Data teams for school improvement: Sharing knowledge

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Preface

This master thesis was performed under the supervision of the University of Twente. It concluded my master programme in Educational Science and Technology.

During the final stages of this programme, I received great support from several persons. This opportunity will be used to thank them.

First, I give special thanks to my parents, Roel en Eelkje, who encouraged me to further educate myself and enrol in this programme. They and supported me in all possible ways. I thank them for always believing in me.

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Summary

When school leaders and teachers base their decisions on data, it can lead to powerful learning and sustainable improvement in education, this is called data-informed decision making. Data can be defined as all the information that teachers and schools need for decision-making, for example demographics of the student population and student test scores. A promising way to increase data-informed decision making in schools is setting up data teams within schools. These teams can consist of teachers and school leaders. Through a structured cyclic procedure, members of a data team learn how to use data to solve a certain educational problem within the school, such as low student achievements. During this procedure, data team members gain knowledge on data use in general and knowledge on the educational problem. The extent to which knowledge is shared between data team members and their colleagues might be of vital importance for increasing data-informed decision making and improving education by solving educational problems. The present study explored knowledge sharing between data team members and their non-data team colleagues. Research was conducted in four schools with a data team. Interviews were conducted with data team members and several of their colleagues. Also, artifacts were collected, such as PowerPoint slides and newsletters. Data analysis provided insight on how knowledge is shared, what types of knowledge are shared and the enabling and hindering factors in knowledge sharing between data team members and non-data team members. The results showed that data teams share their knowledge on data use and the educational both formally (e.g. by using artifacts) and informally (e.g. in informal conversation). Overall, more knowledge was shared on the educational problem than on data use. Results show that data teams were comparable in the types of medium used to share knowledge (e.g. newsletters and presentations). The frequency of knowledge sharing differed between cases. Results showed that overall more knowledge was shared on the educational problem (e.g. hypotheses and problem statement) than knowledge on data use (e.g. data collection and data analysis), respondents were also less able to recollect this knowledge. Several reports were found of management support, the climate of trust, and a sense of responsibility both hindering and promoting knowledge sharing. One promoting factor was found, namely the value of knowledge. Anticipating the importance of knowledge promoted data team members to purposely share this knowledge. Also, one hindering factor was found, namely the gap between the knowledge base of data team members and the knowledge base of colleagues. Within cases, respondents differed in their perception on whether factors promoted or hindered knowledge sharing. This indicated that the influencing factors were subdue to personal perspectives and beliefs. In addition, results also provided unforeseen influencing factors, such as the interest of non-data team members in the data teams' knowledge. Results also showed that perceptions on knowledge sharing differed between knowledge providers (e.g. data team members) and knowledge receivers (e.g. non-data team members), in terms of whether knowledge was shared, indicating that knowledge sharing was not always successful. Further research should explore the success of knowledge sharing by analysing in detail the internalization of knowledge by receivers. Results of this study can provide schools with insight in influencing factors for successful knowledge sharing. Schools may use this insight to their advantage to achieve successful knowledge sharing.

1. Introduction

When school leaders and teachers base their decisions on data, this can lead to powerful learning and sustainable improvement in education (Schildkamp, Lai, & Earl, 2012b). Data can help decrease politics and ideology from decisions, and focus on teaching and learning (Honig & Coburn, 2008). Data can be defined as all the information, collected in a structured manner, that teachers and schools need for decision-making, for example, demographics of the student population and student test scores (Schildkamp, Handelzalts, & Poortman, 2012a). Data needs to be collected, analysed and interpreted in order for it to be meaningful and relevant and to make decisions based on these data. This process is called data-informed decision making.

Even though the Dutch inspectorate (2011) qualified data-informed decision making as an important key to improving education, teachers and school leaders in Dutch schools lack the necessary knowledge and data literacy skills for this process (Visscher & Ehren, 2011). Most teachers do not use data properly, or do not use data at all (Schildkamp & Kuiper, 2010). Thus, professionalization of teachers and school leaders is a necessary step for ensuring data-informed decision making in Dutch schools. According to Wayman, Midgley and Stringfield (2006), setting up data teams may be promising way to professionalize teachers and school leaders and ensure data-informed decision making in schools.

Data teams are composed of approximately four to six teachers and one or two (assistant) school leaders (Schildkamp et al., 2012a). Through a structured cyclic procedure, they learn how to use data to solve a certain educational problem within the school. Data teams collect, analyse and discuss data. By doing so, they gain knowledge on data use in general as well as knowledge on the educational problem they are trying to solve. The data team procedure is aimed at increasing data-informed decision making in the school, and improving education by solving educational problems. In order for the data team procedure to achieve this, data team members need to share their knowledge with their colleagues (Schildkamp & Handelzalts, 2012). When data team members share their knowledge on data use, they can help colleagues to learn how to use data in their decision making, thus improving education. Also, when data teams share knowledge on the educational problem, it will provide colleagues with a deeper understanding of the functioning of the school and how they can contribute to solving the educational problem.

To our knowledge, knowledge sharing has not been researched in the context of data teams and data-informed decision making. Therefore, the present study focused on the process of knowledge sharing between data team members and their colleagues in Dutch secondary schools. The following research questions guided the present study:

1. How is knowledge shared between data team members and their colleagues?
2. What types of knowledge are shared between data team members and their colleagues?
3. What factors influence knowledge sharing between data team members and their colleagues?

2. Theoretical framework

This section will start by discussing data-informed decision making and relating it to the concept of data teams as professional learning communities. Subsequently, the data team procedure will be explained and the knowledge that might be created in this process. Thereafter, the concept of knowledge sharing will be discussed, as well as promoting and hindering factors for knowledge sharing.

2.1 Data-informed decision making

In recent years, schools have been held more and more accountable for the education they provide and schools are often required to provide evidence for the effectiveness of their educational programs. This has put pressure on schools to understand and respond to a growing set of data on school and student performance (Schildkamp et al., 2012b). The most important reason for schools to become data-oriented is that decisions informed by data are more likely to be effective than decisions based on experience and intuition (Schildkamp & Handelzalts, 2011), because data can help schools to detect problems, to identify gaps and to monitor improvements (Carlson, Borman, & Robinson, 2011; Earl & Katz, 2006; Schildkamp et al., 2012b). For instance, Carlson et al. (2011) analysed the effects of data-informed reform initiatives in more than 500 schools, using a rigorous randomized experimental design. They found that the initiatives, such as enhanced data provision and training in data interpretation, had resulted in statistically significant improvements in Mathematics and positive effects for reading. Thus, using data for decision making can lead to sustainable improvements in student learning and achievement.

Schildkamp et al. (2012b) explain that for making data-informed decisions, schools can use different types of data. According to Ikemoto and Marsh (2007), these different sources include input data (e.g. student demographics), process data (e.g. class observations), outcome data (e.g. student test scores and student well-being), and context data (e.g. survey results on school culture and data on the curriculum such as rosters and year guides). It may not be necessary to use all four types of data for every decision, only the data that are relevant to the decision should be used. For example, when analyzing student achievement, it is important to not only use assessment data (e.g. outcome data), but to also use data to understand the context of student achievement, such as survey results (e.g. context data) and class observations (e.g. process data). Schools can use data to improve teaching, address existing educational problems, and improve the functioning of the school in terms of increased student achievement. In order to do this, schools should systematically analyse their data sources within the school, apply analysis results to innovate teaching, curricula, and school performance, and implement and evaluate these innovations (Schildkamp & Kuiper, 2010). This process is called data-informed decision making. For example, a school that is not satisfied with students' examination results can decide to analyse this critically. Based on collected and analysed data, the conclusion may be drawn that students lack knowledge in a certain topic and that changes should be made in teaching practices. As a result, different instructional strategies are implemented that will help teachers to focus more on this topic, thus improving teacher practices. Data of the next examination results will show whether these implementations were successful and if they have led to higher examination results, thus improving the school (Boudett & Steele, 2007).

