very large school so I have some colleagues working in the same age group. So you always have a colleague with whom you can discuss if certain things you observe in the class are normal development. But I think that when you start in a new age group without colleagues teaching the same age, you would just sometimes not know." (Chrissy, teacher in primary education)*

> *"That was also the first year I became a care teacher, so I did not know where to start. I had an amazing initial situation, because improvement opportunities were listed. The inspectors were positive, but they do say… So I had an amazing initial situation and then I started working with the report. Because that is… I don't know if you have ever seen it? That is soooo comprehensive, to distil the essence out of it. So with the team we discussed it. How do you interpret this? Ok, these are the five main improvement points, how are we going to work on them? And then, as a team, we chose: first this, then that. And so we tried to do this." (Karen, care teacher in primary education)*

Helping

Three teachers who report co-operative data use provide evidence for helping activities. The relative frequency of 0.27 (Table 4) indicates that helping activities have a reasonable share in teachers' co-operative data use.

Two of the three teachers who report helping activities (i.e. Kelly and Karen) indicate that their school team is 'close', which indicates that they – according to them - generally interact a lot. Therefore, also in the context of data use, interactions are present. Similar in both teams is that they have invested in coping with a strongly changing school population (i.e. increased percentage of foreign language speakers) through the years, which has resulted in working together intensively to re-arrange the school in terms of structure and instruction.

The three interviews in which helping activities are coded indicate that helping activities are initiated to serve individual purposes. The purposes that are found are different across the teachers, but are mostly related to changes or improvements in teachers' classroom practice. An illustration of how helping situations usually occur is provided by Kim. Kim teaches general subjects in vocational secondary education. She indicates that the school had implemented attitude measurement as an addition to the cognitive results on pupils' monthly school reports. With the exams coming up, the teacher had summarized the attitude figures in a diagram but she did not feel confident in interpreting this type of data. Subsequently, she consulted a colleague in order to help her figure out conclusions that could be made on the basis of the diagram.

> *"I think we are a nice, dynamic and young team. Because teachers in general subjects, there are a mathematic teacher, a foreign language teacher, I studied Dutch, then history, economics, so a great variety. Yes, we are very complementary. […] But I really ask for support from my maths colleague. I know how to derive a diagram out of those attitude measures, but it is thanks to her actually…. She tells me what they mean." (Kim, teacher in general subjects in vocational secondary education)*

Collaborative data use

Three participants report collaborative data use. The limited evidence for joint work activities is reflected in a relative frequency of 0.18 (Table 3). Two of the teachers who use data collaboratively also use data individually and co-operatively. Of the participants who indicate that they use data collaboratively, one teacher (i.e. Kelly) says that in her school team generally a lot of interaction takes place (cf. section on helping). The other teachers (i.e. Martha, Karen and Kim) indicate that their school leader stimulates and models data use at school.

From the interviews, we learn that joint work in the context of data use transcends teachers' individual purposes for data use. Generally, the collaborative situations reported by teachers are about creating alignment in data use goals and improvement actions at school level. Although almost all teachers who report collaborative data use also provide indications for co-operative data use, it is not necessarily so that all collaborating teachers are also co-operating with colleagues in the context of data use. The counter example is Peter, a teacher in primary education. His interview indicates that he takes a sort of an 'expert' role in data use within the school and does not feel the need to engage in storytelling, helping or sharing activities. Compared with his colleagues, he is well-grounded in data use and he also supports the school leader in her data use.

Collaboration in the context of data use is generally about making (school-wide) agreements, mainly in implementing changes or improvement actions on the basis of data. Illustrative in this is a fragment out of the interview of Kelly. Kelly is a care teacher in primary education. During the interview with Kelly, it became clear that within the school, the school leader and the teachers highly value consultation when it comes to implementing changes or thinking out improvement actions that affect teachers' daily practice. The citation below illustrates how information of a seminar which was attended by her and her school leader was deliberated within the school team. Subsequently, agreements were made on how the insights of the seminar would be implemented in the daily practice of teachers.

> *"Together with the school leader, I followed a seminar on child interviews. And afterwards, we had a team meeting about it. We showed the videos that were used at the seminar to the teacher team. And then, we made agreements on whether we would*

start with child interviews in the class and how we would organise these interviews." (Kelly, care teacher in primary education)

Conclusion and discussion

The aim of this study was to widen and deepen the knowledge on teacher interactions in the context of data use. Therefore, we investigated (1) the individual, co-operative and collaborative nature of teachers' data use and (2) the level of interdependency in teachers' interactions in the context of data use. In order to answer these research questions, a qualitative study was set up. Semi-structured interviews were performed with 12 teachers of primary and secondary education in Flanders.

In the practice of the teachers in this study, data are generally used individually. According to the majority of the teachers, they use data individually to some extent. In contrast, co-operative and collaborative data use are less apparent. Storytelling activities (co-operation) are reported by a moderate number of teachers in the present data set, but activities that involve a higher level of interdependency (i.e. co-operative activities such as helping and sharing; collaborative activities such as joint work) are almost absent. A possible explanation for the large proportion of individual data use among the participants might be that these teachers consider their teaching practice as an individual responsibility. Thus, the teachers consult colleagues in order to discuss in the context of data use, but do not go beyond this (low) level of interdependency to improve their practice. Co-operative data use with higher levels of interdependency (helping and sharing) and collaborative data use (joint work) are not common practices among the participating teachers.

The finding of limited collaboration (i.e. joint work) is not uncommon in educational research (Little, 1990; Kwakman, 2003; Katz & Earl, 2010). Moreover, Flemish teachers in particular do not generally engage in activities that demand higher degrees of interdependency with their colleagues (OECD, 2014). Teachers do not tend to feel interdependent in terms of teaching and learning (Little, 1990). Therefore, teachers do not generally engage in activities that might affect their individual responsibility for their classroom practice, such as making arrangements or creating work groups. These findings are extended to the context of data use by means of this study.

Although the limited collaborative data use may not be surprising, in particular given the Flemish context of the study, the finding that several types of co-operative data use are also scarce is a new finding. Despite the research indicating that storytelling is a good illustration of the daily life in schools (Katz & Earl, 2010; Meirink et al., 2009; Bakkenes et al., 2010), the activity was reported by a moderate but not considerable number of teachers in the context of data use. Moving further on the continuum of interdependency, helping activities are limited, which goes against the findings of Meirink et al. (2009) and Katz & Earl (2010), who did find these types of activities in schools. Furthermore, contrary to other research in the context of data use (Hubers et al., 2016; Bolhuis et al., 2016), we do not find evidence for sharing activities independently of the context of intervention studies.

The present study contributes to data use literature in several ways. First, we enhanced conceptual clarity with regard to teacher interactions in the context of data use. In general, interactions in the context of data use are approached by using 'collaboration' as an umbrella concept that comprises different types of interactions without specifying them. This is addressed in the present study. Conceptually as well as empirically, we found a continuum from individual, to co-operative, to collaborative data use, depending on the level of interdependency of data use interactions. Furthermore, the framework of Little (1990),

including interactions with various levels of interdependency (i.e. storytelling, helping, sharing, joint work) is explicitly validated in the present study. However, although indications for the validity of the framework are found in several studies, this study makes the first attempts at validation of the framework as it is invented. Additionally, the present study contributes to theory by integrating two frameworks to describe and investigate data use processes. The way in which we integrated the Hammick et al. (2009) and the Little (1990) framework on interactions resulted in a refinement of the prior set concepts. In particular, we found that the concept of co-operation can include different types of activities (i.e. storytelling, helping, sharing), depending on the level of interdependency in the interaction. Lastly, most of the studies in the data use field are research conducted in an intervention setting. Studying data use collaboration by means of such interventions strongly affects the picture that is drawn of teacher interactions because data use interventions are mostly shaped around teacher collaboration. Therefore, doubts can be raised with regard to the sustainability of teacher interactions when studying them via an intervention setting. This study addresses that problem by examining data use as a part of teachers' daily life. This is crucial in order to understand the potential of data use in general and the success and sustainability of data use interventions in various contexts.

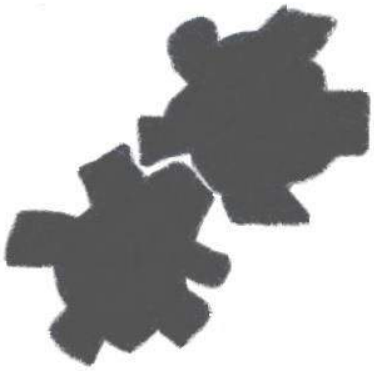
Although the results of this study contribute to data use literature, some limitations have to be taken into account. The methodological choices that were made allowed us to provide a description of individual, co-operative and collaborative data use to some extent. Therefore, a useful framework for studying data use was created. However, the methodology also had its limitations in widening and deepening the research results. Interviews with teachers from diverse teams provided an indication of teachers' individual interactions, but did not provide information about data use interactions in whole teacher teams nor increased understanding regarding the relationships of the studied teachers with their colleagues. Future research could address these limitations by using alternative research methods and analysis techniques, such as social network analysis. Conceptually, there are some limitations in this study with regard to the broad conceptualization of the concept 'data'. Although the research field voices criticism with regard to a too-strict definition of the concept, future research can benefit from taking a more specific type of data into account (for example, pupil learning outcome data). This is helpful to increase the contextualization and the comprehension of the research results. It is recommended that future data use studies try to find the balance between a (too) broad and a (too) narrow conceptualization of the concept 'data'.

In the light of the results on individual, co-operative and collaborative data use, questions arise on differences in 'quality' between these different types of data use. In other words: what kind of data use do we expect or hope to see in schools? Prior research related fruitful data use to interaction (Copland, 2003; Hubbard et al., 2014; Wayman et al., 2006). However, this study makes clear that individual data use remains the most common form of data use among the Flemish participants. Therefore, questions arise about the level of interdependency that is recommended with regard to data use. That is why the link of individual, co-operative and collaborative data use with outcome variables (e.g. professional learning outcomes, the quality of decisions) needs to be addressed. The challenge will be to determine which level of interdependency is appropriate within specific school contexts and with regard to specific data use goals.

Given that interactions are considered as indispensable for fruitful data use (Hubbard et al., 2014), this study draws a rather pessimistic state of the art. The results of this study imply that a supportive environment for data use, in which teachers co-operate and collaborate, cannot be taken for granted. Therefore, attempts need to be made to facilitate co-operation and collaboration in the context of data use. In particular, since teachers do not tend to feel

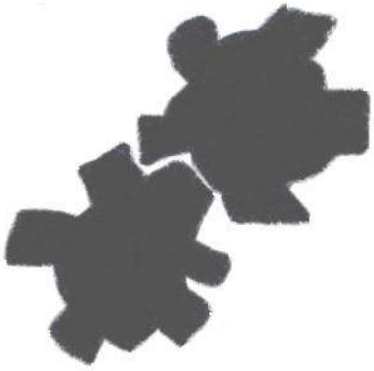
interdependencies, they should be stimulated to create them. A common goal setting related to data use might be one of the keys to successful co-operation and collaboration in schools, as this is important for school-wide data use (Levin & Datnow, 2012; Schildkamp, Rekers-Mombarg & Harms, 2012). This might not be self-evident from a teacher's perspective. Therefore, it is important for practitioners to explicate and formulate problems from which a data use co-operation and collaboration can start (Schildkamp et al., 2015). Discussing, analysing and working together to solve these problems by using data might result in growing interdependencies, which might lead to an enriching environment for teachers' data use.

Literature generally underlines the importance of interactions in the context of data use. This study is a useful first step to bring to the surface differences between co-operation and collaboration that were previously submerged in data use research. The results generate the need for more refined future approaches to interactions and collaboration in the context of data use. Only by enriching the (conceptual) debate on data use interactions can their potential added value come into its own in both research and practice.



Study 3:

Unravelling data use in teacher teams: How network patterns and interactive learning activities change across different data use phases



Abstract[4]

Interactions among teachers are assumed to improve the quality of teachers' data use. Grouping teachers together challenges them to a more in-depth investigation of how pupil learning outcomes can be improved. This study combines social network analysis with qualitative data out of six teacher teams to provide insight into how teacher interactions change across data discussion, interpretation, diagnosis and action. We find that teachers' networks become smaller, and that interactions become more intense and interdependent when progressing through the different phases.

Introduction

Data use, and particularly teachers' use of pupil learning outcome data, has become an important topic in educational research. After all, different types of actions based upon data, such as a change in teaching strategies or differentiation, have potential benefits for student achievement (Campbell & Levin, 2008; Carlson, Borman, & Robinson, 2011). Researchers generally conceptualize data use as a cycle of sub-processes (Ciampa & Gallagher, 2016; Marsh & Farrell, 2015, Schildkamp, Poortman, & Handelzalts, 2016). The translation from raw data into knowledge and improvement actions is guided by the discussion and correct interpretation of data, diagnosis of problems and design and introduction of improvement actions (Verhaeghe, Vanhoof, Valcke, & Van Petegem, 2010). During these phases, teacher interactions are essential (Copland, 2003; Hubbard, Datnow, & Pruyn, 2014). A variety of knowledge and skills is required to accomplish each of the data use phases, ranging from interpretation and analysing skills to advanced pedagogical knowledge (Gummer & Mandinach, 2015). Grouping teachers together to combine and share expertise challenges teacher groups to more thorough discussion and consideration of potential explanations for, for example, poor student results (Bertrand & Marsh, 2015). Therefore, embedding data use in social structures is assumed to result in better-considered instructional changes and provide teachers with opportunities to learn from one another (Van Gasse, Vanlommel, Vanhoof, & Van Petegem, 2016).

Although research has acknowledged the importance of the interactive and cyclical character of data use, there remain gaps in the literature with regard to both characteristics. First, in

[4] This chapter is based on:

Van Gasse, R., Vanlommel, K., Vanhoof, J. and Van Petegem, P. (2017). Unravelling data use in teacher teams: How network patterns and interactive learning activities change across different data use phases. *Teaching and Teacher Education, 67*, 550-560.

particular out of the niche of intervention studies, data use has been insufficiently approached as a cycle of sub-processes. Therefore, teachers' data use often remains a black box in research and little is known on changes in teacher behaviour throughout different data use phases (Little, 2012). Second, 'collaboration' is often used as a container concept to study teacher interactions. However, interactions can vary depending on lower or higher levels of interdependence in teachers' mutual activities (Van Gasse et al., 2016; Little, 1990). For example, teachers are not bound to changing their instruction when collaboration only involves data use discussion. This is different when teachers make arrangements in data use collaboration. Therefore, the granularity in the concept 'collaboration' needs to be better addressed (Bertrand & Marsh, 2015; Van Gasse, Vanlommel, Vanhoof, & Van Petegem, 2017). Approaching teachers' interactive activities on a continuum from lower to higher degrees of interdependence is a crucial step to better understand changes in teachers' interactive behaviour in the different phases of data use.

Examining teacher interactions during different data use phases is an essential contribution to the current knowledge base. Up to now, it remains unclear how a potentially supportive environment for a complex task such as data use is used by teachers. Insights into if and how teachers interact with colleagues are needed to generate knowledge on when and how individual expertise is (not) shared within teams. Extending our knowledge base in this regard is crucial bearing in mind the benefits of teacher interactions for data-based instructional change (Bertrand & Marsh, 2015).

The general aim of this study is to unravel how teacher interactions change across the data use cycle. To do so, we distinguish between structural interaction patterns and interactive activities of teachers. Structural interaction patterns are investigated by means of social network analysis. In this method, the information of both actors involved in interactions is combined. Therefore, social network is powerful to unravel teacher interactions in more detail compared to, for example, survey or interview research that investigate collaboration through general questions.

The structural patterns in themselves provide binary information on the (non-) presence of interactions and not on what exactly happens when people interact (Baker-Doyle, 2015; Mohrman, Tenkasi, & Mohrman, 2003). Therefore, social network analysis is complemented by interviews with teachers to provide insights into interactive activities that provide teachers with learning opportunities (i.e., interactive learning activities) and are embedded within the structural patterns determined. The Little (1990) framework is used to address the granularity in these activities by means of the level of interdependency. Four types of interactive learning activities are distinguished: daily conversations (storytelling), asking for help or advice (helping), sharing materials or strategies (sharing) and making arrangements or work groups (joint work).

Up to now, only few studies in the field of data use have drawn upon social network analysis. In combination with insights into teachers' interactive learning activities, this study provides a detailed picture on how the extent and the interdependency of teacher interactions change across the data use phases. Therefore, the contribution of this study can be found in both the methodological approach and the theoretical aim to expose the changes in teacher behaviour. To do so, two main research questions will guide this paper:

1. How do structural interaction patterns in teacher teams remain similar or change across data use discussion, interpretation, diagnosis and action?
2. Which interactive learning activities are embedded in the structural patterns of teacher networks?

Conceptual framework

To situate data use interactions in a broader context, we first describe the conceptualization of data use and data in this study. Subsequently, characteristics of structural interaction patterns and interactive learning activities will be discussed.

Data use and data

Data use is a way of inquiry-based process monitoring and problem solving in schools. The central idea is that the analysis and interpretation of different types of data is powerful to guide practitioners in instructional and school improvement (Campbell & Levin, 2008; Carlson, Borman, & Robinson, 2011).

The description of diverse data use practices has shown the merit of data use that follows a cycle of sub-processes (Ciampa & Gallagher, 2016; Marsh & Farrell, 2015; Schildkamp et al., 2016). To transform raw data into information and actionable knowledge, a variety in knowledge and skills is needed (Gummer & Mandinach, 2015; Marsh & Farrell, 2015). Approaching data use as an inquiry circle, can guide teachers to accomplish the translation from data into meaningful decisions (Marsh, Bertrand, & Huguet, 2015). This increases the quality of teachers' data use, because the tendency to jump from data to improvement actions without in-depth consideration of potential causes and alternatives is interrupted (Hubers, Moolenaar, Schildkamp, Daly, Handelzats, & Pieters 2017; Schildkamp et al., 2016). Therefore, the approach to data use as a cyclical process is essential in order to expand and refine the knowledge as to how teachers use data to improve educational processes.

In a lot of research, data use phases of discussion, analysis, interpretation and action are distinguished (Gummer & Mandinach, 2015; Marsh, 2012; Schildkamp et al., 2016). Nevertheless, given teachers' difficulties with the translation of data to classroom interventions (Datnow & Hubbard, 2016; Gummer & Mandinach, 2015), we use a conceptualization that explicitly inserts a phase of problem diagnosis. Therefore, in this study, data use is considered as a cyclic process in which phases of discussion, interpretation, diagnosis and action follow on from each other (Verhaeghe et al., 2010). First, data that guides educational decisions must be read and discussed. Second, data must be interpreted correctly. Third, a deliberation of potential causes and explanations is carried out in the diagnosing phase. Finally, improvement actions can be designed and implemented in teachers' classroom practice (Verhaeghe et al., 2010). Although these data use phases may seem linear and straightforward, the literature shows that data use cycles are often interrupted or that teachers return to previous phases (Marsh & Farrell, 2015; Schildkamp et al., 2016).

A great deal of successfully progressing through data use depends on the data that is used (Verhaeghe et al., 2010). This study reports on teachers' use of pupil learning outcome data. These data are generally seen as highly informative given their potential for improving teachers' practice and eventually pupils' achievement (Campbell & Levin, 2008; Carlson et al., 2011).

The use of pupil learning outcome data has been investigated in several studies (Jimerson, 2014). The concept is often delimited to cognitive output indicators, which in themselves fail to provide a complete picture of a pupil's learning (Schildkamp et al., 2012; Schildkamp & Kuiper, 2010). Therefore, our conceptualization of pupil learning outcome data includes cognitive outcomes (i.e. linguistic and arithmetic skills) as well as non-cognitive learning outcomes (i.e. attitudes, art and physical education). Additionally, both quantitative data (e.g. class tests) and qualitative data (e.g. observations) fit into our conceptualization.

Data use interactions

Teachers' data use benefits from interactions with colleagues (Bertrand & Marsh, 2015; Copland, 2003; Hubbard, Datnow, & Pruyn, 2014). The different data use phases require variety complex knowledge and skills. Therefore, inadequate knowledge and skills of teachers can subvert data use (Datnow & Hubbard, 2016). Interactions are seen as a way to cope with teachers' individual pitfalls to data use (Hubbard et al., 2014; Mason, 2003). Grouping teachers together to combine their individual experiences, knowledge and skills challenges teachers to thorough discussion and consideration of potential explanations for, for example, poor student results (Bertrand & Marsh, 2015). Teachers' individual expertise is complemented and broadened by those of colleagues which can lead to instructional changes of higher quality. Social relations are not only assumed to improve the quality of teachers' data use, but embedding data use in social structures has been considered to provide teachers' with valuable learning opportunities (Van Gasse et al., 2016).

Although the data use cycle of discussion, interpretation, diagnosis and action provides a clear guidance for teachers, differences in data use quality and results of the data use cycle have been determined (Hubers, Poortman, Schildkamp, Pieters, & Handelzats, 2016; Schildkamp et al., 2016). For example, Schildkamp et al. (2016) found differences between teams regarding the use of higher level thinking skills throughout the data use phases. Additionally, according to Hubers and colleagues (2016), the same sequence can result in different knowledge gains in teams. This implies that the outcomes of data use may strongly depend on how people interact during the different phases. The quality and effectiveness of teachers' data use can be determined by getting insight into teacher interactions (Bertrand & Marsh, 2015). Therefore, knowledge is needed about the interactions that take place during the different data use phases.

Based on the research questions, we distinguish between structural interaction patterns and interactive learning activities to describe the interactive component of the data use cycle. We examine structural interaction patterns drawing on social network theory. The central idea in social network 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). Structural interaction patterns are useful to determine the number of interactions in teams (Mohrman et al., 2003) and have demonstrated the importance of teacher interactions for different school improvement purposes (e.g. student achievement, reform, professional development) (Moolenaar, Sleegers, & Daly, 2012; Penuel et al., 2009; Penuel, Sun, Frank, & Gallagher, 2012; Rienties & Kichin, 2014).

Structural interaction patterns

Generally, there are three network characteristics to determine structural interaction patterns in teacher teams: density, reciprocity and centralization (Moolenaar, 2012).

Density refers to the cohesion within a network. The measure is calculated as the total number of actual ties in a network, divided by the total number of potential ties in a network (Borgatti, Everett, & Johnson, 2013; Carolan, 2014). Density provides an indication of the total activity of teachers within a network. In dense teams, teachers are more actively engaged. Therefore, resources (e.g. data use knowledge, strategies or skills) are moved more quickly than in sparse teams (Finnigan & Daly, 2012).

Reciprocity is a measure for mutual ties in networks (Borgatti et al., 2013; Carolan, 2014). Whether or not ties are reciprocated provides information on the depth of relations within a network. Reciprocated relations demonstrate more extensive interaction (Mohrman et al.,

2003). Therefore, these relations provide quicker access to others' resources (e.g. data use knowledge, strategies or skills) (Hansen, 2002; Mohrman et al., 2003) and opportunities for sharing complex information and knowledge (Kilduff & Tsai, 2003).

Centralization reflects the involvement of all team members in the network (Borgatti et al., 2013). For example, if a teacher team is highly centralized, a great number of colleagues will consult the same teacher (i.e. an expert-teacher). Depending on the team goal, a more centralized or decentralized structure may be found to be effective (Cummings & Cross, 2003; Daly & Finnigan, 2011; Sparrowe, Liden, Wayne, & Kraimer, 2001). With regard to data use, the involvement of many teachers in the process is generally seen as valuable to support thorough data use and learning opportunities in teacher teams (Keuning, Van Geel, Visscher, Fox, & Moolenaar, 2016).

To our knowledge, few studies have investigated teacher networks in the context of data use. Hubers and colleagues (2017) examined teacher networks on data sharing and discussing educational problems. Keuning et al. (2016) studied different data use discussion networks (i.e. discussing achievement goals, instructional strategies and problems). Both studies took place in an intervention setting in which data use was supported in schools. A study by Farley-Ripple and Buttram (2015) did not take place in an intervention setting and was slightly different because data advice networks were compared to teachers' regular professional network. Nevertheless, across the studies, similar conclusions were drawn. The networks were in all cases relatively sparse. Low density measures were found. Farley-Ripple and Buttram (2015) emphasized that the density measures of teachers' data use networks were low, compared to their regular professional network. Thus, limited interactions took place in the data use networks. Reciprocity measures were investigated in the studies of Hubers et al. (2017) and Keuning et al. (2016) and were also evaluated as being low. In other words, teachers did not tend to engage in deep interactions. Centralization was examined in all studies and identified as being moderate to high. Farley-Ripple and Buttram (2015) assessed the centralization measures of the data advice networks as being high compared to teachers' professional network. This means that, across the studies, the tendency was that teachers consulted few expert colleagues for data use.

Although the aforementioned studies can tell us something about the structural interaction patterns to expect in data use networks (i.e. low density and reciprocity and high centralization measures), it is difficult to generalize these findings into assumptions for the present study. First, we will examine teacher networks outside an intervention setting. Because both the studies by Hubers et al. (2017) and Keuning et al. (2016) included data use support in schools, more teachers might have been engaged in data use than would be the case without the support provided. Second, the limited number of network studies in the context of data use do not provide insight into each of the data use phases. Since the data use cycle inherits different and complex skills in each phase, we expect different structural interaction patterns for discussion, interpretation, diagnosis and action. Insights into these differences are an essential contribution to the knowledge on how teachers use their networks when progressing through the data use cycle.