According to Visscher and Ehren (2011), teachers and school leaders in Dutch schools lack the necessary knowledge and data literacy skills for this process. These skills include collecting and analysing data, formulating goals and linking instruction to data in order to differentiate and make teaching plans.

Thus, professionalization of school leaders and teachers is a necessary step to ensure data-informed decision making in schools. Lee, Louis and Anderson (2012) state that an effective approach to professionalize schools is creating professional learning communities.

2.2 Data teams as professional learning communities

Professional learning communities (PLC) are collaborations wherein teachers work together to develop knowledge and skills and share their wisdom (Farley-Ripple & Buttram, 2013). In schools, they can vary depending on, for example, the size and complexity of the staff, the availability of time needed for collaboration, and the level of teacher autonomy at the school. Dufour and Eaker (1998) identified several characteristics of collaboration in professional learning community, such as having shared vision, values and common goals, actively working towards solutions and evaluating and reflecting on improvement measures. The collaboration in these communities is not only aimed at developing knowledge and skills, but also on ensuring school improvement. PLC's can improve schools, for example, by reducing the isolation of the teaching profession and enhancing individual teachers' professional growth (Handelzalts, 2009; Schildkamp et al., 2012b). The primary rationale to form a professional learning community is to provide an opportunity for teachers to gain knowledge and skills on a particular subject. For instance, teachers can learn how to differentiate, by identifying students who need additional time and support, making group plans for teaching, and evaluating if these improvement measures have had the desired effect. A promising form of teacher collaboration to learn the necessary knowledge and skills for data-informed decision making is teacher collaboration in a data team (Schildkamp et al., 2012b).

The concept of data teams derived from literature on professional learning communities. Research indicates that these data teams can increase the use of data in schools and lead to school improvement (Schildkamp & Handelzalts, 2011). Data teams are PLC's, specifically focused on increasing and enhancing data based-decision making in schools (Wayman et al., 2006), by professionalizing teachers and providing them with the necessary knowledge and skills for data use. Several characteristics of a PLC can be found in the concept of data teams. For example, during the data team procedure, data team members have a common goal, which is solving an educational problem. Also, collaboration is an important characteristic, as the data team collaboratively collects and analyses data to find the cause of the educational problem during their analysis. Moreover, improvement measures will be designed, which after implementation will be evaluated to ensure the intended effect. The data team procedure will be described in the following paragraph.

2.3 Data team procedure

In schools, a data team is composed of approximately four to six teachers and one or two (assistant) school leaders (Schildkamp et al., 2012a). The data team meets approximately once every three weeks for a period of two years. During these meetings they work according to an iterative and cyclic procedure, see Figure 1. A trainer of the University of Twente guides the data team through this process.[1]

In the first step, the data team decides on which educational problem they want to focus their efforts and they formulate a problem definition. For example 'For several years, students' retention rates

[1] In the present study, data teams are involved in a two year cooperation agreement with the University of Twente. This agreement states that data teams will be provided with guidance and expertise. In return, participating schools will allow the university to conduct research into the effectiveness of these data teams.

have been above the national average. Our goal is that within two years our rates will be below the national average'. The second step focuses on formulating hypotheses on the underlying cause of their problem. Subsequently one hypothesis will be chosen for further analysis. An example of this is: 'students who cannot be retained at the pre-university educational track have a significant lower Cito score (e.g. assessment scores from primary school which give information on the entry level for secondary education) than students who can be retained at the pre-university track'. In the third step, data such as student files and assessment data will be collected to investigate this hypothesis. The quality of these data is determined in step four. If they are not reliable and valid, additional data need to be collected, otherwise the data are analysed in step five. In the sixth step, team members will decide whether their hypothesis can be accepted or rejected based on the collected data. When the hypothesis is rejected, they need to go back to step two and another hypothesis needs to be chosen. When it is accepted, the team proceeds to step seven, in which they design and implement improvement measures to solve the problem. The effectiveness of those measures is determined in step eight, wherein the entire procedure is also evaluated. One of the goals for data team members is creating new knowledge, both on data use in general and on the specific educational problem. Results of the pilot study on the functioning of data teams, suggest that the data team procedure is effective in supporting secondary schools in reaching this goal (Schildkamp et al., 2012a).

Figure 1. *The data team procedure (Schildkamp et al., 2012a).*

2.4 Knowledge in data teams

By using the data team procedure, data team members gain knowledge on data use in general and the educational problem. They do this by collecting, analysing and interpreting data to design improvement measurements to solve the educational problem. According to Davenport and Prusak (2000), there is no inherent meaning in data alone, because it provides no interpretation or basis for action. Although data are considered to be of great importance, the authors state that it cannot tell you what to do, without relating it to prior experiences and insights and adding meaning or value to it, thus transforming it into knowledge. Achterbergh and Vriens (2002) call this process 'attaching meaning' to new information by perceiving and interpreting it. When this new information is processed, one decides whether it is relevant and if action should be taken. According to Davenport and Prusak (2000), there are four ways of adding value to data and transforming it into knowledge. Firstly, by providing a purpose for data collection thus defining a problem and forming hypothesis. Secondly, data needs to be analysed by contextualizing (e.g. placing data in purposeful context), categorizing (e.g. classifying units of analysis or key components of data), calculating, connecting, and/or summarizing data. Thirdly, data needs to be interpreted in order to understand what it means and what the implications are for further action. Finally, appropriate action needs to be taken based on data, this can be done by designing and implementing improvement measures (Davenport & Prusak, 2000). These processes continuously take place throughout all stages of the data team procedure, in which the data team gains knowledge by relating data to prior experiences and insights and attaching meaning or value to it, thus transforming it into knowledge.

In the present study, knowledge is defined as a fluid combination of experiences, values and insights, that provide a framework for evaluating and incorporating new information and experiences (Davenport & Prusak, 2000). The present study acknowledges that knowledge can be subject to multiple classifications and can have several meanings. There are several classifications for different types of knowledge (Ipe, 2003). A comprehensive review of the various classifications is beyond the scope of the present study, examples can be found in the work of Polyani (1967), Blackler (2002) and Yang (2003). For data teams, two important types of knowledge can be distinguished that are potentially worth sharing with their colleagues to ensure organizational improvement (e.g. an increase of data-informed decision making and an improvement of education by solving the educational problem). The first is knowledge on the data team procedure and data use in general. For example, knowing when a hypothesis is testable, knowing when data are valid and reliable and knowing how hypotheses are statistically tested. Sharing this knowledge may encourage colleagues to use more data and make data-informed decisions. The second is knowledge on the educational problem studied by the data team, for example, knowledge on what proved to be the cause of their educational problem and knowledge on the design and implementation of the improvement measures. Sharing this knowledge contributes to solving education problems, which in turn should foster educational improvement.

2.5 Knowledge sharing

There is much evidence suggesting that knowledge sharing is critical to organizations (Davenport & Prusak, 2000; Hendriks, 1999). It is, for example, relevant for an organizations' capacity to innovate (Achterbergh & Vriens, 2002; Nonaka, 1994). The reason for this is that knowledge sharing allows the organizations to use knowledge to solve organizational problems (Nonaka, 1994). Knowledge sharing can be defined as the provision or receipt (Cummings 2004) of new information and/or experiences (Davenport & Prusak, 2000). In the definition of knowledge sharing, both the provision and receipt of knowledge are acknowledged, indicating that it is a bilateral process. According to Hendriks (1999) knowledge sharing implies two types of actions. First, the owner of the knowledge has to take action based on it, thus sharing it. For example by explaining it or helping a colleague perform a knowledge-specific task. Second, this knowledge should be internalized by the receivers, who should use their own prior experiences and insights to attach meaning or value to it.

Knowledge can be shared in several ways, thus several distinctions can be made. Firstly, according to Faraj and Sproull (2000), knowledge can be shared through verbal communication (e.g. by explaining data analysis to a non-data team member), by exchanging artifacts (e.g. spread sheets) or by coordinating expertise (e.g. knowing where expertise is located, knowing where expertise is needed, and bringing expertise were it is needed). These activities are not mutually exclusive. For example, during a workshop, artifacts such as hand-outs can be exchanged, but discussions can also take place, which are an example of verbal communication. Secondly, as data teams are composed of individual employees, the distinction can be made between knowledge sharing by an individual member of the data team and knowledge sharing by the data team as a whole. Lin (2007) states that both knowledge sharing on an individual level and on a team level are aimed at helping colleagues and the organization as a whole, the difference lies in the manner in which knowledge sharing takes place. Thirdly, knowledge sharing can occur both formally and informally. Bartol and Srivastava (2002) state that knowledge sharing through informal interactions occurs mostly at the individual level. On a team level, knowledge is mostly shared through formal interactions.

2.6 Influencing factors in the knowledge sharing process

The dominant idea in knowledge sharing literature is that individuals do not readily share knowledge (Davenport & Prusak, 2000; Ipe, 2003), several factors may hinder or promote knowledge sharing (Wang & Noe, 2010). By studying literature on knowledge sharing and related fields, such as organizational behaviour, strategic management, human resource development, applied psychology, information and decision sciences, and organizational communication, several influential factors have been identified. The factors that are hypothesized to influence knowledge sharing between data team members and their colleagues are represented in a model of influencing factors, see Figure 2, and are divided in organizational culture, individual factors and knowledge factors. These factors will be explained in the following paragraphs. This model is a representation of possible influential factors, acknowledging that additional factors may also proof to be influential in the knowledge sharing process.

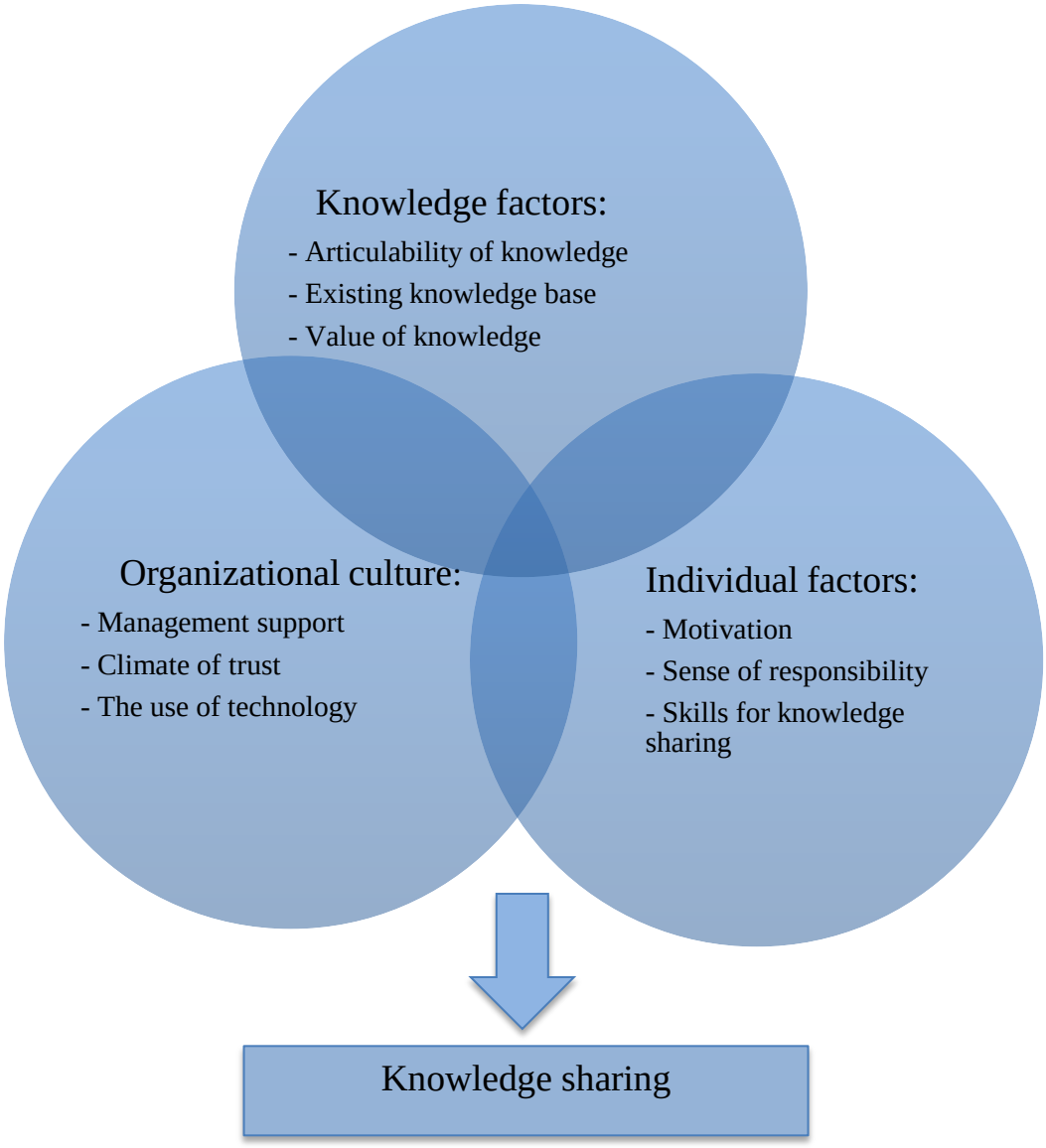

Figure 2. *Influencing factors in the knowledge sharing process.*

2.6.1 Organizational culture

Organizational culture is commonly described as shared values, beliefs or perceptions held by employees within an organization or organizational unit. It provides norms or rules for behaviour in organizations. Creating a culture, according to Schein (1986), is ultimately about setting the norms of behaviour, values and beliefs. Usually, it is perceived as the role of the school leader to set these norms.

Numerous studies have reported components of the organizational culture that influence knowledge sharing (Bartol & Srivastava, 2002; Cabrera & Cabrera, 2002; Hendriks, 1999; Ipe, 2003; Lin, 2006; Lin, 2007; McDermott & O'Dell, 2001; Riege, 2005; Wang & Noe, 2010). According to McDermott and O'Dell (2001), in organizations with a knowledge sharing culture, employees share ideas and insights because they see it as natural, rather than as something they are forced to do. The

characteristics of the organizational culture that are hypothesized to influence knowledge sharing between data team members and non-data team members are: management support, a climate of trust and the use of technology.

2.6.1.1 Management support

The support of management can influence employees' willingness to share knowledge (Connelly & Kelloway, 2003; Lin, 2007). House and Dessler (1974) defined a supportive leader as someone who provides guidance to employees, treats them fairly, and acknowledges their inputs as valuable. Management can lead by example and can create a culture wherein staff is open to new ideas (Wang & Noe, 2010). Also, several researchers stated that leaders should encourage staff to share knowledge (Lin & Lee, 2004), as it will influence the willingness of employees to help others and share knowledge (Lin, 2007; Wang & Noe, 2010). An encouraging leader ensures communication across departments and interaction among employees by providing opportunities to share (Liebowitz & Megbolugbe, 2003; Yang & Chen, 2007). Opportunities to share can be both formal and informal in nature, for example the use of an open workspace (Jones, 2005), or scheduled meetings. According to Bartol and Srivastava (2001), knowledge sharing can also be encouraged by setting up a reward system. Rewards can range from monetary incentives such as bonuses or dinner certificates to rewards such as praise or public recognition. In addition, Lin (2007) stated that management should encourage staff to share their knowledge, by providing sufficient time and means to share knowledge. The lack of time is perceived as a common sharing barrier (O'Dell & Grayson, 1998).