A lot of research has merely focused on structural interaction patterns to obtain insights into teacher interactions. However, deeper insights are reached when complementary evidence is provided about the interactions that are studied (Mohrman et al., 2003; Baker-Doyle, 2015). Insights into the 'stories' behind teachers' networks are useful to describe the actual activities within a network (Van Waes, Moolenaar, Daly, Heldens, Donche, Van Petegem, & Van den Bossche, 2016). Therefore, additionally to the consideration of structural interaction patterns, we will describe the interactive learning activities in data use networks.

Interactive learning activities

In the data use literature, interactions among teachers are often described as collaboration. However, depending on the degree of interdependence in teachers' interactions, a more refined conceptualization is needed (Hammick et al., 2009; Van Gasse et al., 2017).

The Little (1990) framework is particularly useful in order to address the granularity in the 'collaboration' concept. Little (1990) categorizes types of interactions depending on their level of interdependency. Four types of interactive learning activities are distinguished: storytelling, helping, sharing and joint work.

In *storytelling* activities, teachers are nearly completely independent of one another. Teachers quickly exchange information through daily conversations. Whether or not this information is used depends completely on individuals (Little, 1990). In the context of data use, storytelling can include a range from general conversations about data use to topic-specific conversations (Bolhuis, Schildkamp, & Voogt, 2016; Datnow, Park, & Kennedy-Lewis, 2013).

In *helping* activities, individual teachers seek for help or advice. Subsequently, they decide independently to follow or ignore the help or advice that is offered (Little, 1990). Helping is less open ended on the side of the help-seeker compared to storytelling activities because of the underlying purpose of help-seeking. In the context of data use, a lot of emphasis has been laid on interactions because of the helping opportunities they offer (Datnow et al., 2013; Hubbard et al., 2014). Helping activities can be crucial in order to tackle personal barriers with regard to data use, such as difficulties with analysing and interpreting data or setting improvement actions (Datnow et al., 2013; Hubbard et al., 2014; Jimerson, 2014).

Sharing implies the distribution of data, materials and methods, or the open exchange of ideas and opinions (Little, 1990). Teachers take initiatives to make aspects of their work accessible for others, and to expose their materials, choices and rationales. Sharing implies a higher level of interdependence compared to storytelling and helping. Nevertheless, teachers are not bound to share strategies or materials with regard to how they shape their daily practice (Little, 1990). The concept of sharing is also validated in the context of data use. However, there is little insight into the frequency of sharing because of the great differences in sharing across studies (Bolhuis et al., 2016; Hubers et al., 2016; Katz & Earl, 2010; Kwakman, 2003).

Joint work are "encounters among teachers that rest on shared responsibility for the work of teaching". Joint work implies higher levels of interdependency in terms of collective purposes and collective action, such as work groups and agreements (Little, 1990). In general, limited evidence on joint work has been found (Katz & Earl, 2010; Kwakman, 2003; Van Gasse et al., 2016). In the context of data use, some studies report on joint work among teachers, but those are mainly intervention studies (Cosner, 2011; Hubers et al., 2016; Schildkamp et al., 2016).

Method

We used a mixed-method approach. The first research question, regarding the structural interaction patterns in the data use cycle was answered using social network analysis. For the second research question, regarding the interactive learning activities of teachers, a qualitative approach including semi-structured interviews was used. Before going into detail on the combination of both methods, we briefly describe the research context of this study.

Context of the study

The current study took place in secondary schools in Flanders that participated in a project on the assessment of pupils' writing competences. In Flanders, the government's perspective on data use is school improvement oriented. Schools are autonomous in how they achieve the standards that are defined at the end of the second and sixth grade of secondary education (Penninckx, Vanhoof, & Van Petegem, 2011). Central exams and resulting public data bases or rankings of schools do not exist (OECD, 2014). Schools themselves have full responsibility for obtaining insight into attaining the Flemish standards at the end of secondary education. Because of the absence of standardised testing, schools and teachers primarily rely on their own data sources to get insight into pupil learning outcomes.

Social network data

Participants

Because of the intensive data collection (i.e. social network analysis combined with interviews), only six out of 10 schools out of the larger project could be asked to participate in this study to achieve high response rates. Heterogeneity was searched in the geographical location of the schools in Flanders. One of the schools did not achieve a sufficiently high response rate for the social network analysis (i.e. 80%) and was excluded from the analysis.

Social network data were collected in one teacher team in each of the schools. The teams teach fifth grade pupils in an academic track in economics and languages (16- to 17-year-olds) for one school year. These interdisciplinary teams are collectively responsible for the learning of the aforementioned pupil group. 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 whether or not pupils will successfully complete their year.

Apart from team McKinley, in which 13 teachers are involved, the teams generally consist of 11 teachers (Table 1). In team Melrose, the response rate is 82%. The maximum response rate (100%) is reached in all other participating teams.

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

Team name	N	Response rate (%)
Riverbank	11	100
Northvale	11	100
Melrose	11	82
McKinley	13	100
Colby	11	100

The participation of five teams in this study provides opportunities for in-depth investigation into the similarities and differences in structural interaction patterns within and across schools. The high response rates in each school imply that accurate conclusions can be drawn on the similarities and differences between networks across the data use phases. Across the schools, 576 data points ensure that some tendencies can be revealed on network changes across the data use phases. Additionally, sufficient variation is present to allow us to take a closer look at the diversity of network changes across the schools.

Instrument

Data were collected by means of an online survey. Next to general questions (e.g. gender, teaching course), two types of questions regarding teachers' data use interactions were included. The questionnaire distinguished between formal, obliged interactions (i.e. the team meetings to discuss and evaluate pupils' learning outcomes) and informal interactions. The scales on formal interactions were only used to distinguish formal from informal interactions. The analyses of this study only concerned the social network questions on informal interactions with regard to the use of pupil learning outcome data.

For each of the data use phases (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 to discuss pupil learning outcome data?'). Subsequently, all members of the teacher team were listed.

Analyses

For each team, the density, reciprocity and centralization measures were calculated for the data use networks, using the UCINET 6.0 software package (Borgatti, Everett, & Freeman, 2002).

For all the network measures, the value can range between 0 and 1. For density, a value closer to 1 indicates higher cohesion in the network. Reciprocity close to 1 means a high amount of mutual ties, and higher centralization demonstrates the network importance of one or a few actors.

Data use involves phases of discussing, interpreting, diagnosing and taking action upon data. Thus, although data were collected cross-sectionally, the different networks cannot be seen as independent of each other. A first step to examine whether or not networks change across the data use phases was to calculate Quadric Assignment Procedure (QAP) correlations. This type of correlation, specifically designed for social network data, is a measure to evaluate the extent to which the same connections are formed in different networks with the same actors (Borgatti et al., 2002). Therefore, the measure provides an indication of the interrelatedness of different networks with the same actors, and can be used to measure overlap of the different networks in each team. Similar to other correlation coefficients, QAP correlations can range between 0 (no correlation) to 1 (perfect correlation), with values closer to 1 indicating a higher number of the same connections between the same actors across different networks.

In a next step, we obtained insights into how the networks differ across the phases of data use. Next to the interpretation of the density, reciprocity and centralization measures at network level, we provided insight into how individual teachers' networks change, since changes in individuals' networks are reflected at network level. Because of the interdependency of the data use phases and our conceptualization of data use as a cyclic process, we handled the data as longitudinal. This means that the discuss phase is approached as the start of data use, after which phases of interpretation, diagnosis and action complete the process. Although the data were gathered cross-sectionally, the data use phases can be seen as following each other. We specified a Stochastic Actor Oriented Model (SAOM) in Rsiena which provided insights into differences across the data use networks at teacher level (Ripley, Snijders, Boda, Vörös, & Preciado, 2016).

In the development of the SAOM, we first specified a theoretical model that could be tested in the different teams. General structural network characteristics (i.e. outdegree, reciprocity and transitive triplets) were included by evaluation effects following conventional model development in Rsiena (Snijders, Van de Bunt, & Steglich, 2010). The outdegree variable can

be seen as a translation of density measures at actor level and provides insights into how teachers' interaction seeking behaviour changes across different phases of data use. Reciprocity is in this type of analysis also evaluated at actor level. Additionally to the general network characteristics, we added a popularity effect that reflects centralization at actor level. The evaluation effect of indegree popularity evaluates whether teachers generally consult more popular actors (e.g. expert colleagues) throughout the data use cycle.

The described SAOM was tested in all teams separately. Convergence of the effects in all models was sufficient (t-statistic < 0.1). In order to generalize the aforementioned model to some extent across the teams, a meta-analysis was conducted in Rsiena (Ripley et al., 2016). The meta-analysis was used to test the significance of parameters across the teams (Fisher test).

Qualitative data

Next to insights into structural interaction patterns, a purpose of the study was to generate knowledge about teachers' interactive learning activities. For this reason, qualitative data complement the social network data.

Participants

Out of the five teacher teams who participated in the social network questionnaire, 12 teachers were interviewed. Within each teacher team, three teachers were randomly asked to participate in the qualitative data collection process. Due to drop-out in teams Riverbank, Melrose and McKinley, a minimum of two teachers was interviewed within each team. Participation of all teachers was voluntary and not related to their network position, in order to achieve sufficient heterogeneity on teachers' interactive learning activities in the data set.

The 12 teachers varied in gender (six were male; six were female), teaching experience (five to 30 years) and teaching course (Dutch, English, French, German, history and chemistry). An overview of the main characteristics of all participating teachers is provided in Table 2.

Table 2: Characteristics of interview participants

Team name	**Participant**	**Gender**	**Teaching experience**	**Course(s)**
Riverbank	Peter	Male	10-15	Dutch
	John	Male	10-15	German
Northvale	Kristen	Female	0-5	History
	Chandler	Male	10-15	Dutch
	Monica	Female	15-20	French
Melrose	Ross	Male	15-20	History
	Joey	Male	5-10	English
McKinley	Jennifer	Female	5-10	Dutch, English
	Frank	Male	15-20	Chemistry
Colby	Rachel	Female	10-15	English
	Phoebe	Female	15-20	Dutch
	Susan	Female	15-20	German

Interviews and coding

We used semi-structured interviews to investigate the second research question. 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 consulted. Then we asked them which learning activities occurred with these colleagues using an open question so that participants' answers were not restricted to the concepts we had set forward (e.g., 'What actually happens when you consult these colleagues on pupil learning outcomes? Can you recall real-life situations?). Subsequently, we posed additional questions on the Little (1990) framework (e.g., 'To whom amongst your colleagues do you ask advice on pupil learning outcomes? Can you sketch out such a situation?').

The interviews had an average duration of 45 minutes and were transcribed ad verbatim. Afterwards, the interviews were coded using Nvivo 10 software.

First, a researcher (further: researcher A) coded half of the interviews inductively by providing interview fragments with an open code (Pandit, 1996). Second, researcher A discussed the open codes with a second researcher (further: researcher B). Both researchers evaluated the validity of the open codes, which resulted in the need to concretize or rephrase certain codes. Subsequently, researcher A finished the open coding. Agreements were made between researchers A and B on the conceptual characteristics of axial codes (see Table 3).

Table 3: Coding Scheme

	Axial Code	**Conceptual characteristics**
Learning activities (Little, 1990)	Storytelling	- Asking/talking about learning outcomes - Individually driven: gathering information for own practice - Quasi no interdependency
	Helping	- Advice related to learning outcomes - Individually driven: derives from a need/question - Little interdependency: need of the advice-seeker
	Sharing	- Distribution of materials, strategies, information - Driven from a collective perspective: serving the teacher team - Little interdependency: individual responsibility of teachers
	Joint work	- Actively working together (making arrangements, etc.) - Driven from a collective perspective: make the teacher team work more efficient/better - High interdependency: joint work is reflected in individual practice

Subsequently, the coding process took a deductive approach. Researchers A and B independently put open codes of seven randomly chosen interviews under the axial codes (step 4). The inter-rater reliability on the axial coding (headcodes) was calculated. A substantial Cohen's kappa of 0.74 was found (Sim & Wright, 2005). Finally, disagreements between the

coding of both researchers were discussed to assure validity in the rest of the axial coding, which was finalized by researcher A.

Analyses

Whereas the social network data were analysed via a whole network approach, we used an ego network approach in the analysis of the interview data to deepen the results of the social network analyses. To extend and complement the actor-oriented approach of the social network analysis, we binarized the qualitative data on the level of headcodes for each participant. Score 1 was given to a participant if a headcode was present in the interview, score 0 if this was not the case. Binarization is a robust technique to obtain insight into the appearance of phenomena across or within participants (Onwuegbuzie, 2003). Since all conceptual topics were questioned in all semi-structured interviews, this technique was suitable for the present dataset. The advantage of binarizing relative to counting citations is that it purges the personal differences of participants (e.g. talkative versus introverted participants).

We conducted cross-case analysis of the network activities of the 12 participants. We started from the binarization of headcodes. Furthermore, we searched for similarities and differences in the interviews to provide a rich description of participants' interactive learning activities following the principles of framework analysis (Maso & Smaling, 1998).

Results

Structural interaction patterns

In order to answer the research question on similarities and changes in structural interaction patterns in teacher teams, we investigate the density, reciprocity and centralization measures across the network in each team (Table 4).

The average degree in social network analysis reflects the average number of links per teacher. In other words, to how many colleagues teachers head for the use of pupil learning outcome data. Looking at the average degree of teams, we find fluctuations across the data use phases. For example, in team Riverbank, on average 4 to 5 colleagues are consulted to discuss pupil learning outcome data. However, when it comes to the interpretation of data, the diagnosis of problems or taking action, teachers consult less colleagues. In three out of five teams (i.e. Northvale, Melrose, McKinley) the tendency is that the average degree decreases across the data use phases. This means that, on average, teachers in these teams will systematically consult less colleagues from the discussion towards the action phase. For teams Riverbank and Colby, the tendency of degree fluctuation is less clear.

The fluctuation of average degree is reflected in the density statistics. Density is the ratio of the number of interactions and the number of possible interactions in the team. For example, a network in which 10 interactions are possible and 8 interactions are present will have a density measure of 0.80, which indicates that 80% of the possible interactions are used. Overall, the density statistics are low in all the networks of all schools. In team Riverbank, a 0.40 value for density is reached in the discuss and diagnose phase of data use, and in team Colby, the same value is reached in the interpretation network. This means that in these teams and during these phases, 40% of the possible ties are used. However, generally, lower density degrees are measured, ranging from 0.11 (team Northvale – action network) to 0.37 (team

Riverbank – interpretation). This implies that 11% to 37% from all possible network ties are accomplished.

Reciprocity is the ratio of the number of mutual interactions (i.e. if teacher A turns to B for data interpretation, teacher B also turns to A). For example, a network in which 10 interactions are present and 7 of them are mutual, a reciprocity value of 0.70 is calculated, which indicates that 70% of the interactions are mutual. Reciprocity values show that a moderate number of interactions is reciprocated in teams Riverbank, McKinley and Colby and a small number is reciprocated in teams Northvale and Melrose. In teams Riverbank, McKinley and Colby, reciprocity values of 0.29 (team Colby – Diagnose network) to 0.64 (team Riverbank – Interpret network) indicate that 29% to 64% of the ties that exist are mutual ties. In teams Northvale and Melrose, the reciprocity measures are lower, ranging from 0.05 (team Northvale – Diagnose network) to 0.35 (team Melrose – Interpret network). In these teams, 5% to 35% of the ties that teachers send are reciprocated. Within teams, the reciprocity measures fluctuate, which implies that the level of reciprocity depends on the data use phase.

Centralization reflects the extent to which teachers in networks all turn 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). In terms of centralization, Table 5 shows that team Northvale is highly centralized. The centrality measures of 0.60 to 1 in this team indicate that 60% to 100% of the data use relations in the team are directed at one or a few central actors. Centralization values of 0.26 (team McKinley – Interpret network) to 0.73 (team Colby – Interpret network) indicate that centralization is moderately to quite high in all other teams. This means that few actors are more important than others in the data use networks (e.g. data use experts as brokers). Centralization measures fluctuate in all teams, which means that in some data use phases, the popular actors are more important than in others.

Table 4: Descriptive statistics for network composition

Statistic	Team	Discuss	Interpret	Diagnose	Action
Average Degree	Riverbank	4.46	3.73	4.09	3.27
	Northvale	3.09	2.64	1.82	1.09
	Melrose	2.00	2.09	1.55	1.18
	McKinley	3.38	2.56	2.06	2
	Colby	3.64	4.00	2.00	1.82
Density	Riverbank	0.45	0.37	0.41	0.33
	Northvale	0.31	0.26	0.18	0.11
	Melrose	0.20	0.21	0.16	0.12
	McKinley	0.23	0.17	0.14	0.13
	Colby	0.36	0.40	0.20	0.18
Reciprocity	Riverbank	0.58	0.64	0.45	0.44
	Northvale	0.21	0.16	0.05	0.20
	Melrose	0.29	0.35	0.21	0.30
	McKinley	0.54	0.64	0.32	0.33
	Colby	0.43	0.38	0.29	0.33
Centralization	Riverbank	0.43	0.52	0.48	0.58
	Northvale	0.84	0.90	1	0.60
	Melrose	0.49	0.48	0.30	0.34
	McKinley	0.66	0.26	0.38	0.38
	Colby	0.41	0.73	0.37	0.39

The descriptive statistics show fluctuations of all measures (i.e. density, reciprocity and centralization) across the data use phases. However, they do not provide evidence on whether

or not differences between the networks are significant. To do so, a first step is to take a closer look at the QAP correlations of the discuss, interpret, diagnose and action networks (Table 5). These correlations reflect the extent to which connections between teachers are identical across the networks. Overall, we find quite high correlations between the networks (all significant at $p < 0.01$ level). In team Melrose, the discuss and action networks correlate rather weakly, indicated by a correlation coefficient of 0.45. However, all other correlations in all teams exceed the 0.50 value, and in most cases the 0.70 value, whereby the different data use networks can be interpreted as moderately to strongly correlating. This means that there are high similarities in the connections between teachers across the data use phases.

At the same time, we find that in none of the teams are the different data use networks identical across phases, which explains the differences in density, reciprocity and centralization. Although the discuss and interpret networks in team Melrose and the diagnose and action networks in team McKinley approximate a perfect correlation with coefficients of 0.92 and 0.98 respectively, these are exceptions. Generally, we determine at least a small number of differences in structural interaction patterns within the teacher teams across the data use phases. This can both mean that teachers consult a lower or higher number of colleagues, and the same or different colleagues across the data use phases.

Table 5: Network correlations between data use phases

	Riverbank	**Northvale**	**Melrose**	**McKinley**	**Colby**
Discuss – interpret	0.78 **	0.85 **	0.92 **	0.82 **	0.85 **
Discuss – Diagnose	0.85 **	0.70 **	0.60 **	0.68 **	0.61 **
Discuss – Action	0.70 **	0.52 **	0.45 **	0.66 **	0.62 **
Interpret – Diagnose	0.70 **	0.79 **	0.71 **	0.80 **	0.57 **
Interpret – Action	0.82 **	0.58 **	0.57 **	0.81 **	0.58 **
Diagnose - Action	0.84 **	0.67 **	0.78 **	0.98 **	0.83 **

** $p < 0.01$

The differences in structural interaction patterns across the data use phases were further explored at actor level within the five teacher teams. Table 6 presents the results of the Stochastic Actor Oriented Model (SAOM) that was tested in the five teams.

The rate parameters reflect the average number of changes per actor between two data use phases. For example, in team Riverbank, the rate parameter of 1.68 (P1) indicates that teachers in this team have on average 1.68 opportunities to change their ties from the discuss to the interpret phase. This does not mean however that all teachers use all these change opportunities and, for example, drop or establish new connections. The rate parameters suggest that the number of connection changes peaks from interpretation to diagnosing data in teams Riverbank, Melrose and Colby, from diagnosing to action in team Northvale, and from discussion to interpretation in team McKinley.

The structural and popularity effects provide insights into the changes at actor level that do occur across the data use phases. The outdegree of teachers reflects how many colleagues teachers consult in a network. Therefore, the negative outdegree effects in all teams indicate decreasing tie probabilities across the data use phases. In other words, teachers engage in less interactions for action compared to discussion, interpretation and diagnosis. The meta-analysis confirms that there is a tendency for a decrease in outdegree in all teams. This means that, on average, teachers are likely to drop ties across the data use phases. This was also reflected in the fading outdegree values at team level in most teams (Table 4).

In contrast, teachers are more likely to engage in reciprocated ties across the data use phases. Teacher interactions are more often mutual in their action networks, compared to their

discussion, interpretation and diagnosing networks. Although this effect is only significant in team Melrose, the meta-analysis confirms that it is unlikely that reciprocity remains stable or decreases across the data use phases. Thus, the teachers in our participating teacher teams (and particularly in team Melrose) prefer closer relations in the transition from the discuss to the action phase.

Because centralization can only be calculated at network level, indegree popularity was included in the model to approximate this measure at the individual level (cf. method section). This effect reflects whether teachers turn to more popular actors throughout data use. Mixed results are found for the indegree popularity effect. In team Riverbank, teachers show the tendency to engage less in interactions with more popular actors throughout the data use process. In teams Melrose and Colby, the opposite evolution is found. In these teams, teachers tend to search for interaction with more popular actors in the context of data use. Therefore, no clear overall tendency of indegree popularity can be concluded from the meta-analysis.

Table 6: Results for the Stochastic Actor Oriented Model (SAOM)

	Rate parameters	**Structural effects**		**Popularity effects**
	Estimate (s.e.)	Outdegree (s.e.)	Reciprocity (s.e.)	Indegree popularity (s.e.)
Riverbank	P1: 1.68 (0.53) P2: 2.77 (0.93) P3: 1.33 (0.43)	-1.18 (0.60) *	0.56 (0.49)	-0.32 (0.17)*
Northvale	P1: 0.91 (0.34) P2: 1.52 (0.52) P3: 2.90 (1.03)	-3.97 (1.74) *	0.23 (1.18)	0.05 (0.46)
Melrose	P1: 0.39 (0.22) P2: 1.62 (0.57) P3: 0.98 (0.43)	-3.55 (1.36)**	1.66 (0.87)*	0.18 (0.35)*
McKinley	P1: 1.83 (0.53) P2: 1.42 (0.45) P3: 0.13 (0.13)	-3.74 (1.61)**	1.75 (1.18)	0.17 (0.32)
Colby	P1: 0.89 (0.33) P2: 4.00 (1.11) P3: 0.78 (0.34)	-3.62 (0.91)**	0.35 (0.64)	0.26 (0.13)*
Fisher test (meta): L-S χ^2 - R-S χ^2		56.72** - 0.11	2.25 – 20.85*	9.43 – 13.79

* $p < 0.05$
** $p < 0.01$
P1: discuss – interpret
P2: interpret – diagnose
P3: diagnose – action

The social network analyses at team level indicate that changes occur in structural interaction patterns across the data use cycle. Although teams strongly differ in the extent to which the role of central actors changes across the phases (i.e. indegree-popularity), similarities are found in the likeliness to engage in (mutual) connections with colleagues (i.e. density/outdegree and reciprocity). The general tendency is that teachers will engage in a smaller number of ties but are interested in more reciprocated ties throughout the different data use phases.

Teachers' interactive learning activities

The structural interaction patterns indicate that data use networks are rather sparse. This provides teachers with few opportunities for interactive learning activities. Also, teachers tend to reciprocate more ties in later phases in the data use cycle, which increases the depth of relationships. In this section, the qualitative data are used to complement these findings by looking into the degree of interdependency in interactive learning activities that teachers report within their personal (ego) networks in the context of data use.

Depending on the degree of interdependency, we distinguish between co-operative activities (i.e. storytelling, helping and sharing) and collaborative activities (i.e. joint work) to describe teachers' interactive learning activities. Table 7 provides an overview of the binarized results for the network activities that teachers mentioned in all interviews.

We find that, overall, the greatest share of teachers report learning activities with regard to their discussion network, while the smallest share report them with regard to their diagnosing network. Generally, the number of teachers reporting learning activities in their discuss and interpretation networks is higher than teachers providing evidence of learning activities in diagnosing and action networks.

Discussing pupil learning outcome data is often triggered by individual teachers. Most of the time, discussions on pupil learning outcome data are initiated due to poor performances in class tests. In a lot of cases, the other data use phases (interpretation, diagnosis and action) are undertaken individually by the teachers, but teachers feel frustrated about the effort they have put into teaching the subject and feel the need to discuss pupil learning outcome data with colleagues. In the case of interpreting pupil learning outcome data, teachers aim to share their pupil outcomes with colleagues, and add context to it. A common example is that teachers want to discuss pupil learning outcome data with colleagues in order to know how the pupil is doing in other courses. This contextualisation can lead to teachers reframing their first interpretation about the (poor) learning outcomes. In some cases, the contextualisation teachers are looking for results in a common diagnosis of problems on the basis of pupil learning outcome data. For example, teachers may ask colleagues whether or not test questions were too difficult for the pupil group. In addition, the action phase of data use can result from this type of situation. Some participants indicate that these (informal) discussions may result in sharing strategies or making agreements to cope with problematic behaviour or poor learning results.