2.6.1.2 Climate of trust

Nahapiet and Ghoshal (1998) suggest that when there is trust between parties, they are more willing to engage in cooperative interaction, such as knowledge sharing. Yang and Wan (2004) stated that if trust and trustworthiness are embedded in the organizational climate, knowledge sharing will occur more easily. This can be established through personal contact, inter-relationships and networking. In a climate of trust, employees share their knowledge with the belief that this knowledge will be used by others or that action will be taken based upon it (Homans, 1961). For instance, data team members may share their knowledge based on the belief that this knowledge will be used to better the school in terms of enhancing data use or solving the educational problem. A climate of trust also implies that employees can openly discuss things without the fear of repercussions, and that knowledge sharing occurs for improvement purposes.

2.6.1.3 The use of technology

According to Lin (2007), knowledge sharing is frequently linked to the use of technology. Technology-based systems can facilitate knowledge sharing (Bartol & Srivastava, 2002), as it enables rapid search, access and retrieval of knowledge and can support communication and collaboration among employees (Lin, 2007). The use of technology can ensure new methods and applications for knowledge sharing, such as groupware, online databases, intranet, and virtual communities. Moreover, according to Yeh, Lai and Ho (2006), it can provide communication channels for obtaining knowledge and identifying the location of knowledge owners and requesters.

2.6.2 Individual factors

According to Wang and Noe (2010) only a few studies have empirically examined the role of individual personality or dispositions in knowledge sharing. Still, research has indicated that motivation

plays a key role in knowledge sharing. Also, a sense of responsibility and having the necessary skills for knowledge sharing are acknowledged as influencing factors for knowledge sharing by an individual.

2.6.2.1 Motivation

Several researchers have focused on the influence of individual motivation on knowledge sharing (Hendriks, 1999; Hew & Hara, 2007; Lin, 2005; Lin, 2007; Wang & Noe, 2010; Wasko & Faraj, 2005). According to Stenmark (2001), people are not likely to share knowledge without strong motivation. Motivation is defined as the process that initiates, guides and maintains goal-oriented behaviour, such as knowledge sharing. In knowledge sharing literature, several motivational factors can be found. For instance, Lin (2005) found that the enjoyment in helping others, was significantly associated with employee knowledge sharing intentions. According to Lin (2007), motivation can be divided between intrinsic and extrinsic motivation. Extrinsic motivation focuses on the goal-driven reasons (e.g. rewards or benefits earned when performing an activity), while intrinsic motivation indicates the pleasure and inherent satisfaction derived from a specific activity (Ryan & Deci, 2000). Extrinsic motivation to share knowledge include the perceived costs of knowledge sharing (e.g. time and effort), or perceived gains of knowledge sharing (e.g. organizational rewards such as praise). Intrinsic motivation refers to knowledge sharing out of interest, or for the pleasure and satisfaction derived from the experience. For example, through knowledge sharing, employees can be satisfied by enhancing their knowledge confidence in their ability to provide knowledge that is useful to the organization (Lin, 2007).

2.6.2.2 Sense of responsibility

Hendriks (1999) found that a knowledge owner shares knowledge because of a sense of responsibility. In his empirical research, respondents were asked to indicate influencing factors for them sharing knowledge, a sense of responsibility was found to be one of the strongest factors influencing the willingness for knowledge sharing. According to Cabrera, Collins and Salgado (2006), the degree to which an individual shares knowledge is related to the degree of responsibility that is felt for one's work. Employees who feel a high level of responsibility will search for more efficient ways to do their job and one way to do this is sharing knowledge with colleagues. According to Constant, Sproull and Kiesler (1996), this is facilitated by a sense of obligation to the organization.

2.6.2.3 Skills for knowledge sharing

According to Yang and Wan (2004), the lack of knowledge sharing skills is a major obstacle for knowledge sharing. According to Williams (2006), someone who shares knowledge should have social skills to share his or her knowledge with colleagues. These social skills include being able to communicate with others, being able to collaborate, and being able to present the knowledge in a way that it is understandable for others (Buckman, 2004). For example, when sharing knowledge on the educational problem in a PowerPoint presentation, data team members need communicating skills in order to present and explain it. When data team members share knowledge on data use, this requires a certain amount of data literacy skills and research skills, in order to explain it in such a way that colleagues can understand it. Many Dutch school leaders and teachers lack these skills (Visscher & Ehren, 2011). Although, the data team procedure is aimed at providing teachers and school leaders with research skills and skills in data use, the present study did not provide insight in how skilled data team members are, mainly in their own perception on the subject. Unfamiliarity with the subject that has to be shared was found to be one of the most frequently cited reasons for not sharing knowledge (Hew & Hara,

2007). Also, when employees do not master a subject, it is hard for them to explain it to their peers (Wang & Noe, 2010). Summarizing, data team members who believe they are not familiar enough with data use, or lacking enough skills, may be less inclined to share knowledge on data us, because they feel they cannot explain it to others because they do not master data use themselves.

2.6.3 Knowledge factors

Next to factors in the organizational and individual context, influencing factors have also been identified in the context of knowledge. The articulability, the existing knowledge base and the anticipation of the value of knowledge were found to be influential for knowledge sharing.

2.6.3.1 Articulability of knowledge

Data team members can share different types of knowledge, the extent to which this knowledge can be verbalized, written, drawn or otherwise articulated influences the success of knowledge sharing (Bresman, Birkinshaw, & Nobel, 1999). When knowledge is poorly articulated, the receiver will have more difficulty understanding it. Also, some knowledge is hard to explain to others, and individuals know more than they can explain, because they possess certain knowledge that is non-verbalized, intuitive and unarticulated (Polyani, 1966). According to Cummings and Teng (2003), articulable knowledge, which is easily explained to others, is easier to share than knowledge that is difficult to explain.

2.6.3.2 Existing knowledge base

It has been found that, for knowledge sharing to take place, the knowledge distance or 'gap' between two parties cannot be too great (Cummings & Teng, 2003). The knowledge distance is the degree to which the knowledge sharer and recipient possess similar knowledge. The reason that this gap cannot be too large, is that too many learning steps will be required in order for the receiver to attach meaning to the shared knowledge. It is believed that overlapping areas of expertise between sharer and recipient facilitate knowledge sharing (Nonaka and Takeuchi, 1995).

2.6.3.3 Value of knowledge

The perceived value of knowledge influences knowledge sharing. According to Cummings and Teng (2003) employees will be more likely to share knowledge when they believe this knowledge is of great significance, because it may benefit the organization or the employees. For example, if data team members strongly believe their knowledge on the educational problem will help solve the problem, they will be more inclined to share this knowledge. Also, Cummings and Teng (2003) stated that employees will be more interested to receive knowledge when they believe it to be valuable. For example, when non-data team members believe the data teams' knowledge on data use may improve the school, they will be more interested in this knowledge, because they perceive this knowledge as valuable to the organization.

The aforementioned organizational, individual, and knowledge factors can mutually influence each other. For example, management may use an intranet to encourage teachers to put useful information for others on the intranet. Teachers can also use such technologies for features to help them articulate their knowledge. However, the present study only focussed on the association between these factors and knowledge sharing, and not on how these factors might influence each other. The model of influencing factors is a representation of hypothesized influential factors, acknowledging that additional factors may also proof to be influential in the knowledge sharing process.

3. Method

To explore knowledge sharing between data team members and their colleagues a qualitative case study design was used. Four case studies were conducted, each consisting of a data team and several non-data team members of the same school. The participating organizations were part of a large scale study on data teams, conducted by the University of Twente. Although data from only four organizations do not permit extensive generalizations of the findings, they offered meaningful insight into the real life context of knowledge sharing between data teams and their colleagues.

This section will start by discussing the Dutch context of the present study. Subsequently, the respondents, the data collection and instrumentation will be described. Thereafter, the data analysis will be explained. Finally, the quality of this study in terms of reliability and validity will be discussed.

3.1 The Dutch context

Dutch schools traditionally have considerable autonomy, regarding the religious ideological and pedagogical principles on which they base their education (Schildkamp & Kuiper, 2010). This plays an important role in data-informed decision making, because teachers and school leaders need to have a certain amount of autonomy to make decisions based on data (Schildkamp et al., 2012b).

However, schools are still held accountable for students' results and the overall schools' achievements. The Netherlands have an inspectorate, which holds schools accountable for the education they provide. Inspection reports are publicly accessible. This context may influence which data the data teams uses (Schildkamp & Kuiper, 2010). For example, school inspections are based on quality assurance and school self-evaluation data (Handelzalts & Schildkamp, 2012). Thus when data teams use particular data that will paint a pretty picture of the school, instead of a real overview of its status, school inspection reports will be influenced to benefit the school.

Moreover, in The Netherlands, most teachers and school leaders do not possess the knowledge and skills needed to collect, analyse, interpret and use data (Schildkamp & Kuiper, 2010; Ledoux, Blok, Boogaard, & Krüger , 2009). Also, teachers in the Netherlands often do not collaborate with each other, and feel that their primary task is teaching, and this does not include the use of data (Schildkamp, 2007), or sharing knowledge on data use The lack of necessary knowledge, skills, collaboration, and feeling of responsibility are identified as hindering factors for knowledge sharing in the previous paragraphs.

3.2 Respondents

In the present study, four schools participated. These schools were selected based on their participation in the data teams' project of the University of Twente.[2] According to Hendriks (1999), knowledge sharing contains both the provision and receipt of knowledge. To gain insight in this bilateral process, respondents included both data team members and non-data team members, see Table 1. Of each school, all data team members were selected to participate, in order to gain full insight into the provision of knowledge sharing. Of each school, several non-data team members were selected to gain insight into the receipt of knowledge sharing by the data team. The sample of non-data team members was based on voluntary participation. Within each school, an email was sent to colleagues of the data team members,

[2] For more information on the selection procedure, please contact supervisors of the data teams project at the University of Twente.

asking them to participate in the present study. Several colleagues replied this email. In each case three to four respondents were randomly selected, based on their availability during the data collection period.

Table 1. *Number of respondents*

Respondents		Case A	Case B	Case C	Case D
Data team members	(Assistant) School leaders	1	3	1	1
	Teachers	5	5	5	5
	Administrative staff	1	0	0	0
Total		7	8	6	6
Non-data team members	Teachers	4	3	3	3
Total		4	3	3	3

All participating schools are organized according to the same religion, namely Protestant Christian. The first participating school (A) is a school with one location, with a pre-university educational track (VWO), a senior general education track (HAVO), as well as a preparatory vocational education track (VMBO). The school has approximately 1300 students.

The second school (B) is part of a school cluster (group of schools providing secondary education in a particular geographical area). The school has four locations, from which two participated in the present study. The first location is a school with approximately 550 students, the second with approximately 500 students. Both locations have a preparatory vocational education track (VMBO).[3]

The third school (C) is a school with three locations in two cities. One location participated. The location has approximately 1200 students and a pre-university educational track (VWO) and a senior general education track (HAVO).

The fourth school (D) is a school with four locations in four cities, all four locations participated. The first location has approximately 1375 students together, the second has approximately 520 students, the third has approximately 250 students, and the fourth location has approximately 220 students. All locations are schools with a pre-university educational track (VWO), a senior general education track (HAVO), and a preparatory vocational education track (VMBO). [3]

3.3 Data collection and instrumentation

Data were collected by conducting interviews and collecting artifacts. This combination allows to not only rely on verbal responses on knowledge sharing related questions, but also on documentation wherein knowledge was shared. This section will further discuss the interviews and the collection of artifacts analysed in the present study.

[3] As all locations are represented by the individual data team members.

3.3.1 Data team interviews

In cases A, B, and C all data team members were interviewed to gain insight into the provision of knowledge sharing by the data team. In case D, seven of the eight data team members were interviewed. One data team member was excluded in the present study, due to her maternity leave. The semi-structured interview schedule was developed based on the theoretical framework. To answer the first research question, questions were posed on how was shared between data team members and their colleagues. For example: 'in what way do you share knowledge with your non- data team colleagues?'. To answer the second research question, questions were posed on what type of knowledge was shared by data team members. For example: 'what knowledge have you shared with your non- data team colleagues?'. To answer the third research question, the interviews focused on influencing factors for knowledge sharing. For example: 'what makes it easy or difficult to share knowledge with your non- data team colleagues?'.

The interview schedule of data team members has been pilot-tested on a small scale. One school participating in the data teams' project was selected based on availability and proximity. Together with a researcher of the University of Twente, these interviews were conducted and recorded to analyse the difficulty of the questions. It was found that several questions were too difficult to answer, so these questions were refined.

The interviews took place approximately eight to nine months after the data team had started. The duration differed between approximately 25 and 90 minutes. Interviews were summarized and sent to all participants with the question to reply if they did not agree with the content of the summary (member check). Member checking is a technique that consists of testing with informants the researcher's data and respondents' interpretations (Lincoln & Guba, 1985). This strategy of revealing research materials to the informants ensured that the researcher had accurately translated the informants' viewpoints into data (Krefting, 1991). All respondents agreed with the summary, some actively by approving the summary, others passively, by the omission of adjustments.

3.3.2 Non-data team interviews

Within each case, several non-data team members were interviewed to gain insight into the receipt of knowledge sharing by the data team. Triangulation of respondents (e.g. interviewing both data team members and non-data team members) allowed thorough analysis of knowledge sharing, which according to Hendriks (1999) entails both the provision and receipt of knowledge sharing. The semi-structured interview schedule was developed based on the theoretical framework. Questions were similar to the questions for the data team members. Questions were posed on: how knowledge was shared between data team members and non-data team members, whether knowledge was shared on data use or knowledge on the educational problem, and what respondents believed to be stimulating or hindering factors for knowledge sharing in their school (e.g. the influencing factors).

The interviews took place approximately eight to nine months after the data team had started. The duration differed between approximately 15 and 45 minutes. Interviews were summarized and sent to all participants with the question to reply if they did not agree with the content of the summary (member check). All respondents agreed with the summary, some actively by approving the summary, others passively by the omission of adjustments.

3.3.3 Collection of artifacts

Within each case, artifacts were collected from data team members and non-data team members. According to Halverson (2004), artifacts are creations or tools used to serve as occasions to document knowledge in the organizational context. They can establish structures for shaping social interactions, work practices, and learning in schools. For instance, artifacts such as assessments and professional development programs are used to improve student learning, and newsletters and public meetings can be used to enhance school-community relations. Data teams can develop such artifacts as a result of their work (e.g. knowledge on data use), and subsequently use them to complete their work (e.g. solving the educational problem). Data teams can create spread sheets, newsletters, PowerPoint presentation slides, programs, procedures and plans during the data team procedure, with the goal of sharing this knowledge with their colleagues. Data teams were asked to provide all artifacts they created and shared within the school. Non-data team members were asked to provide all artifacts they had received from the data team. This provided insight into how knowledge was shared and what types of knowledge were shared between data team members and non-data team members and the congruence between the provision and receipt of knowledge.

3.4 Data analysis

Qualitative data from the interviews were transcribed verbatim. Due to time constraints, not all interviews were transcribed from case B. Three of the eight interviews were transcribed. The remaining five interviews were analysed without transcripts, using the member check and the audio recording of the interviews. The transcripts were analysed, using Atlas.ti. An a priori coding schedule was applied, based on the theoretical framework and the research questions.