Looking at the level of interdependency, the results show that most network activities on the part of teachers are at the lowest level of interdependency (i.e. storytelling). All interviewed teachers report at least one example of storytelling with (some of) their colleagues in the teacher team. Storytelling appears to be a common learning activity. Given its low level of interdependency, storytelling can occur ad hoc. For example, when a teacher starts a storytelling conversation because he or she has just noticed that a pupil is under-achieving in his or her course. Storytelling activities are mainly reported by teachers in their discuss and interpret networks.

When the level of interdependency increases, fewer teachers report this type of network activity and the learning activities are situated in later phases in the data use cycle. For example, helping is only reported by one teacher in the discuss and diagnosis phase and by four teachers in the action phase. This means that, of the interviewed teachers, the greatest number asks or provides help or advice for action on the basis of pupil learning outcome data. The most common examples of helping activities related to the action phase are related to improving assessment practices. For example, (often language) teachers struggle with

marking specific exercises on tests and ask colleagues for advice on how to better align their marking across pupils and tests. Sharing and joint work activities are almost absent in the interviewed teachers' data use networks. Whereas two teachers report sharing activities in their action network, only one teacher (Peter) indicates engaging in joint work for action upon pupil learning outcome data. The few examples of sharing practices involve, for example, sharing strategies to introduce peer assessment or to assess a particular student with learning disorders. The joint work example refers to making arrangements on curriculum subjects that are (not) evaluated.

Table 7: Teachers' network activities (N = 12)

		Discuss	Interpret	Diagnose	Action
Co-operation	Storytelling	11	9	3	0
	Helping	1	0	1	4
	Sharing	0	0	0	2
Collaboration	Joint work	0	0	0	1

Illustration: the case of John in team Riverbank

The social network analysis and the qualitative analysis are complementary in terms of the finding that data use cannot be considered a linear process, not in terms of structural interaction patterns, nor in terms of interactive learning activities that occur in teachers' personal networks. The core findings are that teachers' networks change by engaging in fewer but more intense connections with colleagues in later phases of the data use cycle. Only in the action phase do learning activities with higher levels of interdependency than storytelling occur. The case of John of team Riverbank is illustrative for these findings.

John's personal networks do not change profoundly across the data use phases, but his diagnosis and action network are slightly smaller than his discuss and interpret networks. Whereas he reports connections with five out of 10 colleagues for discussion and interpretation of pupil learning outcome data (i.e. Lydia, Alex, Gloria, Kelly and Kevin), the connection with Alex is dropped when it comes to diagnosis and action. John indicates that the discussion and interpretation of pupil learning outcome data generally takes place in daily conversations among teachers (i.e. storytelling), for example about pupils' lacking motivation or having a poor attitude with regard to his course (i.e. German language). These storytelling activities also serve John's interpretation of (certain) pupil learning outcome data. For example, when pupils' test scores are low, John often asks his colleagues in foreign languages whether or not they notice the same in their courses. According to John, this helps him to interpret whether the problem is specifically related to the German language course.

> *"In the beginning of the school year, the results of my pupils were very disappointing. Remarkable compared to other years. And then I consulted my colleagues in English language and French language, because these are also foreign languages. They hadn't noticed similar things yet because they were still rehearsing the curriculum of the previous years. But for German language, there was not much to rehearse [laughs].*
>
> *So I thought: 'Then it might be the transition to the fifth grade curriculum that is difficult for my pupils'. And my pupils confirmed this. So I slowed down the tempo of the lessons and proposed remedial work during lunch break so that my pupils would be able to catch up as much as possible."*

In John's diagnosing and action networks, the level of interdependency in his interactive learning activities is higher. John asks help or advice in both networks, for example when he

does not have a clue as to why test results for a certain pupil group remain low (i.e. diagnosis) or in (re)designing workable writing assignments for tests or exams (i.e. action). In his action network, John also aims to share strategies and materials. For example, he asks colleagues to share speaking assignments in order to create a better alignment in speaking assignments across the language teachers. Although John is one of the most interactive teachers in the present data set, he indicates that he almost never engages in joint work activities with colleagues in his data use networks.

> ***"Are there any colleagues in your network with whom you work together to talk about your pupils' learning outcomes and to investigate how these learning outcomes can improve?***
>
> *That is not really working together, but more informal, in the staff room. Those are occasions when you meet each other and you can exchange information. But consciously working together… not so much. Actually,… almost never."*

Discussion and conclusion

Although teacher interactions in the context of data use are highly valued, little is known about similarities and changes in teacher interactions in the data use cycle of discussion, interpretation, diagnosis and action. The combination of social network analysis and qualitative data in this study provided insights into (1) similarities and differences in structural interaction patterns in five Flemish teacher teams across data use phases, and (2) interactive learning activities that are embedded in 12 teachers' personal data use networks within the five teams.

The analysis of both research questions revealed that teachers' networks change across the data use phases, both in terms of structural interaction patterns and in terms of interactive learning activities. Generally speaking, the tendency is that teachers engage in fewer but more intense interactions with colleagues when progressing through the phases. The social network analysis showed that teachers are likely to drop connections with colleagues and invest more in mutual interactions. The qualitative analysis indicated that teacher interactions also become more intense in terms of interactive learning activities. Participants' interactions with regard to discussion and interpretation involve learning activities of lower levels of interdependency (i.e. storytelling). Higher levels of interdependency (i.e. helping, sharing, joint work) are reached in teachers' action networks.

Finding limited (mutual) interactions in teacher teams is similar to the results of the few network studies we found in the context of data use (Hubers, 2016; Farley-Ripple & Buttram, 2014; Keuning et al., 2016). Also, low levels of interdependency in the participating teacher teams is not uncommon, and particularly not given the Flemish (data use) research context (Katz & Earl, 2010; Kwakman, 2003; Little, 1990; OECD, 2014; Van Gasse et al., 2016). In Flanders, data use is often carried out individually by teachers and Flemish teachers in general do not intensively engage in activities that demand high degrees of interdependency with their colleagues (OECD, 2014; Van Gasse et al., 2016).

The novelty of findings can be found in the granularity in which changes in teacher interactions are revealed. The combination of research methods provided opportunities to expose with significant detail how teacher interactions change across the data use cycle. Previous research already showed that data analysing and interpretation skills are needed in the discussion and interpretation phase and advanced pedagogical content knowledge for correct problem diagnosis and the design of appropriate instructional change (Gummer & Mandinach, 2015; Marsh & Farrell, 2015). This study reveals that the 'shift' in the type of knowledge and skills

needed for data use diagnosis and action is accompanied by changes in teacher interactions. Whereas some (more) colleagues may be consulted for the discussion and interpretation of pupil learning outcome data, fewer teachers are preferred to carry out the diagnosis and action phase with. Additionally, the interactions of teachers in the action phase are characterized by activities of higher interdependency (i.e. helping, sharing, joint work).

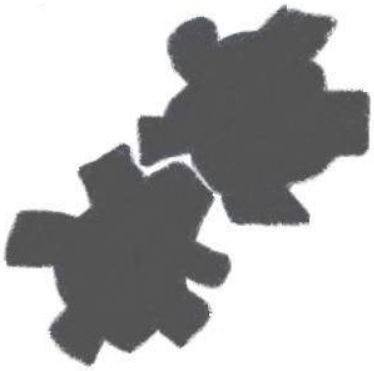
For the participating teachers in this study, fewer colleagues seem convenient to interact with for concrete and course specific problem solving or improvement (i.e. data use action) than for discussion and interpretation of data. At the same time, when the number of teacher interactions decreases, the teachers invest in interactions of higher interdependency. A possible explanation can lie in the advanced pedagogical knowledge required for data use action (Gummer & Mandinach). Although the five teacher teams share the responsibility for the learning of one specific pupil group, the teams are composed interdisciplinary. The qualitative data, including the case of John, indicate the likeliness that teachers search for colleagues teaching related courses when it comes to course-specific problem solving. A footnote in this regard is, however, that there must be additional explanations for whom is consulted in data use. The case of John, for example, shows that not all colleagues in his action network are language teachers. Thus, although the knowledge and skills associated with data use action can explain the smaller and more intense networks of the participating teachers to some extent, future research can invest in examining alternative explanations.

Unravelling teachers' interactions by the combination of social network data and teachers 'stories' behind their personal networks contribute to the current literature base both theoretically and methodologically. Not only does this study confirm that teacher interactions change across the data use phases, in-depth insights are provided into how networks change in terms of structure and activities. Nevertheless, some limitations remain. First of all, there are limitations with regard to the methodological approach. For example, we investigated teacher interactions within specific team boundaries. This implies that interactions of participating teachers with colleagues outside these boundaries were not included. Additionally, the combination of social network analysis and qualitative analysis required an intensive data collection. Therefore, our sample of 5 teams is small, whereby the current findings cannot be generalized. Future research can address both methodological issues, for example by using an ego network approach without strict team boundaries and by investing in a greater sample size. Another limitation is situated at theoretical level. Up to now, it remains unclear how effective networks look like in the context of data use. The network literature generally defines effective networks in terms of high density and reciprocity and low centralization (Moolenaar, 2012). However, it is doubtful whether this can be directly translated to data use networks, given that the complexity of data use may lead to consultation with a few (expert) colleagues to contribute to individual data use rather than engaging in interactions with all team members (Cosner, 2011; Hubbard & Datnow, 2016). Additionally, discussion is still ongoing with regard to the contribution of learning activities with low levels of interdependency (i.e. storytelling or helping) to teachers' professional development and classroom practice. Whereas some studies support the value of these activities (Van Waes et al., 2016), others are more sceptical about their impact on teacher learning (Van Gasse et al., 2016; Katz & Earl, 2010; Meirink, Meijer, Verloop, & Bergen, 2009). Therefore, future research should aim to provide insight into which network constellations and interactive learning activities result in thorough data discussion, interpretation, diagnosis and action.

The kinds of activities in the different data use phases affect how teachers use their networks. This has implications for both research and practice. To start with, teacher collaboration needs to be approached with sufficient granularity. The current study shows that interactions among teachers are very different depending on where they are situated in the data use cycle. For

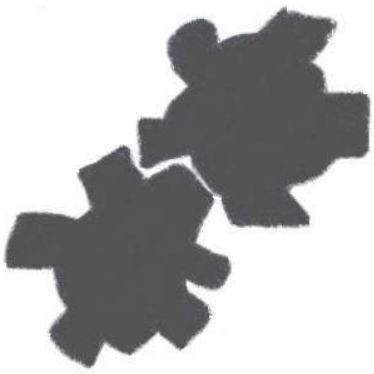
practitioners, awareness is needed that instructional improvement based on data requires higher levels of interdependency. After all, this study shows no storytelling in teachers' small action networks. Therefore, for instructional improvement, the aim does not have to be the involvement of all teachers. More important is setting common goals to encourage teachers' engagement in activities of higher interdependency with (some) colleagues (Levin & Datnow, 2012). For the great number of intervention studies in the field of data use, the results imply that intervention designs need to be well-considered with regard to teacher interactions. Acknowledging that teachers use their network differently and engage in different learning activities across the data use phases can support the outcomes and the sustainability of interventions. Researchers need to think about whether it is more useful to implement rather artificial compositions of teams or to embed interventions in existing social structures. And, in addition, to which extent the purpose should be that all teachers are equally involved and interact with high interdependency across the data cycle. To this end, future research on network constellations, interactive learning activities and their effects on instructional change is essential. Altogether, keeping in mind teachers' natural tendency of interacting throughout the data use cycle can take both research and practice a step further.

Teacher interactions have been valued for some time in the context of data use. This study was a useful first step in exploring how teacher interactions change across different data use phases. The combination of social network analysis with qualitative analysis exposed teacher interactions with great detail. Therefore, the study shed new light on teacher interactions with the theoretical and methodological granularity needed to do justice to the complexity of teachers' daily practice.



Study 4:

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



Abstract[5]

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.

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; Carlson, Borman, & Robinson, 2011). 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 (Schildkamp, Visscher, & Luyten, 2009; Van Gasse, Vanlommel, Vanhoof, & Van Petegem, 2016).

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 (Schildkamp, Poortman, & Handelzalts, 2015). 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,

[5] This chapter is based on:

Van Gasse, R., Vanlommel, K., Vanhoof, J., & Van Petegem, P. (under review). Teacher interactions in taking action upon pupil learning outcome data: A matter of attitude and self-efficacy?

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 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 (Gummer & Mandinach, 2015). 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 (Datnow, Park & Kennedy-Lewis, 2013; Hubbard et al., 2014; Van Gasse, Vanlommel, Vanhoof & Van Petegem, 2017). 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.

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 (Ciampa & Gallagher, 2016; Hubbard et al., 2014; Van Gasse et al., 2016). 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.

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 and colleagues (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.

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 (Datnow et al., 2013; Hubbard et al., 2014; Van Gasse et al., 2017). However, up to now, the impact of both characteristics on teacher interactions for data use action has remained unclear.

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 and Masia 1971). 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., 2017) 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.

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 & 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.

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?

Method

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' conceptualisation 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.

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.

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

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, 762 data points ensure that some general tendencies can be revealed.

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., 2017). 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?'*.

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. To do so, we aggregated the attitude and self-efficacy scores per team.

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. eta² 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 is a way to analyse patterns in social networks and serves to explain specific relationships in social networks. By means of the whole network structure, ERGM predicts the chance of particular relations being present in the network. Thus, ERGM can also assess whether teachers' characteristics (e.g. attitude or self-efficacy) are predictive for their interactions in networks.

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. A better explanation of the baseline model (i.e., AIC in the explanatory model is higher) 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.

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.

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 achieve better teaching and learning. However, the average scale scores per team indicate differences between teachers according to the team they are situated in. 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 the division of teachers out of those teams in the different 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 both teams 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

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.

Sender effects

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 to a certain extent. 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 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.

Table 3. Results of the ERGM per team

		Sender Effects		***Receiver effects***		***Homophily Effects***	
	Intercept	**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

Receiver effects

Receiver 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.

Homophily effects

Because network theory assumes that connections in teams can be explained by similarity between actors, 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.

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, 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, Moolenaar, Schildkamp, Daly, Handelzalts, & Pieters, 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 to some extent. 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 (Datnow et al., 2013; Van Gasse et al., 2017; 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 (Datnow et al., 2013; Van Gasse et al., 2017; 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., 2017). 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

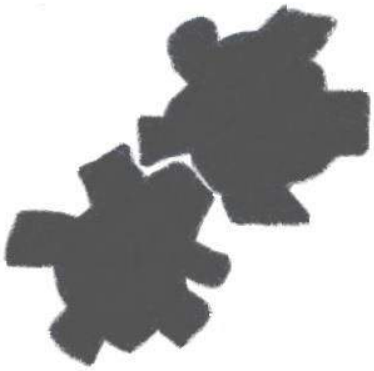
been too much, considering the limited statistical power of the networks in teams Northvale and Easton. Therefore, greater team sample sizes are needed in future research to gain statistical power in complex model testing and to result in more straightforward findings. Secondly, we used a whole network 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; Gummer & Mandinach, 2015). 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.

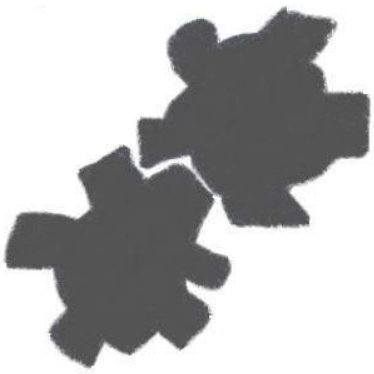
This study has addressed the value that is dedicated to teacher interactions in the context of data use by investigating the impact of attitude and self-efficacy in data use interactions. The method of social network analysis provided us with opportunities to distinguish different types of effects of 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.



Study 5:

Teacher collaboration on pupil learning outcome data: A rich environment for professional learning?



Abstract[6]

Collaboration on data use is expected to provide valuable opportunities for teachers to learn. Therefore, the goals of this qualitative study are to provide insight both into teachers' learning activities (storytelling, helping, sharing, joint work) with regard to collaborative use of pupil learning outcome data, as well as into teachers' professional learning (new or confirmed ideas, changed ideas of the self, consciousness, intention to change behavioural practice, turn new or confirmed ideas into practice) from these activities. We find that teachers mainly undertake storytelling and helping activities in terms of data use and that professional learning resulting from these activities is limited.

Introduction

Data are becoming more and more important for teachers' day-to-day decisions (Kerr, Marsh, Ikemoto, Darilek, & Barney, 2006; Verhaeghe, Vanhoof, Valcke, & Van Petegem, 2010). In particular, pupils' cognitive and non-cognitive learning outcomes are seen as data with great potential for teachers to develop and improve their practice (Jimerson, 2014).

Data use has been described as a cyclical process, in which phases of discussing, interpreting and diagnosing data and taking actions follow each other (Verhaeghe et al., 2010). During this process, interactions among team members are considered to be essential for fruitful data use (Copland, 2003; Hubbard, Datnow, & Pruyn, 2014; Wayman, Midgley, & Stringfield, 2006). Problems that are – at times – attributed to the individual capacity of data users might be overcome by interacting with colleagues (Hubbard et al., 2014; Wayman et al., 2006). Researchers expect that teachers' interactions with colleagues on data use provide valuable opportunities for teachers to learn, so that data use has the potential to serve as a rich environment for teachers' professional learning (Katz & Dack, 2014; Vanhoof & Schildkamp, 2014). This study aims to contribute to existing literature by providing insight into teachers' professional learning in the context of data use.

Up to now, research into data use has fallen short in two areas. First, there is insufficient evidence on the nature of teachers' interactions on the subject of pupil learning outcomes. Although researchers into data use have attempted to study various forms of collaboration, such as team work or communities (Bertrand & Marsh, 2015; Hubbard et al., 2014; Wayman

[6] This chapter is based on:

Van Gasse, R., Vanlommel, K., Vanhoof, J., & Van Petegem, P. (2016). Teacher collaboration on pupil learning outcome data: A rich environment for professional learning? *Teaching and Teacher Education, 60*, 387-397.

et al., 2006), little is known about the learning activities undertaken by teachers during these interactions. Given the potential contribution of data use for teacher learning, more insight into teachers' learning activities with regard to discussing data, interpreting data, diagnosing data and taking actions upon data is needed. Therefore, the first goal of this study is to describe teachers' learning activities with regard to teachers' use of pupil learning outcomes.

Data use is a cyclical process in which interaction can vary depending on each phase (e.g. more interaction in discussing than in taking action). To address this complexity, we use the Little (1990) framework, which incorporates an individual as well as a social perspective on teachers' learning activities. We investigate four types of teacher learning activities that have the potential to enhance teachers' professional learning: daily conversations on pupil learning outcomes (storytelling), asking for help or giving advice with regard to the use of pupil learning outcomes (helping), sharing materials or strategies to use pupil learning outcomes (sharing) and making arrangements or creating work groups with regard to pupil learning outcomes (joint work) (Little, 1990; Kwakman, 2003).

Second, knowledge on teachers' professional learning by means of data use interactions is scarce. A major pitfall for teachers' professional learning from data use activities is that teachers fit data into their current thinking (Katz & Dack, 2014). Although storytelling, helping, sharing and joint work are all activities that have been found to contribute to teachers' professional learning (Bakkenes, Vermunt, & Wubbels, 2010; Meirink, Meijer, Verloop, & Bergen, 2009a; Pareja Roblin & Margalef, 2013; Zwart, Wubbels, Bergen, & Bolhuis, 2007), the extent and type of professional learning results depend on the learning activities that are undertaken. The second goal of this study is to examine whether the learning activities that teachers undertake result in (some types of) professional learning.

Teachers' professional learning is studied using the Zwart et al. (2008) framework because this framework captures professional learning at the level of cognition, attitude and behaviour. We examine seven different types of professional learning: new ideas, conceptions or beliefs; confirmed ideas, conceptions or beliefs; consciousness; turning new ideas into practice; changed ideas of the self; intention to change behavioural practice; and turning confirmed ideas into practice.

In order to expand the current knowledge base on teachers' learning activities regarding the use of pupil learning outcomes and teachers' professional learning, the following research questions are central to this study:

1. Which learning activities do teachers undertake with regard to the use of pupil learning outcomes: storytelling, helping, sharing and/or joint work?
2. Which types of professional learning do teachers report as a result of storytelling, helping, sharing and joint work activities with regard to pupil learning outcomes?

Context of the study

This study took place in Flanders, which has a specific context to study data use in. Compared to other recurring countries in literature, the Flemish government takes a rather school improvement oriented perspective with regard to data use. Whilst standards are defined at the end of the second and sixth grade of secondary education, schools are autonomous in how these standards are reached (the curriculum) (De Volder, 2012; Penninckx, Vanhoof & Van Petegem, 2011). In addition, central exams are absent and no public databases or rankings of schools are available (OECD, 2013; De Volder, 2012). Schools themselves are responsible for

getting insight into whether or not they reach the Flemish standards at the end of secondary education (De Volder, 2012). Thus, governmental expectations towards data use are rather implicit and the responsibility for using data and support for data use lies with individual schools and teachers.

The absence of standardized testing in Flanders has implications for the conceptualization of data in this study. Schools and teachers primarily rely on their own data sources in order to get insight into pupil learning outcomes. Given the wide range of potential data sources (e.g. tests, assignments, observations or portfolios) and potential differences between teachers and schools in the data sources that are used, a broad conceptualization of data is needed within the Flemish context. Therefore, learning outcome data in this study comprise both cognitive (i.e. linguistic and arithmetic skills) and non-cognitive outcomes (i.e. attitudes, art and physical education), which can be both qualitative (i.e. observations) and quantitative (i.e. class tests).

Conceptual framework

To situate teachers' learning activities and their professional learning in their broader context, we first frame teachers' use of pupil learning outcomes within the context of workplace learning. Subsequently, we describe potential learning activities of teachers in regard to the use of pupil learning outcomes and our conceptualization of teachers' professional learning outcomes.

Teachers' workplace learning

Teachers' workplace learning is a comprehensive concept, which has been described from various points of view (Bakkenes et al., 2010; Hoekstra, Brekelmans, Beijaard, & Korthagen, 2009; Levine & Marcus, 2010; Meirink et al., 2009a). Recurrent elements are that teachers' workplace learning is situated within daily practice (Kwakman, 2003; Pareja Roblin & Margalef, 2013) and that teachers act as constructors of new knowledge, beliefs or behaviour (Meirink et al., 2009a).

Research incorporates two major foci in investigating teachers' workplace learning. First, the concept can be approached as a process variable. In these studies, teacher learning is examined as (a sequence of) learning activities that teachers undertake in the workplace (Kwakman, 2003; Little, 1990; Zwart, Wubbels, Bolhuis, & Bergen, 2008). Although this approach provides insights into 'what teachers do' in order to learn, learning results ('what teachers actually learn') are not necessarily brought to the surface. Therefore, the second approach to teachers' workplace learning is to conceptualize it as an outcome variable. Several studies have investigated cognitive and/or behavioural learning results of teachers in workplace settings (Bakkenes et al., 2010; Hoekstra et al., 2009; Levine & Marcus, 2010; Meirink et al., 2009a; Zwart et al., 2008).

Our study will distinguish between process characteristics (learning activities that take place) and the results of learning processes (teachers' professional learning), in order to cover the concept of workplace learning profoundly.

Learning activities

Given that workplace learning is situated in daily practice, one cannot expect that learning activities will be merely individual or social (Kwakman, 2003). We use the Little (1990) framework because it incorporates both the individual and the social perspective on learning

activities. Little (1990) categorizes learning activities depending on the (increasing) level of interdependence between teachers: storytelling, helping, sharing and joint work.

The integration of an individual and a social perspective on learning activities in the Little (1990) framework is particularly useful for this study since social interaction can vary depending on the data use phase (discussing, interpreting, diagnosing, taking action). Whereas discussing data can comprise a wide array of different social interactions, taking (instructional) action upon data can be a merely individual process.

The first learning activity in Little's (1990) framework is *storytelling*. Storytelling is a learning activity in which teachers are nearly completely independent of each other. Due to daily conversations with colleagues, a quick exchange of information takes place. Subsequently, teachers are completely independent in their use of this information in practice (Little, 1990).

Storytelling provides a good illustration of daily life in schools (Katz & Earl, 2010; Meirink et al., 2009a; Bakkenes et al., 2010). Also in the context of data use, daily conversations are reported (Datnow, Park & Kennedy-Lewis, 2013; Bolhuis, Schildkamp & Voogt, 2016) These storytelling activities can range from general conversations about data use to conversations about a specific data use topic within the school.

In this study, storytelling is conceptualized as daily conversations between teachers about the use of pupil learning outcomes in a broad sense. This means that not only specific information concerning using learning outcomes of pupils is the subject of storytelling, but also topics related to learning outcomes (for example, evaluation criteria that are used or actions that are undertaken to improve pupils' learning outcomes).

Helping is a learning activity that refers to giving or asking for help or advice and incorporates a high level of independence (Little, 1990; Kwakman, 2003). Helping activities derive from a question that is asked by an individual teacher, who – subsequently – decides independently to follow or ignore the help or advice that is offered (Little, 1990). Thus, helping is not about interfering in colleagues' work in unwarranted ways; the initiative lies with the teacher in search of help or advice (Katz & Earl, 2010). Due to the underlying purpose of help-seeking, this type of activity is less open-ended for the help-seeker than storytelling activities.