Regarding how knowledge was shared, first the organizational level of knowledge sharing was coded, distinguishing between and individual and team level. Second, the moment of knowledge sharing was coded, distinguishing between a formal and informal moment. Third, the medium used for knowledge sharing was coded, distinguishing between verbal knowledge sharing, or knowledge sharing by hardcopy, email or presentation technologies, such as PowerPoint or other technology features. All codes on how knowledge was shared also distinguished the type of knowledge that was shared, namely on data use in general and/or on the educational problem. Regarding the influencing factors in knowledge sharing between data team members and their colleagues, we coded the organizational culture, individual factors and knowledge factors.

After an initial round of coding a sample of the data, the coding schedule was refined. Additional codes were added for non-data team respondents. Initial codes proved insufficient in analysing the following topics: if non-data team members were able to identify the data team members, if they were aware of the educational problem the data team was analysing and whether they wished to receive certain knowledge of data team members. The topics were coded to provide insight in their ability to recollect who the data team members were, what the educational problem was, and their own personal interest in knowledge of the data team. Relations between these topics may provide us with insight on the receiving end of knowledge sharing by data team members.

Artifacts were analysed by using an a priori checklist, focused on identifying how knowledge was shared, which medium was used, and what type of knowledge was shared in these artifacts. After coding and analysing the artifacts, a detailed report of each case was developed forming within-case analysis,

including a summary of how knowledge was shared, what types of knowledge were shared and what influencing factors were identified.

Furthermore, a cross-case analysis was conducted by comparing all cases on each element of the theoretical framework. With these comparisons, several similarities and differences were identified that provided further insight in the process of knowledge sharing by the data teams. This resulted in cross-case thick descriptions and a description of the congruence with the theoretical framework (Poortman & Schildkamp, 2012). These analytical methods are consistent with a cross-case synthesis approach in which each case is analysed separately for relevant themes and results are also compared across cases.

3.5 Reliability and validity

In the present study reliability was fostered by using a systematic approach to data collection that is consistent with the research questions (Riege, 2003), based on the theoretical framework. A protocol was used for the data collection method and the instruments. During the data collection reliability was enhanced by audiotaping all the interviews, thereby allowing thorough analysis. After the data analysis, the inter-rater reliability was computed for reliability purposes, Cohen's Kappa was 0.87. Misrepresentation and misinterpretation of interviewees' statements were avoided by member-checking based on a summary of the interview (Onwuegbuzie & Leech, 2007). Moreover, reliability and construct validity were enhanced by using multiple sources of evidence (Yin, 2003), namely triangulation of respondents (e.g. interviewing data team members and non-data team members) and triangulation of instrumentation (e.g. using interviews and artifacts). Internal validity was enhanced by highlighting major patterns of similarities and differences between respondents' experiences and beliefs in one table (Poortman & Schildkamp, 2012). External validity was enhanced by providing case-specific and cross-case analysis (Babbie, 2007; Creswell, 2009; Yin, 2003).

4. Results: Within case analysis

Each case will be described in detail, summarizing how knowledge was shared, what types of knowledge were shared and the influencing factors for knowledge sharing. Data were analysed from the collected artifacts, the interviews with data team members and the interviews with non-data team members[4]. Upon starting with the data team procedure, data teams in all cases, send an email to their colleagues. This email was designed by the University of Twente, to ensure that the presence of the data team was properly announced in the school. It included short descriptions on data-informed decision making and the participation of the school in the data teams' project of the university. It stated that 'the data team was a small research team of teachers, guided by the school leader, that would solve educational problems with the use of available data, such as rapport cards, questionnaires and observations'. This email is only mentioned when the data team adjusted this email in some form.

4.1 Results case A

4.1.1 Background

In case A, the data team focused on the problem of students repeating grades in the senior general secondary education track (HAVO). The data team consisted of seven members. Four non-data team respondents participated in this study.

4.1.2 How different types of knowledge are shared

Artifacts

During the first eight to nine months of using the data team procedure, the data team formally shared their knowledge with their colleagues. Upon starting with the data team procedure, the data team send an email to their colleagues[5]. They used this email to introduce themselves, by mentioning the individual data team members.

In the second half of the school year, the data team issued a newsletter with the title: 'a short introduction to the data team procedure'. This newsletter was used for several reasons. First, to announce their upcoming workshop for staff members at the end of the school year. Stating that they were hoping to organize a workshop to share their knowledge on data-informed decision making and ensure further distribution of data-informed decision making in the school. The exact content and structure of this workshop was not specified. Second, to briefly explain data use and the data team procedure by giving examples of types of data and numerating the eight steps of the data team procedure. For example, it stated that 'the term data should be conceived less limited than just in terms of figures and numbers. Class observations and questionnaires could also be used as data'. Only the sixth step of the data team procedure (e.g. interpretation and conclusion phase) was further explained to highlight the extensiveness and thoroughness of the entire process. The data team stated they wanted to highlight this step, explaining that 'this step prevents us from taking measures to overlook the cause of the problem, while in reality this is not the actual cause of the problem'. Third, this newsletter was used to share the educational problem they were working on and their progress throughout the year. It was stated that the data team studied student examination grades. And that the standard deviation was used. Fourth, to ask feedback, by asking

[4] To distinguish these different respondents, the following abbreviations will be used: DM, to indicate a data team respondent and ND for a non-data team respondent.
[5] Standard email designed by the University of Twente.

colleagues to send emails on what they believed to be possible causes of their problem. The aforementioned artifacts were collected from the data team. None of the non-data team respondents were able to provide artifacts which they had received by the data team.

Data team members

During the interviews, all data team members mentioned some form of knowledge sharing. Surprisingly, when asked if they had shared their knowledge with colleagues in the beginning of the interview, five data team members literally stated that they had not shared knowledge with their colleagues at this point. Only after further questioning, for example on whether knowledge was shared during meetings, they could recollect that they had indeed shared knowledge. These five members also stated that knowledge sharing was a 'weak spot' or expressed the wish to do this more in the future. For example, Linda stated 'at this time, the data team does not share knowledge, because we are not at that point in our process, we have no concrete results'. Still, Linda also mentioned to have had conversations during the coffee break about the educational problem and what the data team was researching at that point. Linda stated that she used these conversations as input for forming new hypotheses.

At the individual level, four members of the data team claimed they had informal conversations with their colleagues, wherein knowledge was shared on the educational problem, such as the problem statement and hypothesized causes of the problem. For example, Robert stated he talked to one colleague about the problem statement to get input on what this colleague believed to be the cause of the problem. Results provided no further insight on the frequency of these types of conversations. Two other data team members also stated that they had engaged in informal conversations with colleagues about the data team, but they could not remember exactly what was discussed in this setting or what type of knowledge was shared. Another data team member, Mary, stated the data team agreed to only share knowledge formally as a whole. She was the only data team member who mentioned this agreement and also the only member who did not share knowledge informally.

At the team level, the data team used their artifacts to formally share knowledge with their colleagues. Not all data team members mentioned using these artifacts. For example only four members mentioned sharing knowledge with a newsletter, of which only Mary described the type of knowledge that was shared, stating 'we shared knowledge on the steps of the data team procedure in a newsletter'. Patricia and John stated that Mary published something in the newsletter, but they did not know what knowledge was shared. Also, only Mary mentioned sharing knowledge during meetings. She stated to have shared tentative results of their analysis during management meetings. She stated 'I believed we were on to something when we gained significant results with our chi-squared test, so I shared this'.

Non-data team members

All non-data team respondents were unable to identify all members of the data team; all respondents expressed a certain amount of uncertainty on this subject. Four respondents correctly identified at least one data team member. Only Donald was able to correctly describe what educational problem the data team was working on, stating 'they looked at the problem of students repeating grades'.

Kenneth and Helen stated that the data team was mentioned during a team meeting. They vaguely recollected that it was mentioned that a data team was active in the school. Only Helen mentioned that, during the staff meeting of her department, the data team shared their knowledge on data use in general,

stating that ‘in the meeting, Mary (DM) talked about the use of the standard deviation and what we can do with our own data. We had to look at our own results, you know, grades and the overall average’.