Helping activities are one of the main reasons why emphasis has been laid on collaborative data use (Datnow et al., 2013; Hubbard et al., 2014). The presence of helping activities in data use settings can be crucial in order to tackle personal barriers with regard to data use, such as difficulties with analysing and interpreting data or setting improvement actions (Datnow et al., 2013; Hubbard et al., 2014; Jimerson, 2014).

Mixed results have been found on the prevalence of helping activities in schools. In some studies, a high frequency of helping activities is reported (Katz & Earl, 2010; Katz et al., 2009; Meirink et al., 2009a), whereas helping activities remain limited in other studies (Kwakman, 2003).

In this study, we focus on teachers' helping activities related to the use of pupil learning outcomes and which meet a high level of independence of teachers. This means that the only helping activities are that studied are those which originate from a teacher's question related to using pupil learning outcomes in a broad sense (ranging from, for example, asking advice on evaluating a pupil's writing assignment to, for example, how to interpret a pupil's test scores).

A third learning activity is *sharing*, which implies the distribution of data, materials and methods, or the open exchange of ideas and opinions (Little, 1990). The underlying goal of teachers is to make aspects of their work accessible and expose their ideas and intentions (Katz & Earl,

2010). Thus, teachers create a kind of 'open access environment' of materials and choices and rationales that have been made. Therefore, sharing is seen as a learning activity that incorporates a higher level of interdependence, compared with storytelling and helping (Little, 1990). Sharing activities do not imply that teachers are bound to what is shared with regard to how they shape their daily practice (Little, 1990).

Empirical evidence has validated sharing activities, also in the context of data use. However, there is little insight into their frequency of use, since the extent to which sharing activities are reported differs across studies (Kwakman, 2003; Katz & Earl, 2010; Meirink et al., 2009b; Hubers, Poortman, Schildkamp, Pieters, & Handelzalts, 2016; Bolhuis et al., 2016).

We approach sharing activities with regard to the use of pupil learning outcomes in a broad sense. This means that, for example, ideas about how to deal with pupil learning outcomes or materials to improve learning outcomes can all be part of sharing activities.

The last learning activity in Little's (1990) framework is *joint work*, or "*encounters among teachers that rest on shared responsibility for the work of teaching*". This implies a high level of interdependency - collective purposes that result in truly collective action, such as work groups and agreements (Little, 1990). Felt interdependencies among teachers are few, which is why joint work is rarely found among teachers (Kwakman, 2003; Katz & Earl, 2010; Katz et al., 2009). Within the context of data use, indications for joint work are found, but mainly by means of intervention studies (Hubers et al., 2016; Schildkamp et al., 2015; Cosner, 2011).

In this study, joint work is again conceptualized in a broad sense, and can, for example, include joint work activities on the interpretation of test scores or with regard to strategies to improve learning outcomes. In line with Little's (1990) definition, we approach joint work as activities with a high level of interdependency. This means that joint work among teachers derives from shared goals and that results of joint work activities are reflected in teachers' individual practice (for example, arrangements on evaluation criteria that are made among teachers).

For reasons of conceptual clarity, we have strictly distinguished between storytelling, helping, sharing and joint work in this conceptual framework. However, we assume that in real-life situations more than one learning activity can appear at a time (for example, situations in which storytelling as well as sharing materials appear).

Teachers' professional learning outcomes

Professional learning outcomes of teachers' workplace learning have generally been conceptualized as 'change' in teachers' cognition or beliefs, in teachers' practice or behaviour and in teachers' attitudes (Bakkenes et al., 2010; Hoekstra et al., 2009; Katz et al., 2008; Levine & Marcus, 2010; Meirink et al., 2009b; Zwart et al., 2007). However, teachers can also learn about current practices that are going well. Thus, professional learning is not only about changing, but also about finding confirmation about aspects of teachers' cognition or beliefs, practice or behaviour and attitudes (Bakkenes et al., 2009; Zwart et al., 2008).

We draw on the work of Zwart and colleagues (2008) to map teachers' professional learning to establish both changing and finding confirmation about aspects of teaching into our conceptualization of professional learning. Zwart et al. (2008) distinguish seven types of professional learning, which can be categorized into the three components of professional learning mentioned earlier (see Table 3): new ideas, conceptions or beliefs; confirmed ideas, conceptions or beliefs; changed idea of the self; intentions to change behavioural practice; turn new ideas, conceptions or beliefs into practice; turn confirmed ideas, conceptions or beliefs into practice; and consciousness.

Table 3: Types of professional learning (Zwart et al., 2008)

Component of professional learning	Type of professional learning (Zwart et al., 2008)
Cognition	- New ideas, conceptions or beliefs - Confirmed ideas, conceptions or beliefs - Changed ideas of the self
Practice	- Turn new ideas, conceptions or beliefs into practice - Turn confirmed ideas, conceptions or beliefs into changed behavioural practice
Attitudes	- Intention to change behavioural practice - Consciousness

With regard to teachers' cognition, Zwart et al. (2008) find that workplace learning can result in new ideas, conceptions or beliefs. This are changes in teachers' understanding, thinking or mental models with regard to a certain topic or insights into problems or situations related to this topic (Bakkenes et al., 2010; Zwart et al., 2008). Next to new ideas, conceptions or beliefs, workplace learning can lead to the confirmation of existing ideas, conceptions or beliefs (Bakkenes et al., 2010; Zwart et al., 2008). This means that teachers find support for specific ideas, conceptions or beliefs they already had beforehand (Zwart et al., 2008). A last type of professional learning related to teachers' cognition or beliefs is a changed idea of the self. Zwart et al. (2008) state that teachers have a certain image of themselves and of their profession, which can be changed through workplace learning.

Next, Zwart et al. (2008) distinguish types of professional learning that are related to teachers' practice. Teachers can become convinced of a new idea, conception or belief to such an extent that they have already changed or plan to change their practice accordingly (Zwart et al., 2008; Bakkenes et al., 2010). Also the confirmation of existing ideas, conceptions or beliefs can push teachers to change or continue their current practices or the intention to do so (Zwart et al., 2008; Bakkenes et al., 2010).

Finally, related to teachers' attitudes, Zwart et al. (2008) name intentions to change behavioural practices or teachers' willingness to change as professional learning. Some learning activities lead to teachers explicitly rejecting their current practices. Although these teachers do not necessarily have ideas about or carry out changes in their practice, they (start to) demonstrate willingness to change (Zwart et al., 2008). Teachers' workplace learning can also result in teachers adopting a more conscious attitude towards certain topics or an increased awareness of things because they now hear, see or feel more clearly what is happening around them (Zwart et al., 2008; Bakkenes et al., 2010).

The aforementioned types of professional learning will be used to describe 'what teachers learn' from teachers' learning activities. We will not relate each type of professional learning in the Zwart et al. (2008) framework exclusively to the different learning activities (e.g., the impact of storytelling on the generation of new ideas), because we aim to examine the overall contribution of learning activities to teachers' professional learning.

Method

Participants

This qualitative study took place in the context of a project concerning the assessment of pupils' writing competences. Out of 10 participating secondary schools in the project, six were randomly asked to participate in this study.

In each school, we focused on a particular grade-level teacher team to map teachers' learning activities and their professional learning. The teams are temporary and interdisciplinary (Vangrieken, Dochy, Raes & Kyndt, 2013), and are collectively responsible for the learning of pupils within the fifth grade of an academic track in economics and languages (16- to 17-year-olds). 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 whether or not pupils will successfully complete their year.

We interviewed 14 teachers out of six teacher teams to examine learning activities on the basis of the use of learning outcome data. A minimum of two teachers was interviewed within each teacher team.

The 14 teachers varied in gender (six were male; eight were female), teaching experience (five to 30 years) and teaching course (Dutch, English, French, German, history and chemistry). Participation of all teachers was voluntary. An overview of the main characteristics of all participating teachers is provided in Table 2.

Table 4: Overview of the participants

Team	Participant	Gender	Teaching experience	Course(s)
A	AA	Male	10-15	Dutch
A	AB	Male	10-15	German
B	BA	Female	0-5	History
B	BB	Male	10-15	Dutch
B	BC	Female	15-20	French
C	CA	Male	15-20	History
C	CB	Male	5-10	English
D	DA	Female	+25	Dutch
D	DB	Female	+25	Economics
E	EA	Female	5-10	Dutch, English
E	EB	Male	15-20	Chemistry
F	FA	Female	10-15	English
F	FB	Female	15-20	Dutch
F	FC	Female	15-20	German

Interviews

We used semi-structured interviews to answer the research questions. Participants' answers to questions regarding which team members they consult when discussing, interpreting, diagnosing or taking action upon pupil learning outcomes, deriving from a prior survey, formed the starting point of our interviews.

First, we provided the teachers with an overview of the colleagues they consulted. Then, we asked them what exactly happened in these interactions, using an open question so that participants' answers were not necessarily restricted to the concepts we had set forward (e.g.,

‘What actually happens when you consult these colleagues on pupil learning outcomes? Can you recall real-life situations?). Subsequently, we posed additional questions on the Little (1990) framework (e.g., ‘To whom amongst your colleagues do you ask advice on pupil learning outcomes? Can you sketch out such a situation?’).

For teachers’ professional learning results we also started with an open question (e.g., ‘What have you learned from interacting with these colleagues on using pupil learning outcomes?’). Subsequently, the Zwart et al. (2008) framework guided our questions (e.g., ‘Which new ideas, conceptions or beliefs have been the result of your interactions with colleagues on the use of pupil learning outcomes?’).

The interviews had an average duration of 45 minutes and were transcribed ad verbatim.

Coding process

After transcribing the interviews, a six-step coding process took place using Nvivo 10 software.

First, half of the interviews were coded inductively. A researcher (researcher A) provided interview fragments with an open code, staying as close as possible to the original text (Pandit, 1996).

In step 2, the open codes were discussed with a second researcher (further: researcher B). Both researchers evaluated the validity of the open codes. This resulted in the need to concretize or rephrase certain codes. Subsequently, researcher A finished the open coding.

Step 3 concerned agreements between researchers A and B on the conceptual characteristics of axial codes related to both frameworks (see Table 3).

Table 5: Conceptual characteristics of axial codes

	Axial Code	Conceptual characteristics
Learning activities (Little, 1990)	Storytelling	- Asking/talking about learning outcomes - Individually driven: gathering information for own practice - Quasi no interdependency
	Helping	- Advice related to learning outcomes - Individually driven: derives from a need/question - Little interdependency: need of the advice-seeker
	Sharing	- Distribution of materials, strategies, information - Driven from a collective perspective: serving the teacher team - Little interdependency: individual responsibility of teachers
	Joint work	- Actively working together (making arrangements, etc.) - Driven from a collective perspective: make the teacher team work more efficiently/better - High interdependency: joint work is reflected in individual practice
Professional learning results (Zwart et al., 2008)	New ideas, conceptions or beliefs	- Changed understanding - Changed thinking - Changed picture in the mind
	Confirmed ideas, conceptions or beliefs	- Greater proof of something - Support for an idea, conception or belief
	Consciousness	- Awareness grown from new knowledge - Being/acting more conscious on the basis of new knowledge
	Intention to change behavioural practice	- Reject current practice(s)
	Turn new ideas, conceptions or beliefs into practice	- (Plan to) change behavioural practice because of new ideas, conceptions or beliefs
	Turn confirmed ideas, conceptions or beliefs into practice	- (Plan to) change behavioural practice because ideas, conceptions or beliefs have been confirmed

Subsequently, the coding process took a deductive approach. Researchers A and B independently put open codes of seven randomly chosen interviews under the axial codes (step 4).

In step 5 the inter-rater reliability between researcher A and researcher B on the axial coding (headcodes) was calculated. For the learning activities framework, a substantial Cohen's

kappa of 0.74 was found. For the professional learning results framework, the Cohen's kappa value of 0.86 was almost perfect (Sim & Wright, 2005).

Finally, disagreements between the coding of both researchers were discussed to assure validity in the rest of the axial coding, which was finished by researcher A (step 6).

Analysing process

After finalizing the coding, analysing started by exploring general themes within the headcodes (framework analysis) across participants (cross-case analysis). For example, 'helping' comprised open codes concerning 'improving teaching and evaluation' and 'specific problems in daily practice'.

Second, we binarized the qualitative data on the level of headcodes for each participant. Score 1 was given to a participant if a headcode was present in the interview, score 0 if this was not the case. Binarization is a robust technique to get insight into the appearance of phenomena across or within participants (Onwuegbuzie, 2003). Since all conceptual topics were questioned in all semi-structured interviews, this technique was suitable for the present dataset. The advantage of binarizing relative to counting citations is that it purges personal differences of participants (e.g., talkative versus introverted participants).

Cross-case analyses were conducted, using the headcodes and sub-themes mentioned earlier. The binarized data were used to provide insight into the occurrence of headcodes across participants via the calculation of the relative frequencies (Onwuegbuzie, 2003). For example, 'storytelling' occurred in all 14 interviews. This means that the relative frequency of 'storytelling' is 0.41 (14 of a total of 34 spread over the four learning activities). In theory, this relative frequency is a value between 0 and 1, going from not occurring (0) to being the only occurring code (1). Counting the relative frequencies of all learning activities together ends with a total of 1. Thus, the extent of occurrence of all learning activities compared with each other is reflected by the values (Onwuegbuzie, 2003).

Furthermore, we analysed similarities and differences between participants on the basis of the binary coding. In this process, we started from the binary coding to explore which of the participants behave similarly of differently in their collaborative data use.

Results

We start with describing teachers' learning activities with regard to using pupil learning outcomes. Afterwards, we examine teachers' professional learning outcomes.

Learning activities

Table 6 provides an overview of the relative frequency of teachers' storytelling, helping, sharing and joint work with regard to the use of pupil learning outcomes, as explained in the method section. The first letter in participants' ID identifies the school (teacher team) and the second letter identifies the teacher within the team. For example, participant CA is teacher A out of school (teacher team) C.

Table 6: Binarized results for teachers' learning activities and relative frequency

	Participant ID														Total	Relative frequency
	AA	AB	BA	BB	BC	CA	CB	DA	DB	EA	EB	FA	FB	FC		
Storytelling	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	0.41
Helping	1	1	1	1	0	1	0	0	1	1	1	1	1	1	11	0.32
Sharing	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2	0.06
Joint work	1	1	0	0	0	0	0	1	0	1	1	1	0	1	7	0.21
															34	**1**

Storytelling

All teachers (N = 14) report storytelling with regard to using pupil learning outcomes, which indicates that this is a common learning activity in teacher teams. This finding is also underpinned by the binarized interview data (Table 6), with a relative frequency of 0.41. Thus, of all the activities in the Little (1990) framework, storytelling is most apparent in terms of using pupil learning outcomes.

We found that two of the participating teachers (BC and CB) limit their learning activities in the context of data use to storytelling activities. When asked what triggers their learning activities, both teachers indicated the need to feel comfortable with people when undertaking storytelling activities. This was confirmed by five other teachers. Only with colleagues with whom teachers have a trusting relationship do they feel confident to tell stories related to classroom practice.

Both teachers that reported only storytelling activities indicated that their learning activities are strongly influenced by the course that is taught by colleagues. For example, teacher BC reports that she does not feel the need to invest in deeper forms of collaboration around pupils learning outcomes since she is the only French teacher in the team. According to her, colleagues are not familiar with her course, whereby helping, sharing or joint work activities would not be meaningful.

We find that storytelling with regard to using pupil learning outcomes is triggered by individual teachers. Most of the time, storytelling is initiated due to poor performances on class tests. For example, several teachers indicate that it is frustrating when pupils do not achieve as expected on tests, especially when these teachers have the feeling that they put a lot of effort into teaching the subject. Storytelling can be initiated by these situations because teachers feel the need to talk about them.

Storytelling regarding the use of pupil learning outcomes mostly occurs ad hoc. When teachers notice a pupils' poor performance on several class tests, they will consult colleagues in order to talk about these performances. Subsequently, a conversation originates based on the learning outcomes of the specific pupil. Teachers exchange information on how the pupil performs in their course: they tell stories about how the pupil's class tests are going. In most cases, storytelling is not only about test scores as such but also about how pupils behave in the classroom.

> *"The moment I notice that a pupil has difficulties, I will go chat with my colleagues in foreign languages to find out whether or not his/her reading or listening is weak in my colleagues' courses as well." [Participant A, School C]*

Teachers suggest that storytelling activities offer them opportunities to frame problems they run into. For example, a teacher tells a colleague about a pupil who does not achieve as expected in his/her course. His/her colleague might have the same experience or a different one. Teachers indicate that, in both cases, knowing the experiences of colleagues is useful in maintaining or reshaping expectations towards the specific pupil. By knowing whether or not the experiences of colleagues are similar, teachers can assess whether a problem is only related to the discipline they are teaching or their teaching style, or whether it might derive from the pupil's general cognitive ability or his/her general attitude at school.

Helping

The majority of the interviewed teachers (11 out of 14) report helping activities with regard to using pupil learning outcomes. Helping is the second most frequently reported activity out of the Little (1990) framework with regard to pupil learning outcomes (see Table 6). The number of 11 interviewees reporting helping with regard to the use of pupil learning outcomes results in a relative frequency of 0.32.

We find that for the majority of the teachers (11 out of 14), collaborative learning activities around pupil learning outcomes are limited to storytelling and helping. As in storytelling, teachers indicate that a trusting relationship is needed to share stories about classroom practice and to seek help. Teacher DA is the only teacher that does not report helping activities despite the fact that she undertakes joint work activities. According to this teacher, she does not feel confident to discuss problems she runs into regarding pupil learning outcomes.

As with storytelling, the trigger for helping with regard to using pupil learning outcomes lies with individual teachers. Similarly to storytelling, helping is initiated when teachers experience a problem. For example, a language teacher tells how he imposed a book review, but that the quality of pupils' assignments did not meet the teacher's expectations. This situation triggered the teacher to search for help among colleagues, by asking critical friends to take a look at his assignment in order to know how to improve it. The example illustrates helping situations we find in the interview data. Helping with regard to the use of pupil learning outcomes occurs when teachers run into problems (often disappointing learning results) with the goal of finding a (quick) solution.

In the citations on teachers' helping activities, we find several data sources that can trigger helping activities. Helping activities can occur around (results of) class tests or exercises:

> *"You are correcting tests or assignments in the staffroom and you think, 'How should I mark this?' And then you ask the advice of a colleague: 'How would you mark this?'" [Participant A, School F]*

Helping with regard to using pupil learning outcomes is often initiated with the aim of improving teachers' assessment practice. For example, a teacher states that she often consults a colleague who teaches the same course to the same grade. When she has doubts about her pupils' marks in assignments, she asks this colleague for advice. A lot of examples of helping with regard to using pupil learning outcomes are similar. Teachers have doubts about the scoring of certain exercises or (types of) errors. Subsequently, they consult colleagues in order to solve these problems. Teachers talk less often about helping activities on the basis of class tests or exercises with the aim of improving their teaching practice.

In conjunction with class tests and exercises, teachers' classroom observations can be a source of data around which helping activities occur. These cases are often about pupils' (problematic) behaviour in the classroom. Pupils' behaviour that is or becomes problematic in

teachers' classroom practice can be a trigger for teachers to consult colleagues for help. By telling colleagues about these situations, teachers hope that their colleagues serve them with (quick) solutions for this behaviour.

Sharing

Only two teachers report sharing with regard to using pupil learning outcomes. Compared with the other activities in the Little (1990) framework, evidence on sharing with regard to using pupil learning outcomes is scarce. Sharing in relation to using pupil learning outcomes remains practically absent, which is indicated by a relative frequency of 0.06. The small amount of evidence on sharing activities compared with the extent to which teachers report storytelling and helping activities is remarkable.

The few citations available lead us to presume that sharing can happen ad hoc in daily conversations as well as in structured settings (team meetings). In the team meetings that are reported by teachers, pupils' scores on class tests are the subject of discussion. One teacher for example states that during these discussions, expectations regarding the ability outcomes of pupils at the end of the year can be made explicit. One teacher reports she also shares strategies in the staff room. In conversations with (certain) colleagues, she talked about low test scores and strategies she used to overcome specific problems with these low achievers.

Although it was the expectation that interview data would provide insight into why sharing activities are limited, we do find indications of the absence of sharing activities among some teachers. Two teachers (FB and FC) indicated that they do not feel the need to undertake sharing activities around pupil learning outcomes. According to them, they have become experienced teachers which implies that they have a lot of insight into materials and strategies to improve pupils' learning outcomes.

Our limited evidence on sharing activities compared with storytelling and helping activities indicates that the higher degree of interdependency in sharing activities might be a hindrance teachers to engaging in these activities. Sharing implies that teachers provide each other with information or materials as a result of common goals. However, common goal setting and a systematic approach to sharing activities remain absent.

Joint work

Half of the teachers (7 out of 14) report joint work with regard to using pupil learning outcomes. Thus, compared with storytelling and helping, the number of interviewees who report joint work with regard to using pupil learning outcomes is small (relative frequency of 0.21; Table 6). Notable is that both learning activities with a higher degree of interdependency (sharing and joint work) appear less frequently among teachers.

In contrast to storytelling and helping, joint work with regard to using pupil learning outcomes primarily takes place in structured settings, such as the team meetings that are organized to monitor and evaluate whether pupils will achieve their desired grade. Teachers explain that, at those team meetings, particularly problematic test scores of pupils are discussed. During these discussions, potential causes of low achievement are defined and arrangements for remedial plans are made.

> *"For some pupils, we discuss how their scores can be improved. And then we discuss whether they should receive remedial exercises during holidays or if we should provide a remedial hour during class." [Participant C, School B]*

At team meetings, the process of discussing test scores, diagnosing problems and making arrangements for actions is carried out quite superficially and only in case of problematic test scores. For example, when a teacher indicates that a pupil's test scores remain problematic, teachers can agree that the pupil will receive a remedial plan. However, how the remedial plan will look remains the responsibility of the individual teacher, sometimes in dialogue with the pupil counsellor.

The aforementioned team meetings are mandatory, which implies that joint work activities with regard to using pupil learning outcomes are not undertaken out of teachers' personal interest or motivation.

Little evidence is available on joint work that takes place outside team meetings. These few examples available mainly include making arrangements for marking tests or assignments. Thus, as with sharing activities, it is remarkable that teachers do not tend to undertake joint work activities with regard to using pupil learning outcomes outside the mandatory team meetings.

The interview data provide some insight into why joint work activities around pupil learning outcomes are limited among teachers. Three of the interviewed teachers (AA, AB, EA) that report joint work indicate that they value collaboration around pupil learning outcomes and that more joint work activities are required. However, according to four out of seven teachers that do not undertake joint work activities (BA, BB, BC, FB), the tendency at school is for teachers to solve their own problems. This is confirmed by three other teachers that do report joint work activities (AA, DA, EB).

In sum, we find that storytelling and helping with regard to using pupil learning outcomes are common activities among teachers. However, a limited number of teachers undertake learning activities with a higher degree of interdependency (sharing and joint work) on a voluntary basis.

Teachers' professional learning outcomes

Despite the general assumption that data use contributes to teachers' professional learning, we find little evidence of professional learning on the basis of storytelling, helping, sharing and joint work with regard to using pupil learning outcomes. Of the seven types of professional learning results in the Zwart et al. (2008) framework, we only found citations that can be grouped into four types: new ideas, conceptions or beliefs; confirmed ideas, conceptions or beliefs; consciousness; and turning new ideas, conceptions or beliefs into practice. In each case, the reported learning outcomes are the result of teachers' storytelling, helping, sharing or joint work activities in the context of data use.

Given the assumption that data use provides a rich environment for professional learning, it is remarkable that the other types of professional learning results in the framework (changed ideas of the self; intention to change behavioural practice; and turning confirmed ideas, conceptions or beliefs into practice) were not reported by teachers. Table 7 provides information on the binarized results of teachers' professional learning upon teachers' storytelling, helping, sharing and joint work.

Table 7: Binarized results for teachers' professional learning and relative frequency

	Participant ID														Total	Relative frequency
	AA	AB	BA	BB	BC	CA	CB	DA	DB	EA	EB	FA	FB	FC		
New ideas, conceptions or beliefs	1	1	1	0	1	1	1	0	0	0	0	0	0	0	6	0.22
Confirmed ideas, conceptions or beliefs	1	1	1	0	0	0	1	0	0	0	0	0	0	0	4	0.15
Consciousness	1	1	1	1	1	1	1	0	0	1	1	1	1	0	11	0.41
Turn new ideas, conceptions or beliefs into practice	1	1	1	1	0	0	0	0	0	1	0	0	0	1	6	0.22
Changed ideas of the self	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intention to change behavioural practice	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turn confirmed ideas, conceptions or beliefs into practice	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
															27	**1**

New ideas, conceptions or beliefs

Almost half of the participants (6 out of 14) indicate that their learning activities with regard to using pupil learning outcomes result in the growth of new ideas, conceptions or beliefs. The relative frequency calculated is 0.22 (see Table 5), which indicates that new ideas, conceptions or beliefs have a reasonable share in teachers' professional learning.

New ideas, conceptions or beliefs can be general or specific within a situation. For example, a teacher suggests that interacting with a certain colleague for him resulted in a change in expectations towards particular pupils (specific situations).

> *"Sometimes there is a pupil who behaves differently during your course compared with your colleagues' courses. And knowing that can adjust your image of this pupil in a positive way. I see my pupils only one hour a week and sometimes I think that a pupil is weakly motivated. But in a different course with a different teacher, that can be completely different." [Participant B, School C]*

With regard to general ideas, conceptions or beliefs, a teacher gave the example of test scores that remain low in a pupil group in which he had limited teaching experience. Telling this to a colleague, she told him his tests and assignments were too difficult bearing in mind that those pupils had limited prior knowledge relating to his course. All this led to the teacher having different expectations of pupils in this branch of studies in general.

Altogether, professional learning results in the form of new ideas, conceptions or beliefs reported in the interviews are quite superficial, as illustrated in the examples above. We did not find citations in which teachers suggested that their learning activities with regard to using pupil learning outcomes initiated fundamental new ideas or conceptions in their daily practice.

Confirmed ideas, conceptions or beliefs

Of the 14 interviewees, four participants report that confirmed ideas, conceptions or beliefs resulted from their learning activities with regard to using pupil learning outcomes. This type of professional learning has a small share in this study (relative frequency of 0.15; Table 7). Few teachers find confirmation of existing ideas, conceptions or beliefs in storytelling, helping, sharing and joint work.

Confirmed ideas, conceptions or beliefs can be related to teaching in general. Teachers indicated that their learning activities sometimes confirm them in their teaching practice. For example, a language teacher is convinced that teaching a language should incorporate a stronger focus on language skills than pure knowledge. He says that interactions with colleagues strengthen this conviction because his colleagues share the same opinion. Other, more specific, confirmations of ideas, conceptions or beliefs that teachers mention contain insights into 'the teacher they want to be'. Several teachers suggest that interactions with colleagues on using pupil learning outcomes give them a frame of reference for 'the teacher they try to be'.

> *"These are colleagues who are similar to me. And that has taught me about the teacher I want to be. Like I already said, being committed to your pupils, accompanying them in their learning process." [Participant A, School B]*

Despite the assumption built on data use research, it is remarkable to notice that teachers' learning activities do not genuinely seem to initiate new ideas, conceptions or beliefs, nor to confirm existing ideas, conceptions or beliefs. Thus, at cognitive level, the learning activities found in teachers' use of pupil learning outcomes do not make a strong contribution to teachers' professional learning.

Consciousness

Consciousness is the most reported type of professional learning outcome among teachers. Over three-quarters of the participating teachers (11 out of 14) indicated that consciousness has resulted from their learning activities with regard to using pupil learning outcomes. This resulted in a relative frequency of 0.41 (Table 7).

Teachers suggest that storytelling, helping, sharing and joint work leads to an increased awareness of things that are happening in their classroom practice. For example, a teacher told the anecdote of a colleague who asked him whether or not a pupil had dyslexia. Apparently, this pupil was making a lot of writing errors in the colleague's course but not in this teachers' course. This made him aware that pupils achieve differently depending on the course of the teacher.

Teachers also indicated that their learning activities help them to situate themselves within the teaching team. According to one teacher, interactions made him realize that he has some colleagues with a totally different view of teaching and learning. He gives the example of teachers who are more severe and who assume that pupils, rather than teachers, are responsible for low achievement.

> *"I learned that, beside my teaching method, other ways of teaching are possible. And that those ways are not necessarily worse. So if colleagues come to you to ask advice, this means that they have a problem with which they cannot cope. And those interactions around ways of teaching are enriching." [Participant C, School F]*

It is curious that teachers almost exclusively reported situations in which they became aware of aspects of their teaching compared with aspects of their colleagues' teaching. We found only a very small amount of evidence of profound reflection upon teachers' personal practice. It is notable that teachers' learning activities with regard to using pupil learning outcomes do not seem to result in deeper awareness or consciousness of teaching, since data use implies processes of thorough analysis and reflection. Thus, teachers' learning activities make a contribution to attitude level, although the extent of this contribution can be questioned.

Turn new ideas, conceptions or beliefs into practice

Six participants reported new ideas and intentions to change behavioural practice as a result of their learning activities with regard to using pupil learning outcomes. The relative frequency of 0.22 indicates that learning activities may introduce new ideas and intentions to change behavioural practice to some extent (see Table 7).

We find that learning activities might serve teachers with new, general ideas and intentions to change their behavioural practice. A teacher explains that, through talking about pupil learning outcomes, he heard from a colleague who gave his pupils a rubric and let them evaluate their peers' assignments. The colleague told the teacher that the grades pupils gave each other were similar to the grades given by the teacher and that peer assessment was a useful learning strategy for pupils. Through this story, the teacher became convinced by the idea and tried it himself.

Another finding is that teachers' consciousness of their colleagues' teaching styles leads to teachers trying to change their own teaching practice. For example, a teacher indicates that he is strongly knowledge-oriented, while some of his colleagues are not. Interacting with these colleagues made him realize that he should also explicitly value (social) skills of pupils.

> *"A colleague of mine had low achieving pupils in second grade and she improved her pupils' learning results through study contracts. I remembered it and introduced them in fourth grade when I experienced the same problem." [Participant A, School C]*

In general, the changes in practice reported by teachers take the form of quick changes or solutions to problems. On the basis of the interviews, we cannot presume that teachers' learning activities, with regard to using pupil learning outcomes, result in questioning fundamental aspects of teachers' practice and – subsequently – in (planning) to change these aspects. This is noteworthy because data use is generally assumed to guide these processes. Therefore, it is curious that learning activities with regard to using pupil learning outcomes have a small contribution at practice level.

Discussion and conclusion

Over recent years, the emphasis on collaboration in data use settings has grown. Researchers believe that teachers' interactions with colleagues regarding data provide valuable opportunities for teachers to learn. Up to now, little evidence has been available on teachers' interactive learning activities during their use of pupil learning outcomes and on the types of professional learning resulting from these activities. Therefore, a qualitative study using semi-structured interviews was carried out in Flanders. We examined (1) teachers' storytelling,

helping, sharing and joint work with regard to teachers' use of pupil learning outcomes and (2) what teachers say they learn from these learning activities.

We learned that teachers in this study mainly undertake storytelling and helping activities with regard to their collaborative use of pupil learning outcomes. Within the six teams, teachers primarily engage in learning activities that incorporate no or little interdependency. Sharing and joint work with regard to teachers' use of pupil learning outcomes, learning activities that imply a higher degree of interdependency, are rare.

A possible explanation for this finding might be that the participating teachers experience a great sense of individual responsibility for their pupils' learning outcomes. Thus, although teachers consult (some of their) colleagues in order to discuss, interpret, diagnose or take action upon pupil learning outcomes, they do not tend to feel strong interdependencies with colleagues regarding the use of pupil learning outcomes. Therefore, sharing and joint work might not be common learning activities with regard to the use of pupil learning outcomes among the teacher teams studied.

The limited learning activities with a higher degree of interdependency in our teacher teams is not uncommon in educational research (Little, 1990; Kwakman, 2003; Katz & Earl, 2010). Moreover, with regard to Flanders, the research result confirms our assumption, since Flemish teachers do not generally engage in activities that demand higher degrees of interdependency with their colleagues (OECD, 2014). A limited amount of sharing and joint work among teachers might be the result of teachers not feeling interdependent in terms of teaching and learning (Little, 1990).

Second, we find that the participating teachers' professional learning resulting from the studied learning activities is limited. At cognitive level, we find evidence for new ideas, conceptions or beliefs and confirmed ideas, conceptions or beliefs to some extent. We also find indications that teachers (plan to) change their practice upon new ideas, conceptions or beliefs. Teachers' learning activities contribute the most at attitudinal level. By working together, the interviewed teachers become more conscious of pupils' achievement and of their colleagues' teaching styles. However, overall, the professional learning of teachers resulting from their learning activities regarding the use of pupil learning outcomes in the teacher teams remains limited.

There are two possible ways to explain this research finding. First, the limited impact of teachers' learning activities on their professional learning can be assigned to the learning activities that are found in this study. It might be that storytelling and helping activities are not the activities that lead teachers to professional learning, which has been raised in previous research (Katz & Earl, 2010; Meirink et al., 2009a). Second, teachers' limited professional learning can be explained by the stimuli for learning activities with regard to their collaborative use of learning outcomes. Teachers might primarily aim at support seeking in using pupil learning outcomes collaboratively. Although support seeking can initiate storytelling and helping, learning or practical improvement are not the underlying stimuli. Therefore, these learning activities do not automatically initiate professional learning.

Even though data use is generally supposed to have the potential to initiate profound professional learning, finding limited learning at teacher level is consistent with previous research. One of the major pitfalls in data use is that data users have the tendency to search for quick solutions in data and pass over thorough investigation of (personal) hypotheses (Schildkamp, Poortman & Handelzalts, 2015). This thorough investigation of (personal) hypotheses not only increases the quality of the data use process, but also creates time and space for teachers' professional learning (Hubers et al., 2016). Generally speaking, teachers do not aim to question current practices by themselves (Katz & Dack, 2014). Teachers will

rather try to fit data into their current thinking (Katz & Dack, 2014), whereby existing assumptions are not challenged and professional learning might not be reached.

This study contributes to current data use literature in several ways. First, this study addresses the need to approach data use as a means for teachers' professional development (Vanhoof & Schildkamp, 2014) and shows that the Little (1990) and the Zwart et al. (2008) frameworks can be useful to do so. Second, contrary to the high amount of intervention studies, data use is examined as a part of teachers' daily life, which is crucial in order to understand the potential of data use in general and the success and sustainability of data use interventions in various contexts. Last, the Flemish context of the study contributes to the school improvement versus accountability debate in the data use field since the results indicate that learning in collaborative data use is not necessarily self-evident in a school improvement oriented context.

The methodology in this study provided a rich description of teachers' learning activities and professional learning results in a data use context. However, the approach used also has its limitations. The results remained descriptive at participant level, without the data having the potential to reveal micro-processes. To provide more insight into the relation between learning activities and teachers' professional learning, more micro-level research is needed (e.g. through an intervention study). Additionally, the current methodology does not account for which colleagues are consulted in the learning activities studied. However, one cannot look at these activities profoundly without taking into account features of the colleague who is consulted. The characteristics of colleagues might have implications for learning activities that are undertaken and professional learning that is reached. Embedding social network theory would provide opportunities to study whether or not teachers (only) consult colleagues with a similar mindset with regard to pupil learning outcomes and the way this influences their professional learning.

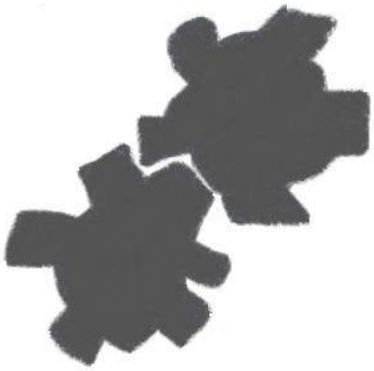
Altogether, this study draws a rather pessimistic image of learning activities in the six teacher teams with regard to discussing, interpreting, diagnosing and taking action upon pupil learning outcomes. Despite the interest dedicated to collaboration with regard to data use (Hubbard et al., 2014; Wayman et al., 2006), the quality and impact of learning activities leading from this collaboration remain unclear. Moreover, since research has shown the value of a greater interdependency among teachers (Katz & Earl, 2010; Meirink et al., 2009a, 2009b) for teachers' professional learning, questions can be raised at the assumption that teachers' collaboration on data use in any case results in profound professional learning (Katz & Dack, 2014; Vanhoof & Schildkamp, 2014). Therefore, the need arises to generate insights into aspects of collaboration that are needed for teachers to learn. More in-depth research on discussing, interpreting, diagnosing and taking action upon data is needed to reveal how collaboration within these processes does or does not contribute to teachers' professional learning.

Additionally, the preconditions for fruitful collaboration on data use have not yet been brought to the surface. This study indicates that interdependencies might be a part of the puzzle. Therefore, future research should take preconditions to initiate and support interdependencies in teacher teams into account, such as structural conditions (for example, structured time for collaboration on using pupil learning outcomes), de-privatizing of the classroom and team-wide goals with regard to pupil learning outcomes (Levin & Datnow, 2012; Verbiest, 2011).

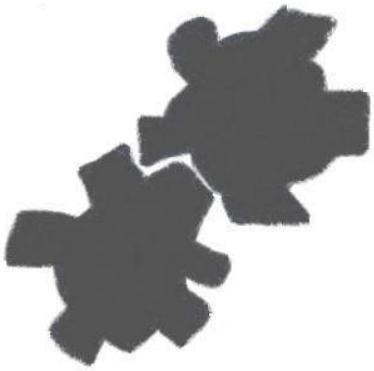
The results of this study imply that teachers' professional learning upon collaborative data use cannot be taken for granted. As interdependencies between teachers are few, one cannot expect that teachers automatically learn from collaborative data use. If data use is set up in schools with the aim of professional learning, a first step could be to support teachers to go beyond storytelling and helping activities, since sharing and joint work are thought of as

activities that are more promising for professional learning. Since teachers do not tend to feel these interdependencies, they should be stimulated to create them. A common goal setting related to data use might be the key to success in schools (Levin & Datnow, 2012; Schildkamp, Rekers-Mombarg & Harms, 2012). This is not self-evident from a teacher's perspective. Therefore, it is important for practitioners to explicate and formulate problems from which a data use collaboration starts (Schildkamp et al., 2015). Working together on solving these problems by using data might result in growing interdependencies, which might lead to an enriching environment for teachers to learn.

There is a growing tendency in data use literature to believe that, next to pupils, teachers themselves also benefit from attempts to use pupil learning outcomes to improve teaching. Despite the fact that the results are not as promising as the research field would expect, this study has provided an important first step in exposing teachers' professional learning related to their use of pupil learning outcomes.



Discussion



This dissertation contributes to our understanding of the development of data use interactions among teachers and their impact on teachers' professional learning. In this chapter, we first resume the current research lacunas this dissertation aimed to address. Subsequently, answers are formulated to the general research goals originating from these lacunas. Next, we will summarize the main theoretical and methodological contribution of this research and reflect on its limitations. Last but not least, we will discuss interesting directions for future research and implications of this research for policy and practice.

The need to explore teacher collaboration in the context of data use

In recent years, data use has been increasingly emphasized in educational research and practice. A strong belief has been established that inquiry circles involving the discussion of, for example, pupil learning outcome data, its interpretation, diagnosis and formulation of improvement actions are a powerful way to improve instructional practices. As such, data use is believed to create an environment within which teachers can learn (Katz & Dack, 2014; Schildkamp & Vanhoof, 2014).

Although individual data use is perfectly possible from a theoretical stance, the literature emphasizes the merit of collaboration in data use. Certain hindrances with regard to perceived prerequisites for teachers' data use, such as teachers' beliefs in the merit of data for school improvement (i.e. attitude) and their perception of their capabilities to use data to improve instructional practices (i.e. self-efficacy), are perceived to be overcome by means of teacher collaboration (Datnow et al., 2013; Hubbard et al., 2014). Moreover, according to research, collaboration bears large potential for the building of support, shared ideas and knowledge and can be an important means for facilitating teachers' data use and their professional learning in terms of cognition and behaviour (Bertrand & Marsh, 2015; Hubers et al., 2016; Keuning et al., 2016). As such, a lot of research has invested in investigating *the use of data within a collaborative setting*, such as data teams or data use professional learning communities.

However, a limited amount of research has focused on in-depth investigations of teacher *collaboration in the context of data use*. This is particularly so out of the niche of intervention studies, in which collaborative teams are used as an intervention to support data use. Consequently, little is known about how teachers use data in their daily practice and about the role and the merit of collaboration in this regard. Moreover, collaboration is often used as an umbrella concept for a variety of activities involving multiple actors. To date, conceptual clarity in the concept has not been reached in data use research. This implies that a great lacuna has remained regarding the characteristics of data use interactions underlying such 'collaboration', which is essential to address in order to fully understand the potential of collaboration for data use and teacher learning. For example, activities can strongly differ depending on the mutual

commitment among teachers, which is stronger in collaborative activities and more superficial in co-operative activities (Hammick et al., 2009). This commitment is further reflected in the concrete learning activities among teachers, in a sense that co-operation involves learning activities in which teachers bear high individual responsibilities (e.g. quickly exchanging information needed for individual data use practices) whereas in collaboration teachers develop shared responsibilities (e.g. making agreements on evaluation criteria) (Little, 1990). Up to now, in-depth descriptions on teacher collaboration have lacked in data use research, which has resulted in limitations to understand the value of collaboration for data use and teacher learning.

In order to enlarge the current knowledge base on data use in general and on data use collaboration in particular, this dissertation was built around four central research goals. Together, these research goals aimed to generate broad understanding of the process, the influential factors and the effects of teacher collaboration in the context of data use. As such, greater and clearer insights into the (current) potential of data use collaboration in Flanders for teachers' professional learning was achieved.

A first aim was to *explore the nature of teachers' data use and its dynamics*. More specifically, this dissertation investigated how collaboration needs to be situated in teachers' data use activities. To this end, this dissertation *unpacked* teacher collaboration in a sense that teachers' data use was explored using a continuum ranging from individual data use and co-operative data use to collaborative data use. Moreover, interrelations between different of those types of data use and *dynamics* of teachers' data use during the inquiry circle of data discussion, interpretation, diagnosis and action were examined.

The second goal in this dissertation was to *examine learning activities in teachers' data use*. Because the value of teacher collaboration has generally been attributed to the existence of mutual support, knowledge sharing and knowledge creation (Bertrand & Marsh, 2015; Hubers et al., 2016; Keuning et al., 2016), *unpacking* teacher collaboration implied that insights were achieved on how interactions among teachers can be considered learning activities. As such, a broader understanding was reached regarding the potential of teacher interactions to their professional learning.

A third aim of this dissertation was to *investigate the relations between data use collaboration and teacher characteristics that influence data use*. To this end, whether teachers' attitude and self-efficacy, that are assumed to serve as prerequisites for data use, also serve as *drivers* for data use interactions was explored. In doing so, the insights into the effect of teachers' attitude and self-efficacy on their data use practices was enlarged.

The last research goal was to *explore the impact of data use collaboration on teachers' professional learning*. This implies that, next to insights into which learning activities are inherent to data use collaboration, also insights into the learning results these activities produce were generated. This contributed our understanding regarding to the value of data use collaboration for teacher learning at cognitive, attitudinal and behavioural level.

To address these research goals, five studies were designed drawing upon a variety of methodological approaches. Generic analyses were combined with in-depth analyses at team level and individual level in order to use the complementary of methods for data triangulation and refined and in-depth research results. As a result, a combination of purely quantitative and qualitative research design and mixed method approaches led to the main outcomes of this dissertation. In the next sections, these main findings will be discussed with reference to the central research goals.

The nature of teachers' data use and its dynamics

Studies 1, 2 and 3 provided insights into the nature of teachers' data use and its dynamics. In the first two studies, a distinction was made between data use practices that were purely individual and data use practices that incorporated an interactive component. In **study 1**, quantitative analyses of survey data of 1,472 teachers was used to evaluate to what extent data use collaboration takes place among Flemish teacher and to examine the impact of such data use collaboration on teachers' individual data use.

Subsequently, **study 2** deepened these insights by qualitative analyses of 12 teachers' individual, co-operative and collaborative data use practices. Co-operative activities were characterized as loose and without a common goal setting and included situations in which teachers used data individually, yet consulted colleagues for help or more information when required. Collaborative activities involved a different set up and were built on long-term engagement and shared responsibilities. They included situations in which teachers use data to tackle shared problems or to collectively determine improvement actions (Hammick et al., 2009; Stoll et al., 2006).

Last, **study 3** focused on the dynamics of data use interactions to gain insight into whether teacher interactions can be considered as straightforward throughout the data use cycle of inquiry. Social network analysis within five teacher teams was used to analyse how the structural interaction patterns (i.e. the connections between teachers) in teacher teams remained similar or changed across data use discussion, interpretation, diagnosis and action.

Teachers' data use is mainly individual, but can also be stimulated and informed by means of teacher interactions

The first two studies of this dissertation showed that Flemish teachers' data use is mainly an individual practice. Interactions in the context of data use are not common among teachers. When data use interactions were established in these studies, their character was loose and lacked the setting of common goals (co-operative data use). Interactions characterized by long-term engagements and shared responsibilities (collaborative data use) were scarce.

Additionally, teachers' individual data use and more interactive types of data use were found to be interrelated. On the one hand, we identified a statistically significant positive relationship between teacher collaboration in the context of data use and teachers' use of pupil learning outcome data. Thus, the more teachers engaged in data use collaboration, the more they reported individual use of pupil learning outcome data. As such, collaboration was identified as important for teachers' individual data use. At the same time, we found that co-operative and collaborative data use practices can be grafted on to individual data use practices. Teachers consider data use mainly as an individual practice, in which interactions of a different nature can be embedded. This means that teacher interactions serve both as stimuli and as resources in teachers' individual use of data.

Our findings on the nature of teachers' data use extends the current knowledge base on data use in several ways. Up to now, there was limited knowledge available on how data use is integrated into teachers' authentic daily practices. The insights into how data use is initiated and how data use interactions relate to individual data use practices deepened the insights into (and explanations for) good practices via controlled intervention settings (e.g. Ciampa & Gallagher, 2016; Marsh, 2012; Michaud, 2016; Schildkamp et al., 2016). Moreover, they provide a straightforward picture of teachers' interactive behaviour that is independent from the boundaries of the research or intervention setting.

Moving beyond the intervention setting has additionally contributed to the conceptual exploration of collaboration in the context of data use. Prior research was often restricted to specific forms of collaboration (e.g. team work or communities) (e.g. Ciampa & Gallagher, 2016; Marsh, 2012; Michaud, 2016; Schildkamp et al., 2016). Conducting research in less restricted data use contexts has provided opportunities to explore the concept of collaboration with respect to the granularity that is inherent in the concept. As a result, a fine-grained view on the nature of teachers' data use and how teachers interact in the context of data use was established.

The individual nature of teachers' data use raises questions about the collective responsibility teachers have for teaching and learning. Across all the studies in this dissertation, interactions were primarily formed when teachers felt the 'need' for it. Teacher interactions therefore served both as stimuli and as resources for individual data use. This implies that data use goals are primarily shaped by individual perspectives. The first aim teachers have is to depend on themselves. Given that the high level of individuality in teaching and learning is not data use specific (OECD, 2013), it appears that teachers do not necessarily experience pupils' learning as a team goal. This issue was also raised in research of Datnow et al. (2013). Teachers consider themselves individually responsible for pupils' learning. Thus, teachers may use data to improve their own instructional practice and achieve better learning outcomes, but may not perceive their colleagues as essential partners in this process.

The nature of teachers' data use interactions is dynamic across the data use cycle

Given that data use is not a static process, but an inquiry circle that involves phases of discussion, interpretation, diagnosis and action, this dissertation unravelled how teacher interactions changed across different phases of data use.

We found that teacher interactions change according to the dynamics of the data use inquiry circle. Processes of data discussion, interpretation, diagnosis and action require different knowledge and skills across the phases. Skills in data analysis and interpretation are needed for discussion and interpretation of data use, while advanced pedagogical knowledge is needed for problem diagnosis and action (Gummer & Mandinach; 2015; Marsh & Farrell, 2015). Teacher interactions follow these dynamics. Teachers tended to interact with a greater number of colleagues when engaged in discussion and interpretation of data use. Regarding the more advanced phases of diagnosis and action, teachers interacted with fewer colleagues but their interactions became more intense. Collaboration, for example, was only observed when instructional actions on pupil learning outcome data were considered.

Although the conceptualization of data use as an inquiry circle suggests that data use is a straightforward process, it has been established that it is not. For example, there have been examples where data use circles are interrupted, or teachers returned to previous phases rather than progressing through the circle as described (Marsh & Farrell, 2015; Schildkamp et al., 2016). This dissertation extends this knowledge, producing evidence that both the sequence of phases and the interactive component within them are dynamic. A great contribution in this regard can be found in the methodological approach used to explore teacher interactions across the data use phases. Only a limited number of social network studies are available in the field of data use (e.g. Farley-Ripple & Buttram, 2014; Hubers et al., 2016; Keuning et al., 2016). Nevertheless, the method is promising when the aim is to describe and explain teacher interactions. Social network analysis provides a fine-grained lens through which to scrutinize teacher interactions. Using the relationship between teachers within teams as the unit of analysis provided opportunities to extend the theoretical knowledge base. The relational level of analysis in social network analysis enabled us to deepen knowledge on how

teachers interact within data use in a sense that interactions decrease yet becoming more intense throughout the data use circle of inquiry.

The dynamics found in teacher interactions emphasize the individual manner in which data use is approached among teachers. At first sight, the dynamic character of teacher interactions seems a logical consequence of the diverse knowledge and skills needed to accomplish each of the data use phases. Differences in the need for support can result in different approaches towards resolving these needs and, consequently, different patterns of interaction. However, close scrutiny of the way interactions change clarifies the individual stance teachers take towards data use. This dissertation shows that data use is not widely supported in schools and in teacher teams. Individual goals determine if and how teachers consult colleagues in the context of data use. Interactions are perceived as resources that are available but not necessary when using pupil learning outcome data to improve instructional practices. Therefore, teachers select the data use interactions that are of interest to them. Although a greater number of colleagues can be convenient for data use discussion, teachers prefer to downsize their personal data use network when acting upon pupil learning outcome data. An explanation for this can be found in the extent to which teachers feel individually responsible for their instructional practices. Discussing pupil learning outcome data with their colleagues can be informative, but adapting instruction to achieve better learning is a task that teachers might perceive to need to be address individually. As a result, the data use interactions between teachers reveal teacher centralized, rather than team or pupil centralized, practices in data use.