Donald, Kenneth and George mentioned talking to a data team member about the educational problem during non- scheduled social time. They did not mention how often these conversations took place. Donald stated ‘it was mentioned that they researched something, but that data rejected their statements’. He also mentioned reading about the schools’ retention rates. Overall, the non-data team respondents mentioned more knowledge sharing on the educational problem. Only Helen mentioned the data team shared knowledge on the use of data.

4.1.3 Influencing factors

This paragraph will describe the influencing factors for knowledge sharing by the data team, based on interviews with data team members and interviews with non-data team members.

Individual factors

Two data team members believed it was not their *responsibility* to share knowledge. Robert believed it was not necessarily important to share knowledge with colleagues, it was more important that management received their results. After further questioning, Robert stated that although not necessary, the data team could share their starting point and results with colleagues. Still he believed it was the responsibility of management to share knowledge, not the responsibility of the data team.

Organizational culture

All data team members expressed their *trust* in management to act upon their recommendations, indicating a climate of trust. Four data team members did not believe that staff would act upon their knowledge at this time, because they believed colleagues did not read the documents wherein knowledge was shared by the data team. Linda talked about the fact that although knowledge can be shared in documents or emails, colleagues do not internalize this knowledge, because they do not read these documents. Of the non-data team members, Kenneth stated that he believed the organization to be ‘honest, transparent and open’. Of the non-data team members, Donald explained that ‘units do not openly share knowledge with each other’, but the respondent did not explain this further.

One data team member stated that he did not share knowledge because he did not have the time to do so, the respondent did not state whether time was not facilitated by management. Another member, Barbara, did mention that the *management did not provide sufficient time* to share knowledge, stating ‘in the past all teams gathered once a month, unfortunately these meetings were cancelled. Thus, an important platform for knowledge sharing was eliminated by management’. Of the non-data team respondents, Donald confirmed this, stating that: ‘management wants us to do things differently, but does not provide the time to do so’. Helen (NDM) also claimed the unavailability of time to influence knowledge sharing.

Two data team members mentioned that *technology* could help to share more knowledge in the future. Of the non-data team members, George mentioned that the school has sufficient means to share knowledge, for example technologies such as Magister (e.g. the schools’ digital student tracking system), can promote knowledge sharing in school. This technology is easily accessible for the entire staff, and messages can be placed within this system.

Knowledge factors

Of the data team, John stated that it is hard to share knowledge on data use with colleagues, because they lack the knowledge in statistics, claiming that 'the results of a chi-square test would not be understood by most colleagues'. Thus the gap between data teams' knowledge and the *existing knowledge base* was perceived to be too significant. According to Robert and James, the level of knowledge and skills of colleagues on data use is hindering the data team to share knowledge on this subject, because 'colleagues will not understand what has been researched and how'. Thus, they claim, it is better to just share the data teams' results and conclusions instead of the entire research process.

4.2 Results case B

4.2.1 Background

In case B, the data team focused on the problem of students repeating grades in the preparatory vocational education track (VMBO). The data team consisted of eight members. Three non-data team respondents participated in this study.

4.2.2 How different types of knowledge are shared

Artifacts

During the first eight to nine months of using the data team procedure, the data team formally shared their knowledge with their colleagues, using several artifacts. First, an email[6] was sent to all colleagues, which was distributed in both locations[7], in alternate forms. In location B1, the newsletter announced the presence of the data team, stated who the data team members were, explained in short the data team procedure, and the educational problem (e.g. students repeating grades) they were working on. The problem was defined as 'we are not satisfied with the number of students repeating grades. Students do not reach the educational level that is expected, we want to improve our inspection reports'. In location B2, the newsletter announced that a data team would start, and shortly explained what this entailed. Stating that 'a data team is a small research team of teachers and school leaders that learn how to solve educational problems with the use of available data, such as grades, questionnaires and observations'. Location B1 also used two additional school newsletters to announce the upcoming questionnaire of the university.

Thereafter, the data team gave a staff presentation in both locations about: the data team procedure, their problem statement, their data collection and analysis in short and their overall progress and tentative results. This was done based on the analysis of the first hypothesis, describing in detail how the data team performed each step in the data team procedure. The analysed hypothesis was 'we believe that students who cannot be retained at the educational track have a significant lower Cito score than students who can be retained at the educational track'. The presentation stated that data was collected on Cito scores of all students in the past three years. Also, slight alternations can be found between the presentation of the first and the second location. The presentation of location B1 focused more on the exact activities of the data team, providing descriptions of actions undertaken by the data team in the first six steps of the data team procedure, and explaining that after the rejection of the first hypotheses, the process needed to be repeated with a second hypothesis. This presentation started with a slide showing the figure of the data team procedure, see Figure 1. Next, step 1-6 was described. For example, one slide stated their activities in step 4, stating 'we noted that the quality of our data was sometimes poor, of some students we did not have Cito scores, also the numbers of students was small'. The presentation of location B2 provided less detail on the steps of the data team procedure. It included a description of what general data analysis entailed, stating that 'it has to do with: quality care, data-informed decision making and conducting reliable research'. The presentation of location B2 was also used to introduce the data team members, which the presentation of the location B1 did not. The aforementioned artifacts were

[6] Standard email designed by the University of Twente.
[7] To distinguish these locations, the following abbreviations will be used: B1, to indicate the first location, and B2 to indicate the second location as described in the respondents section.

collected from the data team. None of the non-data team respondents were able to provide artifacts which they had received by the data team.

Data team members

Although all data team members reported some form of knowledge sharing, overall, they could mention few moments wherein knowledge sharing had taken place. William, Elizabeth, Charles and David mentioned both types of knowledge were shared in a presentation. Charles stated that 'in the very beginning we decided what problem we wanted to work on, and shared this with staff. Later we presented the steps we had taken and what our hypotheses were, we shared this with staff during a presentation'.

At the individual level, five data team members mentioned having informal conversation with colleagues about the activities of the data team. They did not specify what type of knowledge was shared, but more generally that they talked about the activities of the data team.

At the team level, six data team members mentioned knowledge was shared in a presentation. Charles stated 'in the very beginning we decided what problem we wanted to work on, and shared this with staff. Later we presented the steps we had taken and what our hypotheses were'. Two data team members mentioned knowledge sharing in a newsletter, but they did not clarify what type of knowledge was shared. Only Charles mentioned that the data team placed a blank flap-over in the staff room, so that colleagues could help to brainstorm on possible causes of the educational problem. Also, only Jennifer mentioned sharing knowledge during team meetings. She stated 'I explained more on the use of data and the importance of analysing your own results'.

Non-data team members

All non-data team members were unable to identify all members of the data team; all respondents expressed a certain amount of uncertainty on this subject. All three respondents correctly identified at least one data team member. Sandra was surprised to hear during the interview, that some of her close colleagues were members of the data team, because they had never mentioned this. None of the respondents were able to describe the educational problem the data team was working on, giving vague descriptions such as Edward, who stated 'they are trying to improve the quality of our education'.

Of the non-data team members, Sandra stated that she had only read something about the data team in the newsletter, which stated that a data team meeting was scheduled for the upcoming week. According to Sandra, no knowledge was shared. She even had to ask a colleague what a data team was. Coincidentally, this colleague was a data team member, who shortly explained to her what a data team was. Both Edward and Steven mentioned that the data team shared their knowledge during a full staff meeting. Edward stated that 'David (DM) explained in his presentation how they work and what they have to evaluate. He explained they had to go back to the first step because their research questions were incorrect. At that moment it was all very clear, but it didn't quite stick'. Both Edward and Steven also mentioned that they were given frequent updates on the data teams' activities, by their team leader during unit meetings. They did not specify what was shared in these updates.