Learning activities in teachers' data use

To increase understanding of how teacher interactions potentially contribute to professional learning, learning activities embedded within teacher interactions were investigated in this dissertation. We used the framework of Little (1990) to examine learning activities as this framework addresses the interplay between individual and collective purposes in teachers' daily practice. Little (1990) distinguishes four types of learning activity, based on how interdependent teachers (inter)act. Ranging from lower to higher degrees of interdependency, these activities are: storytelling, helping, sharing and joint work (Little, 1990).

Study 2 and **study 5** contributed to this research goal by means of qualitative analyses of teachers' learning activities. These studies triangulated each other in a sense that similar analyses were conducted on a sample of 12 and 14 teachers respectively.

In **study 3**, the insights on teachers' interactive learning activities in data use were deepened by investigating which learning activities were embedded in the structural patterns of teacher networks. Moreover, the dynamics of data use interactions were examined in the learning activities of teachers through the data use circle of inquiry. Qualitative analysis of the dynamics in the learning activities of 12 teachers was conducted.

Teacher interactions are characterized by low degrees of interdependency

Throughout this dissertation, teachers' learning activities in the context of data use were characterized by low degrees of interdependency. Considering 'what teachers do' more closely when interacting in relation to pupil learning outcome data, we found that teachers primarily rely on themselves for data use. Teachers only consult colleagues when they feel the need to broaden their frame of reference regarding a certain pupil (e.g. 'how is he/she doing in your course?') or need help on data interpretation or diagnosis. When interactions occur among

teachers, they are less likely to engage in activities in which they share responsibilities with colleagues. We found that teachers will primarily engage in discussions about daily practices to elicit extra information about pupils (storytelling). To a lesser extent, help is asked for or offered, but sharing data, materials or strategies (sharing), or working together in groups and making agreements (joint work), are almost absent when it comes to the use of pupil learning outcome data.

In the field of data use, knowledge about teachers' learning activities is limited. Although data use is increasingly considered to be a means for professional development (Vanhoof & Schildkamp, 2014), hardly any evidence is available on how data use contexts also function as professional learning contexts. Some attempts have been made to explore knowledge sharing and building (e.g. Hubers et al., 2016; Horn & Little, 2011), but these have been limited in number. This dissertation therefore adds understanding regarding how data use contexts do, or do not, operate as learning contexts. Specifically designed to describe teachers' daily life in schools, viewing learning activities through Little's (1990) framework has provided a useful contribution to data use research. It has proved valuable in enabling us to classify interactions and situate data use activities within teachers' professional learning.

Consistent with existing findings in the field of teacher learning, we found that data use interactions among teachers are generally characterized by low levels of interdependency (Katz & Earl, 2010; Little, 1990; Meirink et al., 2009a; Van Waes et al., 2016). If teachers do not feel interdependent regarding how instruction towards pupils can be improved based on learning outcome data, the question then arises as to what teachers consider the team task towards their pupils should be. Is it about taking decisions on whether pupils have mastered the curriculum sufficiently, or about collectively striving to provide the best learning conditions for every pupil? Using data individually may adequately inform team decisions. For instance, if every teacher has accurate insights into how pupils master their part of the curriculum, a team decision will be well informed. However, it is questionable whether an individual stance towards data use serves the goal of creating the best learning environment for every pupil. This purpose may benefit, to a greater extent, from teachers who often share information on pupils' achievements and which adjustments will facilitate better learning for certain pupils. In so doing, greater interdependency and alignment can be created in teaching approaches towards students.

Teachers' learning activities in data use change across the data use cycle

Aside from consideration of how the nature of teachers' data use changes across discussion, interpretation, diagnosis and action, a dynamic was also found in teachers' learning activities. This dissertation has found that, if interactions occur in data use discussion, interpretation and diagnosis, they are characterized by lower levels of interdependency. Within the aforementioned data use phases, teacher's interactions serve to gain information, for example by filtering information out of daily conversations (i.e. storytelling) or by asking for help or advice. Higher degrees of interdependency, such as work groups or when making agreements (i.e. joint work), were only found when the aim of teachers was to change instruction based on pupil learning outcome data (i.e. data use action).

This dissertation demonstrates the value of the data use cycle when considering how data use results in learning activities. Although the data use cycle is common in research on data use, not many studies have, to our knowledge, examined how learning activities change across the cycle. Nevertheless, the data use cycle has often been used to support teacher learning in the context of data use (Schildkamp et al., 2016). Therefore, the knowledge that different data use phases initiate different interactive learning activities deepens the existing knowledge base on

data use. The finding highlights the importance of taking into consideration teachers' progress through the data use phases when the aim is to understand why teachers do (not) learn in data use circles of inquiry. Moreover, learning activities cannot be considered straightforward across the data use phases. Conversely, knowing that teachers' learning activities differ according to specific data use phases implies that the data use cycle is an important framework within which to examine teacher learning.

When interactions occur in the data use action phase, teachers exhibit greater interdependency than they do in the other phases. A possible explanation lies in the nature of data use action. This phase requires mastery of complex knowledge and skills (Gummer & Mandinach, 2015). Consequently, greater interdependence may result in better improvement actions. It may be the data use phase that is therefore most fruitful in terms of teachers involving colleagues to share and build complex knowledge. On the other hand, designing instructional adaptions based on pupil learning outcome data is a task that highly affects teachers' practice. Bearing in mind the high degree of individuality in teachers' data use, it is not surprising that interactions in data use action are few. However, *if* interactions are involved in this data use phase, these appear more intense, and teachers are more interdependent. The colleagues that are involved in these processes share responsibility for the way in which their joint actions contribute to pupils' learning. Their mutual task transcends the level of awareness of the way pupils achieve, and involves collaborating to adjust instructional practices to affect pupils' learning positively.

The impact of teacher characteristics on teacher interactions

The third research goal was to gain insight into how teacher characteristics affect teachers' data use, and, more specifically, the interactive nature of such data use. Because teachers' attitude and their self-efficacy regarding data use are considered as prerequisites for interactive data use (Datnow et al., 2013; Hubbard et al., 2014), this dissertation has focused on the interplay between these characteristics and teachers' data use interactions.

In **study 1**, the impact of teachers' attitude and self-efficacy on their data use was examined by means of Structural Equation Modelling (SEM) on a data set of 1,472 teachers. This analysis was used to investigate the interrelation between attitude and self-efficacy and both teachers' individual data use *and* their data use collaboration.

Subsequently, **study 4** aimed to deepen these research results. Using social network data of 7 teacher teams, Exponential Random Graphs Models (ERGM) were used to investigate how teachers' attitude and self-efficacy affect teachers interaction seeking behaviour, the extent to which they are consulted and the extent to which they interact with similar others in data use action networks.

Perceiving the merit of data use does primarily affect data use of an interactive nature

This dissertation focused on the cognitive component of attitude (i.e. believing in the merits of data use for instructional improvement) rather than the affective component (i.e. enjoying the use of pupil learning outcome data). Our analyses revealed that the perceived value of data use affects teachers' data use, but only its interactive nature. This means that teachers' attitude does not matter in terms of the extent to which teachers use data individually, but is related to if and how teachers interact in the context of data use. A positive attitude towards data use, or believing that data use is important to achieve better learning among pupils, is essential for engagement in collegial interactions. However, in terms of a positive baseline attitude, higher

levels of positive attitude do not explain teachers' interaction seeking behaviour in a straightforward manner. This means that, once a positive attitude is established among teachers, teachers' data use interactions will be influenced by other factors than their attitude.

Various research studies on data use have identified teachers' attitudes as an important prerequisite for data use in schools (Datnow & Hubbard, 2016; Schildkamp & Kuiper, 2010; Verhaeghe et al., 2010). Using advanced methodological approaches, this dissertation exposed in detail how teachers' attitude affects data use processes. The finding that attitudes affect teacher interactions in data use, but not necessarily teachers' individual data use, refines current knowledge on the impact of teachers' attitude on data use. It implies the need to rethink teachers' attitude as a prerequisite for data use. Instead of explaining *if* teachers use data, teachers' attitude appears to be more important in terms of *how* teachers use data. Furthermore, the role of attitude in teachers' individual data use becomes insignificant when compared to how attitude is related to data use interactions. This means that teacher interactions are more important in facilitating data use than teachers' attitude. Additionally, given this refinement of the role of attitude in teachers' data use, our results add nuance to the idea that the greatest contribution to teachers' data use lies in the highest levels of positive attitude (Datnow et al., 2013; Van Gasse et al., 2015; Vanhoof et al., 2014). We found that differences between positive and extremely positive stances towards data use do not result in straightforward conclusions regarding the impact of attitude on interactive behaviour. This knowledge adds to the current literature base in that, when a certain level of attitude is reached, other factors will become more important in determining teachers' interactive behaviour.

These findings can be attributed to the purposes of teachers' data use. Data use can derive from both accountability and school improvement purposes. For example, teachers may use pupil learning outcome data to justify their decisions. In this instance, data is used from an accountability perspective and a positive attitude towards its use may not exert any notable influence. In such contexts, how teachers think about data use may not be so important given that, from an accountability perspective, data will be used anyway and not (exclusively) to improve instructional practices. In contrast, from a school improvement perspective, data are used to improve teaching and learning. This type of data use will only originate from the belief that data use provides opportunities to improve instructional practices (i.e. a positive attitude towards data use). When school improvement is the ultimate purpose of data use, teachers will be less likely to perceive data use as an individual practice. For instance, with a learning-oriented focus, teachers will be expected to interact more with colleagues and exploit opportunities to use data in a way that can make a difference to pupils. Although accountability and school improvement perspectives can be distinguished conceptually, teachers are not necessarily characterized by one or the other (Van Gasse, Vanhoof, & de Vos, 2015; Vanhoof et al., 2014). Depending on contextual factors (e.g. an upcoming school inspection), teachers may switch between both perspectives or one may become more important than the other. Therefore, it is likely that the impact of teachers' attitude will not be the same for different types of data use.

Feeling competent in using data stimulates individual data use and interaction seeking behaviour

Unlike the diverse impact of attitude on teachers' data use, this dissertation found that self-efficacy is an important prerequisite for all types of data use, both individual and interactive. Thus, the more teachers feel competent in using data, the more they will engage in individual data use and the more likely they are to consult colleagues. On the other hand, self-efficacy is not a significant explanatory factor in terms of the extent to which certain teachers are

consulted regarding data use. In other words, feeling competent in data use does not necessarily mean that one becomes a more 'popular' partner.

Although a link between teachers' self-efficacy and various types of data use (i.e. individual and more interactive types) is suggested in the literature on data use (Datnow et al., 2013; Hubbard et al., 2014; Jimerson, 2014), it has rarely been confirmed statistically. In determining how self-efficacy affects individual and interactive types of data use, this dissertation moves the field forward in several ways. First, we found that teachers' self-efficacy is a prerequisite for data use, which statistically confirms the hypothesized link between self-efficacy and data use (Datnow et al., 2013; Vanhoof et al., 2014). Alongside statistical confirmation of the need for positive self-efficacy regarding individual and interactive data use, our research revealed how self-efficacy affects the formation of interactions among teachers. The role of self-efficacy cannot be delimited to that of a prerequisite as this teacher characteristic also appears to explain how data use interactions are formed. Although a certain level of self-efficacy is needed to engage in individual data use, we found that the teachers who feel most competent in using data are the ones who engage in data use interactions. Unlike teachers' attitude, our analyses did not show that the effect of self-efficacy varies according to level. This means that the more competent teachers feel in using data, the more data use can be characterized by extensive interaction seeking behaviour.

Given that research on data use has considered teacher interactions to be an important factor supporting teachers' data use, the finding that higher levels of self-efficacy are needed to engage in data use interactions is remarkable. It implies that teachers who already feel quite confident may be the teachers that are better supported in data use compared to teachers with lower levels of self-efficacy. It appears that teachers who need less support may therefore receive the most. Lower levels of self-efficacy may be a barrier, not just to engaging in individual data use, but also to engaging in data use interactions. It may be that teachers who feel less confident in using data may not want to be confronted with teachers whom they assume possess better data use knowledge and skills. After all, not knowing how to use data adequately may be perceived as a shortcoming in teachers' own knowledge and skills. This would not only explain why teachers with lower levels of self-efficacy do not engage in teacher interactions but also why teachers with higher levels of self-efficacy are not necessarily those who are most popular to interact with. Although these teachers may be useful partners for the purposes of support, colleagues may, to some extent, fear a confrontation with better-skilled colleagues in relation to data use.

The impact of interactions on teachers' professional learning

The fourth research goal of this dissertation was to generate insights into the impact of data use interactions on teachers' professional learning. In **study 5**, the Zwart et al. (2008) framework was used to distinguish learning outcomes at the level of cognition (e.g. new or confirmed ideas, opinions or beliefs), attitude (e.g. increased consciousness) and educational practices (e.g. turning new or confirmed ideas into practice). Interview data of 14 teachers served to examine which types of professional learning outcomes were reported by teachers as a result of their data use interactions.

Teachers professional learning is limited and generally situated at the level of attitudes

Although we found some indications of professional learning, it appeared that professional learning based on data use interactions remains limited and is mostly situated at attitudinal

level. The results of interacting around pupil learning outcome data can be primarily found in a higher level of consciousness regarding pupils' achievement and colleagues' teaching approaches.

Although the merits of collaboration for teacher learning in the context of data use have been repeatedly emphasized in the literature (Katz & Dack, 2014; Vanhoof & Schildkamp, 2014), few attempts have been made to relate teacher interactions to professional learning in the context of data use (e.g. Hubers et al., 2016; Bolhuis et al., 2016; Ciampa & Gallagher, 2016). Given that data use research has mainly focused on describing and explaining best practices, we contributed to the literature base through the tentative introduction of an effect variable (i.e. teachers' professional learning). Currently, the relevant literature has mainly focused on describing data use processes rather than relating good practices to specific outcomes. This dissertation has taken a step forward in this regard by investigating the assumption that data use has the potential to create an effective learning environment for teachers. Moreover, determining the effects of certain (data use) processes is crucial in providing sufficient contextualization and deeper understanding of the pure description of data use. Ascertaining whether data use resulted in better decisions, better instructional practices or changes in teachers' knowledge, skills or attitudes, is essential in identifying and obtaining greater insight into best practices in data use.

This dissertation revealed that teachers take an individual stance towards data use. Interactions take place to serve individual purposes rather than collective goals. The professional learning that originates out of this type of interaction appears to be limited. Explanations for teachers' learning outcomes need to be sought in their interactive behaviour. Although we have not gained insight into teachers' goals regarding interactions, the different studies conducted in this dissertation suggest that interactions primarily function to shape individual data use. Therefore, the question arises as to which colleagues teachers choose to interact with to use pupil learning outcome data. From an individual perspective, interactions can originate from a desire to search for confirmation in colleagues' opinions or from a desire to search for contrasting ideas to broaden their own point of view. Our assumption, based on the different studies, is that the teachers who participated in this dissertation mainly interact with colleagues who share similar ideas or opinions. Teachers may therefore be exposed to confirmation of their own ideas rather than what is termed constructive conflicts (i.e. learning from opposing or contrasting ideas or opinions) (Van den Bossche, Gijselaers, Segers, Woltjer, & Kirschner, 2011). Consequently, professional learning may be not as far-reaching as when teachers are engaged in interactions with colleagues with different ideas or opinions about teaching and learning.

A broader question concerns what teachers are expected to learn in interactive data use contexts and how 'teacher learning' can be defined. Data use originated from the idea that better informed instructional decisions would result in better learning for students (Campbell & Levin, 2009; Carlson, Borman, & Robinson, 2011). Thus, learning can be approached broader than merely creating new knowledge, confirming personal opinions or gaining new insights into teaching and learning. It can also be about putting already acquired knowledge into practice more effectively. For example, when a student struggles with mathematics, the solution in terms of remedial actions may lie in the mathematics teacher's content knowledge. However, it may be that the teacher will only decide on the appropriate remedial actions after an in-depth analysis of errors on a diagnostic test, or after discussion on appropriate remedial actions with a colleague. To the teacher in question, it will not feel like the process resulted in learning. The contribution does not lie in acquiring new knowledge, but in a more efficient use of already existing knowledge. Thus, when asking teachers what data use interactions produce in terms of professional learning, teachers' answers may appear disappointing. However, using already

acquired knowledge more effectively can also be considered learning but may not come to surface as learning in teachers' perceptions.

Theoretical and methodological takeaways

This dissertation combined different theoretical and methodological approaches to formulate answers to the different research goals. This has resulted in both theoretical and methodological contributions of the work. In the following sections, the central theoretical and methodological lessons learned will be summarized.

Data use collaboration: its conceptualization and value

In this dissertation, a lot of effort was made to achieve conceptual clarity in what is meant by 'data use collaboration', regardless of different collaborative constellations that may occur. This dissertation learned us about the occurrence of different types of data use interactions, that can be classified based on different levels of interdependence inherent to the data use activities. The true 'data use collaboration' in this regard only refers to the type of interaction that incorporates activities in which teachers strongly depend on each other for success. Such activities are the result of common goals among teachers and great involvement, as reflected in, for example, making agreements on changes in instructional practices. The variety in data use interactions determined resulted in a changing terminology to achieve more accurate descriptions and move away from 'collaboration' as a container concept. After all, appropriate naming of the concepts under examination is essential to reach deeper understanding of the processes observed. Therefore, a first takeaway for the field of data use is to strive to clear and accurate terminology when it comes to data use interactions.

Next to elaborating on *what* collaboration is in a data use context, this dissertation aimed to determine *how* such collaboration is established. In this regard, this dissertation showed that nuance is needed when investigating 'data use collaboration'. The idea that putting teachers together will result in collaboration is somewhat simplistic. We learned that teachers will interact to a certain point, but that collaboration is easier said than done. This work illustrated teachers' strong individual drive in interactions, whereby the level of collaboration was hardly reached. The common goals and long-term engagement inherent to the concept were often absent in data use interactions and shared responsibilities were barely established.

As a result, caution is needed when approaching interactive data use settings as 'professional learning communities', as they are often called in data use research (e.g. Bolhuis et al;, 2016; Farley-Ripple & Buttram, 2014). The main characteristic of such communities is their goal to share experiences and instructional practices in order to learn together, improve instruction and achieve better learning among pupils (Stoll et al., 2006). In other words, the central idea in such communities is active knowledge sharing and building around a certain topic (e.g. data use). However, this dissertation indicates that it is not likely that teachers' data use interactions are initiated from such common goals and striving to knowledge sharing and building. Moreover, formalizing such professional learning communities in data use passes that teacher interactions may not derive from collective responsibilities and perspectives on education. As a result, a learning of this dissertation is that the interactions established in such formal constellations may not be by definition considered the ones that are qualitative or sustainable to establish a data use professional learning community.

Our considerations regarding what collaboration is and how collaboration is established result in reflections on the value of data use interactions. This dissertation illustrates that the

examined data use interactions of teachers bear limited value for their professional learning. Therefore, the strong emphasis on teacher interactions in data use may need some more nuance or some reframing. When the interactions established do not involve strong interdependent activities, as in true collaboration, it is questionable whether the added value needs to be sought in terms of teacher learning. However, this does not imply that such interactions are inefficient when it comes to achieving effective data use. After all, the merit of data use interactions does not solely lie in their potential for support or teacher learning, but also in the triangulation of interpretations and analyses of data. This implies that, although teacher interactions may not be as valuable as expected for professional learning, they remain essential in creating a more objective framework for decision-making. Considering that this is the starting point out of which data use originated (Johnson, 1997; Kerr et al., 2006), data use interactions need to be primarily emphasized because of their contribution to objectifying and their potential for more valid decisions.

The role of teacher interactions and defining professional learning

This dissertation largely invested in closely examining how interactions between teachers are formed and their role in teachers' professional learning. A major lesson in this regard is that, although interactions may be necessary for learning and may provide indications for learning, caution is needed in considering interactions *as* learning. This dissertation indicates that the formation of certain relations among teachers, does not necessarily imply that these interactions contribute to teacher learning. Moreover, determining relations in itself does not inform us sufficiently on the resources that flow through these interactions to directly relate interactions to learning. The social position of actors within networks does inform us on their access to resources and their *potential* for learning but not on teacher learning in itself (Mohrman et al., 2003). Therefore, from a theoretical stance, social network theory provides a valuable lens to look at teachers' potential for learning, but needs to be complemented by additional frameworks to look into the activities within or the resources running through the relations established.

Next to looking into teacher interactions, this dissertation related these interactions to teachers' professional learning. And although a particular framework was selected for 'professional learning' in a data use context (i.e. Zwart et al., 2008), this dissertation shows that approaches to 'learning' may need to be stronger contextualised. The cause of finding limited merit of data use interactions for teachers' professional learning, may not lie in the (absent) merit of interactions, but in what is deemed to constitute 'learning'. Therefore, careful consideration is needed regarding the definition of learning at teacher level in different contexts, including in the context of data use.

The specificity of different professional activities may result in the need for different operationalisations of workplace learning within these contexts. For example, data literacy research indicates that in data use the interpretation and analysis of particular types of data inform the development of very specific, context-related knowledge that is variable across situations (Gummer & Mandinach, 2015). Such knowledge is, for example, about the selection of appropriate remedial actions for a certain pupil with a certain background and a certain schooling history. The difficulties for teachers in data use mainly lie in the construction of such specific knowledge (Gummer & Mandinach, 2015). As a result, the learning in data use may not primarily lie in generating generic new ideas on, for example, teaching and learning. It is more likely that the learning *is* the adequate construction of the specific knowledge required to reflect on the educational problem in front. In other words, professional learning in data use might be about learning about and reflecting on current situations or problems and how to

overcome these rather than about generating some generic insights. Thus, the emphasis on professional learning in a data use context need to come to lie on how data literacy is constructed, and more specifically the context-specific knowledge needed to address the educational problem in front.

The power and pitfalls of social network analysis

This dissertation invested in a combination of qualitative and quantitative research methods and social network analysis to create an in-depth understanding of data use interactions among teachers. Particularly social network analysis was found to bear large potential when it comes to increasing the understanding of social relations among teachers.

Social network analysis generated powerful methodological handles to look at teacher interactions. The analyses at relational level were found to contribute to theory development to a large extent. The methodology provided opportunities for new and in-depth insights into teachers' data use interactions. For example, the interaction as the unit of analysis introduced the idea of different levels in interactions, in a sense that relations between teachers are not necessarily reciprocal and can differ according to the other colleague involved in the interaction. Moreover, the method was interesting to capture the involvement and activity of teachers within certain group constellations. Thus, a first learning of this dissertation at methodological level is that method provides opportunities for in-depth and refined descriptions of teacher interactions.

Next to the descriptive power of social network analysis, this dissertation moved theory on data use interactions a step further due to opportunities of the method with regard to exploring dynamics and explaining interactions. The use of Stochastic Actor Oriented Models (SAOM) and Exponential Random Graph Models (ERGM) was innovative in the study of data use interactions, and appeared particularly useful to generate deeper findings on teachers' interactive behaviour. For example, the SAOM introduced the idea that interactions with certain colleagues are context-dependent, in a sense that different interactions may occur among the same actors within different phases of the data use cycle. The relational unit of analysis was extremely suitable to gain such understanding. The same rationale can be applied to the use of ERGM, which served to explain the existence of certain relations within teacher teams. This analysis introduced new insights into how teachers' attitude and self-efficacy affect their interaction seeking and popularity in teams. Thus, next to the power of in-depth description of interactions, we learn that social network bears tremendous opportunities for in-depth exploration and explanation of teacher interactions.

At the same time, this dissertation learns us that social network analysis as a stand-alone method has its limitations. For example, pure descriptions of social networks may be in-depth, but at the same time they remain somewhat information-poor. Determining teachers' social position within a team reveals something about the potential of their activities, but lacks information that can give us insight into the value of this position for, for example, their learning. As a result, using social network as a stand-alone method in this dissertation would have brought the fields of data use and professional learning less far. Using the structural characteristics of teacher interactions revealed by social network analysis provides a valuable starting point for close examinations. However, it is the combination with other methods that can help to move beyond the structural characteristics of teacher interactions to understand them fully. In this regard, interviews were found useful to deepen the structural patterns by exploring the 'stories behind the structures' and survey research to increase the understandings into why relations did (not) occur.

Limitations

Although this research takes the fields of data use and professional learning steps further, both theoretically and methodologically, there are several limitations to reflect on in the concluding stages of this dissertation.

This research attempted to establish an outcome variable in the form of professional learning. Nevertheless, the insights provided on the outcomes of data use were less extensive than hoped. In general, the field of data use needs well-chosen outcome variables that can provide insights into the quality of the processes described. The conviction that data use contributes to better-informed decisions in the context of teaching and learning is widely supported (Carlson et al., 2011; Feldman & Tung, 2001; Kerr et al., 2006), but remains underexposed until now. In this respect, this dissertation has also stayed at surface. Although teachers were asked for their professional learning outcomes following interactive behaviour, we still do not know what effective networks look like in the context of data use, or how teacher networks result in teacher learning.

A second limitation of this dissertation can be found in the definition of teacher teams. We conceptualized teacher teams as comprising a collection of teachers who were teaching the same group of pupils throughout a school year. This implies that the constellation of teams differs across school years. The rationale behind this choice resides in the fact that this type of team should bear a collective responsibility for the learning and progress of the pupil group and that grade-levels can, to a certain extent, explain teacher interactions (Moolenaar, 2012). However, as outlined in the general discussion, teachers may not have felt they were a team. It is possible that the teachers in this dissertation feel more closely connected to colleagues in other formal structures that are more fixed across the years, such as work groups based on subject type (e.g. language teachers, mathematics teachers and so on) (Meredith et al., 2017). These types of formal group structure have a longer history, which may influence the interactions that take place within teams. Therefore, in future research, it will be important to consider carefully the boundaries that are used to determine which teachers belong to a certain group of teachers and who we expect to interact.

Next to that, our approach to data use interactions as individually initiated and affected may also be a limitation. We investigated data use interactions based on the assumption that individual characteristics of teachers (e.g. their attitude or self-efficacy) can initiate and affect teacher interactions. However, in so doing, we somewhat obscured the multiple levels in which teacher interactions are embedded (i.e. interactions within teachers; teachers within teams; teams within schools). Moreover, although we have not claimed causality for the relationships established, this stance did not consider the fact that the relationship between teacher characteristics and their interactive behaviour may equally work the other way around. For instance, it is just as likely that interactions in which teachers are engaged affect their self-efficacy or attitude as it is that teachers' characteristics affect their interactive behaviour. Thus, individual characteristics can be both the initiators as well as the outcomes of data use interactions. This suggests that future research needs to address data use interaction as an integrated process of individual characteristics, team characteristics and school characteristics.

A final recurring limitation across all the studies concerns the specificity of the Flemish educational context. It is likely that the findings within this dissertation are influenced by the Flemish context. For example, it has been determined that teacher collaboration in Flanders is limited and that teachers predominantly rely on themselves in teaching and learning (OECD, 2013). Additionally, data use is a relatively new phenomenon in Flanders and only limited standardized data sources are available, unlike other educational systems (e.g. the

Netherlands or England). Although the results in this dissertation are in line with international research, they remain somewhat context-dependent. Therefore, cross-contextual research is needed to generalize and deepen the major findings of this dissertation.

Questions in front for future research

Next to providing answers to the present research goals, this dissertation introduces new questions for future research. This dissertation shows that the key in future data use research lies in discovering the value of interactive settings for data use.

A first question that raises in this regard is to further explore learning in data use settings. As outlined above, this learning may not necessarily relate directly to the (mutual) construction of generic knowledge or skills. Interesting would be to unravel how teacher teams apply knowledge, skills and experiences of team members in order to achieve a better understanding of the educational problem in front and formulate adequate decisions in order to solve it. This implies that future examinations of learning in data use should move beyond the individual aspect of data literacy (e.g. data interpreting and analysing skills) by taking a close look at how such individual literacy skills inform mutual, context-dependent knowledge building in teams. As such, better understanding will be reached on how teacher teams in data use can interact in order to achieve common understandings, develop shared goals, norms and values, and – as such – take steps forward to serve as data use learning communities.

Another approach to gain insight into the merit of teacher interactions in data use, is to discover which teacher interactions contribute to more objective and valid decision-making and how they do so. Considering the hazards of inadequate knowledge and skills for individual data use (Datnow et al., 2013; Hubbard et al., 2014), implies that the value of data use interactions may lie in the triangulation of teachers' individual perspective with that of colleagues. However, the strongly individually steered interactions found in this dissertation, implies that closer investigation is needed on which teacher interactions contribute to more objective or valid decision-making of teachers. And, if such interactions can be discovered, how they contribute to objectifying and validating the decision-making process.

Next to finding out whether and how the value of teacher interactions need to be situated within the learning or objectifying and validating decisions, future research will need to address why certain interactions or group constellations are more effective or efficient than others. For example, when it comes to the mutual construction of knowledge among teachers, the 'why' question will need to be addressed to gain understanding. To what extent does such knowledge building, for instance, depend on the type of interactions between teachers or the characteristics of the group? In this regard, the influence of generic data literacy skills (e.g. data interpretation or analysis) of teachers on which interactions are formed and how these interactions contribute to mutual knowledge building can be a valuable angle of incidence.

Implications for policy and practice

The overall learnings of this dissertation introduce some implications for policy and practice. The central idea is that closer connections between teachers need to be facilitated in order to achieve more extensive use of pupil learning outcome data in general and more learner-centred teaching practices in particular.

Set common goals and start sharing responsibilities

This dissertation makes clear that current data use interactions among teachers are quite superficial and steered from a strong individual perspective. Teachers appear to consult colleagues when they feel the need for it. For example, when they seek additional information to inform their own data use or when they seek help or advice. Nevertheless, closer connections between teachers are more interesting for quicker exchanges on information, knowledge sharing or closer collaboration (Cummings & Cross, 2003; Daly & Finnigan, 2011; Finnigan & Daly, 2012; Hansen, 2002; Mohrman et al., 2003).

Establishing such closer and deeper connections among teachers requires to move away from the teacher-centred perspective. It requires to define team-wide or school-wide learner-centred goals to work on. The key is to identify the goals you are striving to achieve within a certain pupil group and to define which data at which time points will be needed to monitor or evaluate this process. As such, agreements are made and long-term engagements are discussed, whereby deeper interactions can be established and greater interdependence will be created in teachers' data use activities.

However, a critical footnote that needs to be made in this regard is that this might be easier said than done due to how education in Flanders is currently structured. Up to now, schools are generally structured by a clear division of tasks. For example, in primary schools teachers are usually teach one pupil group individually during the whole school year and in secondary schools, teachers often teach one or sometimes two courses to a certain pupil group. As such, the responsibility for the learning of pupils either lies entirely with a specific teacher or is distributed among a teacher team. Moreover, the division of the curriculum into specific courses within specific age groups does not facilitate interdependent activities among teachers, horizontally (i.e. among teachers teaching a similar age group) nor vertically (i.e. among teachers teaching a different age group). For example, it is not likely that teachers teaching different courses in the same age group or teachers teaching the same course in different age groups will feel mutually responsible for pupil learning. As a result, common goals among teachers and shared responsibilities will require attempts to cross the boundaries of curricula or formal structures within schools.

Stimulate know-who with regard to data use

Next to the finding that data use interactions cannot be considered close connections between teachers, this dissertation shows that the likeliness that the appropriate colleagues are consulted for data use can be questioned. Teachers being the most confident in data use are not necessarily most popular with regard to data use interactions. This implies that other factors may be considered more important to establish data use interactions with colleagues (e.g. friendship or trust). However, when the idea is that data use interactions can improve the data use circle of inquiry, it is necessary that the colleagues with data use expertise become popular partners to interact with.

When it comes to supporting data use or sharing and creating knowledge, it is crucial that those teachers become involved that are capable of using data. Bearing in mind that data use interactions generally are individually steered, this implies that, for teachers, it will become important to know whom of their colleagues possesses certain data use knowledge and skills. In other words, it is essential that "know who" with regard to data use is stimulated in teacher teams.

Know who refers to awareness about colleagues' expertise in data use. To increase such awareness, open communication and transparency on data use activities in teacher teams will

be needed. It is crucial for teachers to gain insight into what types of data are used by colleagues and how, but also into past experiences of colleagues in data use and difficulties they encountered. The challenge in this regard will be to create a safe environment in which teachers are open to look beyond the boundaries of their own specific teaching-task and willing to share ideas and experiences related to data use.

Support interactions at different levels of interdependence

Although the majority of data use interactions cannot be considered close relations, this dissertation shows that teachers' data use interactions can be situated at different levels of interdependence. Moreover, within the data use circle of inquiry, the level of interdependence in teachers' interactive activities varies depending on the inquiry phase. In data discussion, interpretation and diagnosis, more open-ended co-operative activities take place, whereas only in data use action true collaboration is reached. This implies that teachers may perceive different supportive needs depending on the data use task in front.

To support and increase teacher interactions in the context of data use, it is crucial to meet teachers' various needs in interactions. Moreover, this support will be more effective when it accounts for the differences in teacher interactions according to the task in front. Therefore, strategies need to be thought of to provide teachers with opportunities to establish the relations they consider appropriate.

Meeting the variety in teacher needs with regard to data use interactions implies that both strategies for the support of open-ended co-operative activities and for the support of close collaboration need to be developed. For example, supporting data use interactions involving low levels of interdependence will need colleagues who are visible within the school and easy to approach. Such colleagues need to be appropriate for better informing or triangulating teachers' individual data use and may, for instance, provide support in the analysis or interpretation of data. Next to that, close collaboration with colleagues may require different types of support. In this regard, it is important that teachers perceive opportunities for more dedicated data use together, which originates from common goals and in which responsibilities are shared.

Unpacking teacher collaboration was useful to increase our understanding on the drivers and dynamics of data use interactions in teacher teams. Teachers' great individual stance in data use initiates reflection upon how collectively responsible teacher teams consider themselves for pupil learning and achievement. Therefore, when the aim is to move education towards more pupil centred teaching and learning, an important key may lie in the definition of common goals and shared responsibilities for teaching and learning in teacher teams.

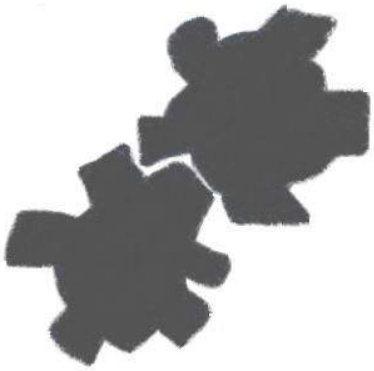
"There is no I in TEAM,

unless you count the vertical part of the T"

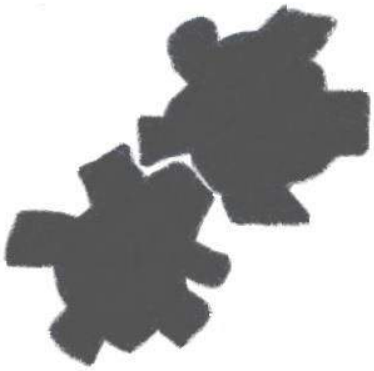
(Demetri Martin)

Key findings

- The extent to which teachers collaborate in data use is related to the extent of individual data use. [study 1]
- Teachers generally use pupil learning outcome data individually. Interactions with colleagues are predominantly undertaken to gain extra information within individual data use practices. [study 1 and study 2]
- Interactive learning activities among teachers are usually characterized by low levels of interdependency. This means that teachers are not likely to share responsibilities with colleagues in their use of pupil learning outcome data. [study 2, study 3 and study 5]
- In data use networks within teacher teams, interactions are generally few, superficial and centred around a few team members. [study 3]
- Data use interactions in teacher teams decrease in number, but become more intense during data use discussion, interpretation, diagnosis and action. [study 3]
- The learning activities reported by teachers reach higher levels of interdependence (i.e. shared responsibilities) when designing actions based upon pupil learning outcome data. [study 3]
- Teachers' cognitive attitude is related to whether teachers interact in data use, not to how they interact nor to whether they use data individually when controlled for collaboration. [study 1 and study 4]
- A positive baseline attitude towards data use is needed for teacher interactions, but whether higher levels of attitude result in more extensive interactions depends on the team context. [study 4]
- Teachers' self-efficacy is related both to their individual data use and their interactive behaviour in data use. [study 1 and study 4]
- Low self-efficacy in data use is a barrier to teachers' interaction seeking behaviour. [study 4]
- High self-efficacy of teachers regarding data use does not imply that colleagues will consult these teachers for data use interaction. [study 4]
- Data use interactions result in limited perceived learning by teachers. Perceived learning outcomes are generally situated at the level of attitudes (e.g. increased consciousness of problems of pupils). [study 5]



Nederlandstalige samenvatting



Dit proefschrift draagt bij tot onze kennis over hoe interacties in datagebruik tussen leerkrachten gevormd worden en de impact ervan op hun professioneel leren. In deze samenvatting situeren we eerst de noodzaak om interacties in datagebruik diepgaand te verkennen. Nadien gaan we dieper in op de belangrijkste conclusies uit dit proefschrift.

De nood aan onderzoek naar interacties in datagebruik

De laatste jaren wordt een steeds sterkere nadruk gelegd op datagebruik in onderwijscontexten. Met name prestaties van leerlingen worden als interessante data gezien om de instructie van leerkrachten en het leren van leerlingen te verbeteren. Dit vanuit een sterk geloof dat cycli van discussie, interpretatie, diagnose en actie systematische en doordachte verbeteringen teweeg brengen in scholen.

In datagebruik wordt het belang van samenwerking onderstreept. Belangrijke valkuilen in het datagebruik van leerkrachten, bijvoorbeeld weinig geloof in de meerwaarde van datagebruik of in de eigen capaciteiten met betrekking tot datagebruik, zouden vermeden kunnen worden, onder andere door middel van samenwerking. Samenwerking biedt immers een groot potentieel met betrekking tot het komen tot ondersteunende relaties, kennisdeling en kennisopbouw onder leerkrachten.

Toch heeft weinig onderzoek zich gericht op het exploreren van dit potentieel. Over het algemeen weten we nog weinig over wat samenwerken in datagebruik nu precies inhoudt, welke interacties we kunnen onderscheiden en hoe deze interacties een impact hebben op het leren van leerkrachten. Tot nu heeft dit geleid tot beperkingen om de meerwaarde van samenwerking in datagebruik tot in de diepte te begrijpen. Deze insteek was de centrale focus in dit proefschrift. Aan de hand van vier overkoepelende onderzoeksdoelen hebben we meer inzicht verkregen in de processen, de effecten en de verklarende factoren voor datagebruik interacties in lerarenteams. Ten eerste hebben we de aard en het dynamische karakter van datagebruik diepgaand onderzocht. Daarnaast hebben we geëxploreerd in hoeverre interacties in het datagebruik van leerkrachten ook blijk geven van bepaalde leeractiviteiten. Ten derde hebben we onderzocht hoe bepaalde karakteristieken van leerkrachten hun interacties in datagebruik beïnvloeden. Ten slotte zijn we gaan verkennen tot welke leeruitkomsten interacties in datagebruik kunnen leiden bij leerkrachten.

Belangrijkste bevindingen van dit proefschrift

Het antwoord op de voorgenoemde onderzoeksdoelen werd verkregen via vijf empirische studies. In de volgende secties vatten we de belangrijkste bevindingen uit deze studies bondig samen.

Datagebruik is vaak een individueel gegeven en een dynamisch proces

De aard van het datagebruik van leerkrachten en het dynamische karakter ervan werden onderzocht in studie 1, studie 2 en studie 3. In deze studies werd een onderscheid gemaakt tussen datagebruik dat puur individueel uitgevoerd wordt en datagebruik waarin een interactieve component aanwezig is. In **studie 1** werd gebruik gemaakt van grootschalig survey-onderzoek bij 1472 leerkrachten om de mate van samenwerking in datagebruik te evalueren. Bijkomend werd in deze studie de impact van samenwerking op het individueel datagebruik van leerkrachten onderzocht.

Studie 2 onderzocht het datagebruik van leerkrachten vervolgens meer in de diepte. Kwalitatieve analyse van interviews met 12 leerkrachten beoogde het datagebruik van deze leerkrachten te situeren op een continuüm van individueel, over co-operatief tot samenwerkend datagebruik. Daarbij werden co-operatieve activiteiten gezien als meer vrijblijvende interacties, waarin duidelijke gemeenschappelijke doelstellingen ontbreken terwijl samenwerkende activiteiten vanuit zulke gemeenschappelijke doelstellingen ontstaan en een sterker lange-termijn engagement vertonen.

Ten slotte lag de focus in **studie 3** op de dynamieken in datagebruik. Netwerkanalyse in 5 lerarenteams genereerde inzichten in hoe interactiepatronen (of de connecties tussen leerkrachten) veranderden afhankelijk van de fase in de cyclus van datagebruik (discussie, interpretatie, diagnose en actie).

De eerste twee studies leerden ons dat datagebruik in Vlaanderen voornamelijk een individueel gegeven is. Interacties in datagebruik blijken over het algemeen niet zo gangbaar onder leerkrachten. En wanneer interacties voorkomen, zijn ze eerde vrijblijvend en blijken deze niet te ontstaan vanuit gemeenschappelijke doelen (co-operatie). Interacties gekenmerkt door gemeenschappelijke doelen, verantwoordelijkheden en engagement op langere termijn (samenwerking) zijn nagenoeg afwezig. Daarbij aansluitend blijkt individueel datagebruik samen te hangen met meer interactieve types van datagebruik. Hoe sterker leerkrachten aangeven betrokken te zijn in interacties met betrekking tot datagebruik, des te meer individueel datagebruik zij ook rapporteren. Vormen van samenwerking blijken dus belangrijk voor het individueel datagebruik van leerkrachten. Datagebruik start voornamelijk vanuit een individueel perspectief, waarin verschillende vormen van interacties ingebed kunnen zijn. Dit maakt dat interacties het individueel datagebruik van leerkrachten zowel kunnen stimuleren als informeren en ondersteunen.

Uit de derde studie bleek dat het interactieve karakter van datagebruik geen statisch gegeven is, maar varieert naargelang de fase in de cyclus van datagebruik (discussie, interpretatie, diagnose en actie). Over het algemeen verschillen interactiepatronen doorheen deze cyclus. Leerkrachten blijken met een groter aantal collega's te interageren voor het bediscussiëren en interpreteren van prestatie data van leerlingen. Naargelang er meer diepgaande kennis en vaardigheden nodig zijn in data gebruik, bijvoorbeeld bij het stellen van specifieke diagnoses en het uitwerken van verbeteracties, wordt er met een kleiner aantal collega's in interactie getreden, maar zijn deze interacties intenser. Samenwerking werd bijvoorbeeld enkel vastgesteld bij het uitdenken van verbeteracties.

Leeractiviteiten kenmerken zich door beperkte wederzijdse afhankelijkheid

Om meer inzicht te krijgen in hoe interacties van leerkrachten bijdragen in hun professionele ontwikkeling, was een objectief in dit onderzoek om te exploreren hoe interacties in datagebruik ook als leeractiviteiten dienen. De wederzijdse afhankelijkheid in de relaties van leerkrachten werd als uitgangspunt genomen om de leeractiviteiten van leerkrachten (verhalen vertellen, helpen, delen en samenwerken) te evalueren. Deze leeractiviteiten werden door middel van kwalitatieve interviews bij respectievelijk 12 en 14 leerkrachten onder de loep genomen in **studie 2** en **studie 5**.

In beide studies kenmerkten de leeractiviteiten van leerkrachten zich door lage niveaus van wederzijdse afhankelijkheid. Over het algemeen wezen de resultaten uit dat leerkrachten sterk op zichzelf vertrouwen wanneer het gaat om datagebruik. Interacties komen voornamelijk voort uit eigen noden aan meer informatie of aan een breder referentiekader (bijvoorbeeld, “hoe doet die leerling het in jouw les?”), of wanneer leerkrachten een nood aan hulp ervaren voor de interpretatie of diagnose van data. Dit maakt dat leerkrachten voornamelijk betrokken zijn in laagdrempelige gesprekken over de prestaties van leerlingen. In beperktere mate worden collega’s om hulp gevraagd of dienen interacties om materialen of strategieën te delen. Intensievere vormen van samenwerking zijn bijgevolg nagenoeg afwezig met betrekking tot het gebruik van leerlingenprestaties.

Geloven in de meerwaarde van datagebruik en een hoger gevoel van competentie stimuleren samenwerking

Het derde onderzoeksdoel richtte zich op het genereren van kennis over hoe kenmerken van leerkrachten hun datagebruik beïnvloeden, en meer specifiek ook de interactieve component binnen hun datagebruik. Dit proefschrift richtte zich daarbij op de invloed van attitude en de persoonlijke doelmatigheid van leerkrachten op datagebruik. Met andere woorden werd onderzocht hoe geloven in de meerwaarde van datagebruik voor onderwijs en in de eigen capaciteiten om data te gebruiken (interacties in) het datagebruik van leerkrachten beïnvloeden.

In **studie 1** werden structurele padmodellen toegepast op een set van 1472 leerkrachten om te onderzoeken of en hoe de attitude en persoonlijke doelmatigheid van leerkrachten intergerelateerd zijn aan hun individueel datagebruik en samenwerkend datagebruik.

Daarnaast beoogde **studie 4** deze resultaten te verdiepen. Sociale netwerk analyse op de netwerkpatronen van 7 lerarenteams werden gebruikt om na te gaan hoe de attitude en persoonlijke doelmatigheid van leerkrachten hun zoeken naar interacties, hun populariteit in interacties en de mate waarin interacties plaatsvinden met gelijkgezinden op vlak van attitude en persoonlijke doelmatigheid beïnvloeden.

De studies wezen uit dat de attitude van leerkrachten, of de mate waarin zij geloven in de meerwaarde van datagebruik hun datagebruik beïnvloedt, zij het enkel de interactieve component ervan. Met andere woorden doet de attitude van leerkrachten er minder toe voor de mate waarin zij individueel data gebruiken en sterker voor de mate waarin zij in interactie treden met betrekking tot datagebruik. Een positieve attitude faciliteert interacties in datagebruik. Daarbij komend blijkt het, in het geval van attitude, niet noodzakelijk hoe hoger hoe beter. Zodra een positieve attitude aanwezig is, wordt de invloed van nog sterkere positieve attitudes ten opzichte van het interactiegedrag sterk afhankelijk van de team context. In dit geval zullen de waargenomen interacties in datagebruik beter verklaard kunnen worden door andere factoren dan attitude.

Met betrekking tot de persoonlijke doelmatigheid van leerkrachten, maakt dit proefschrift duidelijk dat een hoger gevoel van bekwaamheid in datagebruik een positieve impact heeft op zowel individuele als interactieve vormen van datagebruik. Een hoger gevoel van competentie leidt er dus toe dat leerkrachten vaker zelf data gebruiken en dus ook vaker in interactie treden met collega's. Aan de andere kant is deze variabele niet verklarend voor de mate waarin bepaalde leerkrachten interessanter zijn om mee in interactie te treden in datagebruik. Met andere woorden, een hoger gevoel van competentie in datagebruik maakt van leerkrachten niet noodzakelijk een interessantere partner voor interacties in datagebruik.

Leeruitkomsten naar aanleiding van interacties in datagebruik blijven beperkt

Dit proefschrift beoogde ten slotte inzichten te genereren in de impact van interacties in datagebruik op leeruitkomsten bij leerkrachten. **Studie 5** analyseerde aan de hand van interviews met 14 leerkrachten in de diepte in hoeverre hun interacties in datagebruik ook leiden tot leeruitkomsten op cognitief vlak (bijvoorbeeld nieuwe of bevestigde ideeën of opinies), op vlak van attitude (bijvoorbeeld in de vorm van een groter bewustzijn) en op vlak van instructie (bijvoorbeeld het in praktijk brengen van nieuwe ideeën).

In deze studie werden indicaties gevonden van hoe interacties in datagebruik tot professioneel leren kunnen leiden bij leerkrachten. Toch bleven deze effecten al bij al beperkt en waren ze voornamelijk gesitueerd op het vlak van attitudes. Interacties met collega's rond het gebruik van leerlingenprestaties leiden vooral tot hogere niveaus van bewustzijn over het leren en presteren van leerlingen en de impact van bepaalde instructiepraktijken hierop.

Conclusie

Een gedetailleerde blik op samenwerking tussen leerkrachten is erg bruikbaar gebleken om diepgaande inzichten te verwerven in de processen, effecten en beïnvloedende factoren van interacties rond datagebruik in lerarenteams. Het grote individuele perspectief van waaruit leerkrachten deze interacties aangaan noopt tot reflectie over de collectieve verantwoordelijkheid voor het leren van leerlingen die in deze teams gepercipieerd wordt. In het achterhoofd houdende dat sterker leerling gecentreerd onderwijs hoog op de beleids- en onderzoeksagenda staat, is het noodzakelijk om het leerkrachtperspectief om te vormen tot een leerlingperspectief. Een belangrijke sleutel in deze ligt in het definiëren van gezamenlijke doelen en verantwoordelijkheden voor lesgeven en leren in lerarenteams.

References

Baker-Doyle, K. J. (2015). Stories in networks and networks in stories: a tri-modal model for mixed-methods social network research on teachers. *International Journal of Research & Method in Education, 38*(1), 72-82.

Bakkenes, I., Vermunt, J. D., & Wubbels, T. (2010). Teacher learning in the context of educational innovation: Learning activities and learning outcomes of experienced teachers. *Learning and Instruction, 20*(6), 533-548. doi: 10.1016/j.learninstruc.2009.09.001

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.

Barrett, P. (2007). Structural equation modelling: Adjusting model fit. *Personality and Individual Differences, 42*, 815-824.

Barrezeele, G. (2012). *Informatiemanagement. Een nieuw tijdperk, een nieuwe aanpak*. [Information management. A new era, a new approach] Leuven: Acco.

Bertrand, M., & Marsh, J. A. (2015). Teachers' sensemaking of data and implications for equity. *American Educational Research Journal, 52*(5), 861-893.

Blink, R. J. (2007). *Data-driven instructional leadership*. Larchmont, New York: Eye On Education.

Bolhuis, E. D., Schildkamp, K., & Voogt, J. M. (2016). Improving teacher education in the Netherlands: data team as learning team? *European Journal of Teacher Education*, 1-20. doi: 10.1080/02619768.2016.1171313

Borgatti, S. P., Brass, D. J., & Halgin, D. S. (2014). Social network research: Confusions, criticisms, and controversies *Contemporary Perspectives on Organizational Social Networks* (Vol. 40, pp. 1-29): Emerald Group Publishing Limited.

Borgatti, S. P., Everett, M. G. and Freeman, L. C. (2002). *Ucinet for Windows: Software for social network analysis*. Harvard, MA: Analytic Technologies.

Borgatti, S. P., Everett, M. G., & Johnson, J. C. (2013). *Analyzing social networks*. Los Angeles: Sage.

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network Analysis in the social sciences. *Science, 323*, 892-895.

Brown, G. T., Lake, R., & Matters, G. (2011). Queensland teachers' conceptions of assessment: The impact of policy priorities on teacher attitudes. *Teaching and Teacher Education, 27*(1), 210–220.

Campbell, C., & Levin, B. (2008). Using data to support educational improvement. *Educational Assessment, Evaluation and Accountability, 21*(1), 47-65.

Carlson, D., Borman, G., & Robinson, M. (2011). A multistate district-level cluster randomized trial of the impact of data-driven reform on reading and mathematics achievement. *Education Evaluation and Policy Analysis, 33*(3), 378-398.

Carolan, B. V. (2014). *Social network analysis and educational research: Theory, methods, and applications*. Thousand Oaks, CA: SAGE Publications.

Ciampa, K., & Gallagher, T. L. (2016). Teacher collaborative inquiry in the context of literacy education: Examining the effects on teacher self-efficacy, instructional and assessment practices. *Teachers and Teaching, 22*(7), 858-878.

Chen, F., Curran, P.J., Bollen, K.A., Kirby, J., & Paxton, P. (2008). An empirical evaluation of the use of fixed cutoff points in RMSEA Test Statistic in Structural Equation Models. *Sociological Methods & Research, 36*(4), 462-494.

Coburn, C. E., & Talbert, J. (2006). Conceptions of evidence use in school districts: Mapping the terrain. *American Journal of Education, 112*(4), 469–495

Coburn, C. E., & Turner, E. O. (2011). Research on data use: A framework and analysis. *Measurement: Interdisciplinary Research & Perspective, 9*(4), 173-206.

Copland, M. A. (2003). Leadership of inquiry: building and sustaining capacity for school improvement. *Educational Evaluation and Policy Analysis, 25*(4), 375-395.

Cosner, S. (2011). Supporting the Initiation and Early Development of Evicence-Based Grade-Level Collaboration in Urban Elementary Schools: Key Roles and Strategies of Principals and Literacy Coordinators. *Urban Education, 46*(4), 786-827.

Cummings, J. N., & Cross, R. (2003). Structural properties of work groups and their consequences for performance. *Social Networks, 25*, 197-210.

Daly, A. J. (2012). Data, dyads and dynamics: Exploring data use and social networks in educational improvement. *Teachers College Record, 114*(11), 1-38.

Daly, A. J., & Finnigan, K. S. (2011). The ebb and flow of social network ties between district leaders under high-stakes accountability. *American Educational Research Journal, 48*(1), 37-79.

Datnow, A., & Hubbard, L. (2015). Teachers' use of data to inform instruction: Lessons from the past and prospects for the future. *Teachers College Record, 117*(4), 1–26.

Datnow, A., & Hubbard, L. (2016). Teacher capacity for and beliefs about data-driven decision making: A literature review of international research. *Journal of Educational Change, 17*(1), 7-28.

Datnow, A., Park, V., & Kennedy-Lewis, B. (2013). Affordances and constraints in the context of teacher collaboration for the purpose of data use. *Journal of Educational Administration, 51*(3), 341-362.

Dawson, D. L., Meadows, K. N., & Haffie, T. (2010). The effect of performance feedback on student help-seeking and learning strategy use: Do clickers make a difference? *The Canadian Journal for the Scholarship of Teaching and Learning, 1*(1), 1-20.

Deci, E. L., & Ryan, R. M. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*, 227-268.

DeVellis, R. F. (2012). *Scale development: Theory and applications (3rd ed.)*. Thousand Oaks, CA: Sage.

De Volder, I. (2012). *Externe schoolevaluaties in Europa*. Antwerpen - Apeldoorn: Garant.

Farley-Ripple, E. N., & Buttram, J. L. (2014). Developing collaborative data use through professional learning communities: Early lessons from Delaware. *Studies in Educational Evaluation, 42*, 41-53.

Farley-Ripple, E. N., & Buttram, J. L. (2015). The development of capacity for data use: The role of teacher networks in an elementary school. *Teachers College Record, 117*(4), 1-34.

Feldman, J., & Tung, R. (2001). Using data-based inquiry and decision making to improve instruction. *ERS Spectrum, 19*(3), 10-19.

Finnigan, K. S., & Daly, A. J. (2012). Mind the gap: Organizational learning and improvement in an underperforming urban system. *American Journal of Education, 119*, 41-71.

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods, 18*(1), 59-82.

Gummer, E. S., & Mandinach, E. B. (2015). Building a conceptual framework for data literacy. *Teachers College Record, 117*(4), 1-22.

Hammick, M., Freeth, D., Copperman, J., & Goodsmith, D. (2009). *Being interprofessional*. England: Polity Press.

Handcock, M. S., Hunter, D. R., Butts, C. T., Goodreau, S. M., & Morris, M. (2016). Statnet: Software tools for the statistical modeling of network data (Version 2016.9).

Hansen, M. T. (2002). Knowledge networks: explaining effective knowledge sharing in multiunit companies. *Organization Science, 13*(3), 232-248.

Hoekstra, A., Brekelmans, M., Beijaard, D., & Korthagen, F. (2009). Experienced teachers' informal learning: Learning activities and changes in behavior and cognition. *Teaching and Teacher Education, 25*(5), 663-673. doi: 10.1016/j.tate.2008.12.007

Horn, I. S. (2007). Fast kids, slow kids, lazy kids: Framing the mismatch problem in mathematics teachers' conversations. *The Journal of the Learning Sciences, 16*(1), 37-79.

Horn, I. S., Kane, B. D., & Wilson, J. (2015). Making sense of student performance data: Data use logics and mathematics teachers' learning opportunities. *American Educational Research Journal, 52*(2), 208-242.

Horn, I. S. & Little, J. W. (2010). Attending to problems of practice: Routines and resources for professional learning in teachers' workplace interactions. *American Educational Research Journal, 47*(1), 181-217.

Hubbard, L., Datnow, A., & Pruyn, L. (2014). Multiple initiatives, multiple challenges: The promise and pitfalls of implementing data. *Studies in Educational Evaluation, 42*, 54-62. doi: 10.1016/j.stueduc.2013.10.003

Hubers, M. D., Moolenaar, N. M., Schildkamp, K., Daly, A., Handelzats, A., & Pieters, J. M. (2017). Share and succeed: The development of knowledge sharing and brokerage in data teams' network structures. *Research Papers in Education*, 1-23. doi: 10.1080/02671522.2017.1286682

Hubers, M. D., Poortman, C. L., Schildkamp, K., Pieters, J. M., & Handelzalts, A. (2016). Opening the black box: knowledge creation in data teams. *Journal of Professional Capital and Community, 1*(1), 41-68. doi: 10.1108/jpcc-07-2015-0003

Hulpia, H., Valcke, M., & Verhaeghe, J. P. (2004). *The use of performance indicators in a school improvement policy. What do experts say about it?* Paper presented at the American Educational Research Association, San Diego.

Jimerson, J. B. (2014). Thinking about data: Exploring the development of mental models for data use among teachers and school leaders. *Studies in Educational Evaluation, 42*(2014), 5-14. doi: 10.1016/j.stueduc.2013.10.010

Johnson, J. (1997). Data-driven school improvement. *Emergency Librarian, 24*(4), 30-31.

Katz, S., & Dack, L. A. (2014). Towards a culture of inquiry for data use in schools: Breaking down professional learning barriers through intentional interruption. *Studies in Educational Evaluation, 42*, 35-40. doi: 10.1016/j.stueduc.2013.10.006

Katz, S., & Earl, L. (2010). Learning about networked learning communities. *School Effectiveness and School Improvement, 21*(1), 27-51. doi: 10.1080/09243450903569718

Katz, S., Earl, L., Ben Jaafar, S., Elgie, S., Foster, L., Halbert, J., & Kaser, L. (2008). Learning Networks of Schools: The key enablers of successful knowledge communities. *McGill Journal of Education, 43*(2), 111. doi: 10.7202/019578ar

Kelchtermans, G. (2006). Teacher collaboration and collegiality as workplace conditions: a review. *Zeitschrift fur Padagogik, 2*(2), 220-237.

Kellaghan, T., & Stufflebeam, D. (2003). *International handbook of educational evaluation*. Boston: Kluwer Academic Publishers.

Kerr, K. A., Marsh, J. A., Ikemoto, G. S., Darilek, H., & Barney, H. (2006). Strategies to promote data use for instructional improvement: Actions, outcomes and lessons from three urban districts. *Americal Journal of Education, 112*, 496-520.

Keuning, T., Van Geel, M., Visscher, A., Fox, J.P., & Moolenaar, N.M. (2016). Transformation of schools' social networks during a data-based decision making reform. *Teachers College Record, 118*(9), 1-33.

Kilduff, M., & Tsai, W. (2003). *Social networks and organizations*. Thousand Oaks, CA: Sage.

Kowalski, T. J., & Lasley, T. J. (2009). Part I: Theoretical and Practical Perspectives In T. J. Kowalski & T. J. Lasley (Eds.), *Handbook of Data-Based Decision Making in Education* (pp. 3-86). New York: Routledge.

Kwakman, K. (2003). Factors affecting teachers' participation in professional learning activities. *Teaching and Teacher Education, 19*(2), 149-170. doi: 10.1016/s0742-051x(02)00101-4.

Levin, J. A., & Datnow, A. (2012). The principal role in data-driven decision making: Using case-study data to develop multi-mediator models of educational reform. *School Effectiveness and School Improvement, 23*(2), 179e201.

Levine, T. H., & Marcus, A. S. (2010). How the structure and focus of teachers' collaborative activities facilitate and constrain teacher learning. *Teaching and Teacher Education, 26*(3), 389-398. doi: 10.1016/j.tate.2009.03.001

Little, J. W. (1990). The persistence of privacy: Autonomy and initiative in teachers' professional relations. *Teachers College Record, 91*(4).

Little, J. W. (2012). Understanding data use practice among teachers: the contribution of micro-process studies. *American Journal of Education, 118*(2), 143-166.

Marsh, J. A. (2012). Interventions promoting educators' use of data: Research insights and gaps. *Teachers' College Record, 114*, 1-48.

Marsh, J. A., Bertrand, M., & Huguet, A. (2015). Using data to alter instructional practice: The mediating role of coaches and professional learning communities. Teachers College Record, 117(4), 1–40.

Marsh, J. A., & Farrell, C. C. (2015). How leaders can support teachers with data-driven decision making: A framework for understanding capacity building. *Educational Management Administration & Leadership, 43*(2), 269-289.

Maso, I., & Smaling, A. (1998). Kwalitatief onderzoek: *Praktijk en theorie. [Qualitative research: Practice and theory]* Amsterdam: Boom.

Mason, S. A. (2003). *Learning from data: the role of professional learning communities* Paper presented at the annual conference of the American Education Research Association, Chicago.

Mc Pherson, M., Smith-Levin, L., & Cook, J. M. (2001). Birds of a Feather: Homophily in Social Networks. *Annual Review of Sociology, 27*(2001), 415-444.

Meirink, J. A., Meijer, P. C., Verloop, N., & Bergen, T. C. M. (2009a). How do teachers learn in the workplace? An examination of teacher learning activities. *European Journal of Teacher Education, 32*(3), 209-224. doi: 10.1080/02619760802624096

Meirink, J. A., Meijer, P. C., Verloop, N., & Bergen, T. C. M. (2009b). Understanding teacher learning in secondary education: The relations of teacher activities to changed beliefs about teaching and learning. *Teaching and Teacher Education, 25*(1), 89-100. doi: 10.1016/j.tate.2008.07.003

Meredith C., Van Den Noortgate W., Struyve C., Gielen S., Kyndt E. (2017). Information seeking in secondary schools: A multilevel network approach. *Social Networks, 50,* 35-45.

Michaud, R. (2016). The nature of teacher learning in collaborative data teams. *The Qualitative Report*, 21(3), 529-545.

Miles, M., & Huberman, M. (1994). *Qualitative Data Analysis*. London: Sage.

Mohrman, S. A., Tenkasi, R. V., & Mohrman Jr., A. M. (2003). The role of networks in fundamental organizational change: A grounded analysis. *The Journal of Applied Behavioral Science, 39*(3), 301-323.

Moolenaar, N. M. (2012). A social network perspective on teacher collaboration in schools: Theory, methodology, and applications. *American Journal of Education, 119*(1), 7-39.

Moolenaar, N.M. (2012). *Ties with Potential* (Dissertation). University of Amsterdam, Amsterdam.

Moolenaar, N. M., Sleegers, P. J. C., & Daly, A. J. (2012). Teaming up: Linking collaboration networks, collective efficacy, and student achievement. *Teaching and Teacher Education, 28*(2), 251-262. doi: http://dx.doi.org/10.1016/ j.tate.2011.10.001

Moolenaar, N. M., Sleegers, P. J. C., Karsten, S., & Daly, A. J. (2012). The social fabric of elementary schools: a network typology of social interaction among teachers. *Educational Studies, 38*(4), 355-371. doi: 10.1080/03055698.2011.643101

Morrow, S. L. (2005). Quality and trustworthiness in qualitative research in counseling psychology. *Journal of Counseling Psychology, 52*(2), 250-260.

OECD (2014). *TALIS 2013 Results: An international perspective on teaching and learning*, TALIS, OECD Publishing, http://dx.doi.org/10.1787/9789264196261-en.

Onwuegbuzie, A. J. (2003). Effect sizes in qualitative research: A prolegomenon. *Quality & Quantity, 37*, 393-403.

Pandit, N. R. (1996). The creation of theory: A recent application of the grounded theory method. *The Qualitative Report, 2*.

Pareja Roblin, N., & Margalef, L. (2013). Learning from dilemmas: teacher professional development through collaborative action and reflection. *Teachers and Teaching, 19*(1), 18-32. doi: 10.1080/13540602.2013.744196

Penninckx, M., Vanhoof, J., & Van Petegem, P. (2011). *Evaluatie in het Vlaamse onderwijs. Beleid en praktijk van leerling tot overheid*. [Evaluation in Flemish education. Policy and practice from student to government] Antwerpen-Apeldoorn: Garant.

Penuel, W., Riel, M., Krause, A., & Frank, K. (2009). Analyzing teachers' professional interactions in a school as social capital: a social network approach. *Teachers College Record 111* (1), 124–163.

Penuel, W., Sun, M., Frank, K.A., & Gallagher, H.A. (2012). Using social network analysis to study how collegial interactions can augment teacher learning from external professional development. *American Journal of Education, 119* (1), 103–136.

Pierce, R., & Chick, H. (2011). Teachers' intentions to use national literacy and numeracy assessment data: a pilot study. *Australian Educational Researcher, 38*, 433-447.

Ripley, R. M., Snijders, T. A. B., Boda, Z., Vörös, A., & Preciado, P. (2016). *Manual for SIENA version 4.0 (version August 18, 2016)*. Oxford: University of Oxford, Department of Statistics; Nuffield College. http://www.stats.ox.ac.uk/siena/

Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. *Computer supported learning, 128*(1995), 69-97.

Scheerens, J. (1990). School effectiveness research and the development of process indicators of school functioning. *School Effectiveness and School Improvement, 1*(1), 61-80.

Schildkamp, K., Ehren, M., & Lai, M. K. (2012). Editorial article for the special issue on data-based decision making around the world: from policy to practice to results. *School Effectiveness and School Improvement, 23*(2), 123-131.

Schildkamp, K., & Kuiper, W. (2010). Data-informed curriculum reform: Which data, what purposes, and promoting and hindering factors. *Teaching and Teacher Education, 26*(3), 482-496.

Schildkamp, K., Poortman, C. L., & Handelzalts, A. (2016). Data teams for school improvement. *School Effectiveness and School Improvement*, *27*(2), 228-254. doi: 10.1080/09243453.2015.1056192

Schildkamp, K., Rekers-Mombarg, L. T. M., & Harms, T. J. (2012). Student group differences in examination results and utilization for policy and school development. *School Effectiveness and School Improvement, 23*(2), 229-255.

Schildkamp, K., & Teddlie, C. (2008). School performance feedback systems in the USA and in the netherlands: A comparison. *Educational Research & Evaluation, 14*(3), 255-282.

Schildkamp, K., Visscher, A., & Luyten, H. (2009). The effects of the use of a school self-evaluation instrument. *School Effectiveness and School Improvement, 20*(1), 69-88.

Schumacker, R. E., & Lomax, R. G. (2004). *A beginner's guide to structural equation modeling (2nd ed.)*. Mahwah, NJ: Lawrence Erlbaum Associates.

Seashore Louis, K., Dretzke, B., & Wahlstrom, K. (2010). How does leadership affect student achievement? Results from a national US survey. *School Effectiveness and School Improvement, 21*(3), 315-336.

Sijtsma, K. (2009). On the use, misuse, and the very limited usefulness of Cronbach's Alpha. *Psychometrika, 74*(1), 107-120.

Sim, J. & Wright, C. C. (2005). The Kappa Statistic in Reliability Studies: Use, Interpretation, and Sample Size Requirements. *Physical Therapy, 85*(3), 257–268.

Sparrowe, R. T., Liden, R. C., Wayne, S. J., & Kraimer, M. L. (2001). Social networks and the performance of individuals and groups. *Academy of Management Journal, 44*(2), 316-325.

Spillane, J. P. (2012). Data in practice: Conceptualizing the data-based decision-making phenomenon. *American Journal of Education, 118*, 113–141.

Spillane, J. P., Hopkins, M., & Sweet, T. (2015). Intra-and inter-school interactions about instruction: exploring the conditions for social capital development. *American Journal of Education, 122*(1), 71 -110.

Snijders, T. A. B., Van de Bunt, G. G., & Steglich, C. (2010). Introduction to actorbased models for network dynamics. *Social Networks, 32,* 44–60

Stoll, L., Bolam, R., McMahon, A., Wallace, M., & Thomas, S. (2006). Professional learning communities: a review of the literature. *Journal of Educational Change, 7*(4), 221-258.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2011*(2), 53-55.

Vangrieken, K., Dochy, F., Raes, E., & Kyndt, E. (2013). Beyond individualism and isolation in schools: What types of teacher teams are there in schools? Or can we merely speak about groups? *Frontline Learning Research*, 1(2), 86-98.

Vanhoof, J., & Schildkamp, K. (2014). From 'professional development for data use' to 'data use for professional development'. *Studies in Educational Evaluation, 42*, 1-4. doi: 10.1016/j.stueduc.2014.05.001

Vanhoof, J., Vanlommel, K., Thijs, S., & Vanderlocht, H. (2014). Data use by Flemish school principals: impact of attitude, self-efficacy and external expectations. *Educational Studies, 40*(1), 48-62.

Vanhoof, J., & Van Petegem, P. (2007). Matching internal and external evaluation in an era of accountability and school development: lessons from a Flemish perspective. *Studies in Educational Evaluation, 33*(2), 101-119.

Vanhoof, J., Van Petegem, P., Verhoeven, J. C., & Buvens, I. (2009). Linking the policymaking capacities of schools and the quality of school self-evaluations. *Education Management Administration and Leadership,37*(5), 667-686.

Vanlommel, K., Vanhoof, J., & Van Petegem, P. (2016). Data use by teachers: the impact of motivation, decision-making style, supportive relationships and reflective capacity. *Educational Studies, 42*(1), 36-53.

Van den Bossche, P., Gijselaers, W., Segers, M., Woltjer, G., & Kirschner, P. (2011). Team learning: building shared mental models. *Instructional Science, 39*(3), 283-301.

Van Gasse, R., Vanhoof, J., & de Vos, W. (2014). Informatiegebruik in verantwoordingsgerichte en schoolontwikkelingsgerichte onderwijssystemen: een Nederlands-Vlaams perspectief. *Pedagogiek, 34*(2), 84-106.

Van Gasse, R., Vanhoof, J., Mahieu, P., & Van Petegem, P. (2015). *Informatiegebruik door schoolleiders en leerkrachten*. Antwerpen: Garant.

Van Gasse, R., Vanlommel, K., Vanhoof, J. and Van Petegem, P. (2016). Teacher collaboration on the use of pupil learning outcome data: A rich environment for professional learning? *Teaching and Teacher Education, 60*, 387-397. doi: 10.1016/j.tate.2016.07.004

Van Gasse, R., Vanlommel, K., Vanhoof, J. and Van Petegem, P. (2017). The impact of collaboration on teachers' individual data use. *School Effectiveness and School Improvement, 28*(3), 489-504. doi: 10.1080/09243453.2017.1321555.

Van Gasse, R., Vanlommel, K., Vanhoof, J. and Van Petegem, P. (2017). Individual, co-operative and collaborative data use: A conceptual and empirical exploration. *British Educational Research Journal, 43*, 608–626. doi:10.1002/berj.3277

Van Gasse, R., Vanlommel, K., Vanhoof, J. and Van Petegem, P. (2017). Unravelling data use in teacher teams: How network patterns and interactive learning activities change across different data use phases. *Teaching and Teacher Education, 67*, 550-560.

Van Waes, S., Moolenaar, N., Daly, A., Heldens, H., Donche, V., Van Petegem, P., & Van den Bossche, P. (2016). The networked instructor: The quality of networks in different stages of professional development. *Teaching and Teacher Education, 59*, 295-308.

Verbiest, E. (2011). *Developing Professional Learning Communities*. Paper presented at the AERA conference, New Orleans.

Verhaeghe, G., Vanhoof, J., Valcke, M., & Van Petegem, P. (2011). Effecten van ondersteuning bij schoolfeedbackgebruik. [Effects of support in school feedback use] *Pedagogische Studiën, 88*, 90-106.

Verhaeghe, G., Vanhoof, J., Valcke, M., & Van Petegem, P. (2010). Using school performance feedback: perceptions of primary school principals. *School Effectiveness and School Improvement, 21*(2), 167-188.

Visscher, A. (2002). School performance feedback systems. In A. J. Visscher & R. Coe (Eds.), *School improvement through performance feedback* (pp. 41-71). Lisse: Swets & Zeitlinger.

Visscher, A., & Coe, R. (2003). School performance feedback systems: Conceptualisation, analysis, and reflection. *School Effectiveness and School Improvement, 14*(3), 321-349.

Wahlstrom, K. L., & Louis, K. (2008). How teachers experience principal leadership: The roles of professional community, trust, efficacy, and shared responsibility. *Educational Administration Quarterly, 44*(4), 458-495.

Wayman, J. C. (2005). Involving teachers in data-driven decision making: using computer data systems to support teacher inquiry and reflection. *Journal of education for students placed at risk, 10*(3), 295-308.

Wayman, J. C., & jimerson, J. B. (2014). Teacher needs for data-related professional learning. *Studies in Educational Evaluation, 42*, 25-34.

Wayman, J. C., Jimerson, J. B., & Cho, V. (2012). Organizational considerations in establishing the Data-Informed District. *School Effectiveness and School Improvement, 23*(2), 159-178.

Wayman, J. C., Midgley, S., & Stringfield, S. (2007). Leadership for data-based decision making: Collaborative educator teams. In A. B. Danzig, K. M. Borman, B. A. W. Jones & W. F. Wright (Eds.), *Learner-centered leadership: Research, policy and practice* (pp. 189-205). New Jersey, USA: Lawrence Erlbaum Associates.

Wayman, J. C., & Stringfield, S. (2006). Technology-supported involvement of entire faculties in examination of student data for instructional improvement. *American Journal of Education, 112*, 549-571.

Woolfolk, A. (2008). Educational psychology. Active learning edition (2nd ed.). Boston, MA: Allyn & Bacon.

Young, V. M. (2006). Teachers' use of data: loose coupling, agenda setting, and team norms. *American Journal of Education, 112*, 521-548.

Zwart, R. C., Wubbels, T., Bergen, T. C. M., & Bolhuis, S. (2007). Experienced teacher learning within the context of reciprocal peer coaching. *Teachers and Teaching, 13*(2), 165-187. doi: 10.1080/13540600601152520

Zwart, R. C., Wubbels, T., Bolhuis, S., & Bergen, T. C. M. (2008). Teacher learning through reciprocal peer coaching: An analysis of activity sequences. *Teaching and Teacher Education, 24*(4), 982-1002. doi: 10.1016/j.tate.2007.11.003