Only Steven mentioned informal knowledge sharing, stating 'I talked to David (DM) on the phone last night, because, I have difficulty formulating research questions and goals for my own studies. I quite often talk to David about this. He explained me how to do this, which he himself learned on a data

team seminar'. Overall, non-data team members only mentioned knowledge being shared on the educational problem.

Of the non-data team respondents, Steven mentioned more moments wherein knowledge was shared. He also stated that he would like to become a member of the data team, because then all units would be represented in the data team. He believed a representation of all units was important, but did not explain this further. He did state 'I have certain ideas and I see myself working with them'.

4.2.3 Influencing factors

Individual factors

Of the data team members, Elizabeth mentioned that if she was asked to share knowledge on data use, she would not have the *skills* to do this. She stated 'if people ask me, for example, how we gathered our data, I would not be able to answer this question'.

Organizational culture

Three data team members expressed that they *trusted* management to act upon their results. Also one of these members stated that the school had a climate wherein things could easily be discussed. This indicated that the climate of trust promoted knowledge sharing.

Of the data team members, Richard mentioned that enough *time was facilitated by management* to share knowledge. He stated that group sessions or large meetings were organized on a regular basis. The data team would 'claim a certain amount of time and this was always given'. This indicated that the support by management promoted knowledge sharing.

Unforeseen factors

In this case, several unforeseen influencing factors were mentioned by respondents. One data team member claimed there was a tension between transparency and the *sensitivity of data*, explaining that it was considered to be confronting to get feedback on ones' functioning. This was confirmed by a non-data team member, Edward. He stated that it is sometimes hard to be confronted with hard numbers on your own functioning. He did not trust all data team members to do this in a proper way, stating 'I believe a trustworthy person should do this'.

Two data team members mentioned that *close personal relations* promoted them to share knowledge with colleagues. For instance, Jennifer stated 'knowledge sharing is promoted when you have close personal relations with colleagues, because it makes it easier to have interesting discussions'.

Also, of the data team members, David, Michael and Elizabeth, believed that the amount of *interest* of their colleagues hindered knowledge sharing. Elizabeth stated that 'people do not read documents, people are tired of change, so they are not receptive of new information'. Whether this was due to the anticipated value of knowledge was not mentioned.

Of the non-data team members, Steven mentioned that in the organization *communication* is sometimes faulty. Sometimes people receive information too late, or not at all. According to Steven this results in friction between colleagues, which could easily be prevented.

4.3 Results case C

4.3.1 Background

In case C, the data team focused on the problem of student retention rates in the pre-university educational track (VWO). The data team consisted of six members. Three non-data team respondents participated in this study.

4.3.2 How different types of knowledge are shared

Artifacts

During the first eight to nine months of using the data team procedure, the data team formally shared their knowledge with their colleagues. Upon starting with the data team procedure, the data team placed a blank flap-over in the staff room. Teachers were given the opportunity to write down what they believed was the cause of the educational problem. The purpose was to gain insight on colleagues' perspectives of the underlying causes of their problem.

Several months later, the schools' newsletter was used to ensure colleagues that their contributions would be investigated during the next data team meeting. All statements written down on the flap-over were summarized. For example, colleagues believed the problem was caused by changing parent participation. Also, the school board used the newsletter to announce that colleagues would be asked to participate in the universities' research, by filling in the issued questionnaire[8], during their next unit meeting. Explaining that the university conducted on-going research on the functioning, effects and sustainability of the data teams and provided their data team with support in data use. Furthermore, during a staff meeting the data team presented the results of the questionnaire on data-informed decision making in the school. In their PowerPoint presentation, the data team also explained more on the use of data, describing results on the questionnaire on data-informed decision making in the school. The perceived accessibility of certain data, the usefulness of data and the quality of data in the school. Also, the data team procedure, their first hypothesis and their tentative results were highlighted. Their hypothesis was: 'students who cannot be retained at the pre-university educational track have a significant lower Cito score than students who can be retained at the pre-university track'. One sheet displayed results on their analysis of Cito scores. Also, the data team announced the second hypothesis to be researched. Stating 'students who cannot be retained at the pre-university educational track have significant lower grades than students who can be retained at the pre-university track'. The aforementioned artifacts were collected from the data team. None of the non-data team respondents were able to provide artifacts which they had received by the data team.

Data team members

According to all the data team members, knowledge was shared at the team level, during formal structured meetings, such as the monthly unit meeting. According to Maria, this knowledge entailed their tentative results of analysed Cito scores. Other members did not specify what exact knowledge was shared, stating they had presented something on their results. Only Susan mentioned that knowledge was also shared on data use. According to Susan, data use and the data team procedure was explained in the PowerPoint presentation. At the individual level, both Thomas and Dorothy stated they had shared their knowledge during an informal conversation. They did not mention which type of knowledge was shared.

[8] Questionnaire issued by the University of Twente to gain insight into data-informed decision making at the school.

Overall, data team members expressed to purposely share knowledge. Margareth stated 'we purposely updated staff, even though we had no tentative results. Staff should know what we are doing, and that we continuously do this'. According to Margareth, when forming the data team, the school purposely tried to form a good representation of all units in the school, so that each member could share his or her knowledge with his nearest colleagues, anticipating the importance of knowledge sharing. According to her, this enhanced involvement of non-data team members. According to Chris, sharing knowledge was important, because only then colleagues knew, if they were interested, who they could approach to gain more knowledge on data use or the educational problem. Still, Thomas believed the data team should limit knowledge sharing for the moment, because there were no concrete results at this point.

Non-data team members

All non-data team respondents were unable to identify all members of the data team. All three respondents correctly identified at least one data team member, all respondents expressed a certain amount of uncertainty on this subject. All respondents were able to describe what exact educational problem the data team was working on, namely the problem of student retention rates in the pre-university educational track (VWO). Anthony stated 'they are working on the retention rates of VWO'. Besides being aware of the exact educational problem being investigated, both Brian and Anthony could describe the process of the data teams' analysis, comparable to the actual steps in the data team procedure. Anthony stated 'when problems are detected, the data team collects available data from different areas in the school. Then they use this data to find possible explanations for the educational problem. That way, they can try to solve the problem'.

None of the non-data team members mentioned knowledge being shared in a newsletter. In contrast, all three of the non-data team members mentioned knowledge being shared in unit meetings, two of them mentioned seeing a PowerPoint presentation. Brian stated that 'the presentation was used to explain what the data team was working on and how they operated'. During these meetings, non-data team members mentioned knowledge was shared verbally. According to Brian and Anthony, the data team had given several updates in these meetings. According to Brian, Margareth (DM) regularly updated them on what the data team was working on and how they approached the problem. The data team was even a specific point on the agenda in these meetings. Brian expressed to be satisfied with the way knowledge is shared in these units. He explained that 'because when knowledge is shared in a larger setting, a lot of colleagues do not feel addressed, this way they do'. Of the three non-data team members, only Anthony mentioned a flap-over in the staff room, which the data team used to ask feedback on their problem statement. Also, only Ronald mentioned informal knowledge sharing on the educational problem and data use, during a non- scheduled informal conversation with Margareth (DM), He stated that 'they talked about the importance of placing students in the right educational track based on their abilities, and what type of data can be gathered to analyse this further'.

According to the non-data team members, knowledge was mostly shared on the educational problem. Ronald claimed he was not interested in the data team sharing their data analysis, but more in the data teams' results. He believed the results will spark discussion based on content instead of emotions. In contrast, Anthony was interested to get a full report on data analysis, claiming this was not for everyone, but he had a specific interest. Although he trusted the data team to analyse data correctly, he wanted to verify if the right data was used, because in the past school based decisions on the wrong data.

4.3.3 Influencing factors

Individual factors

The influence of the *responsibility* to share was mentioned by two data team members. Maria felt it was her responsibility to share knowledge, because she wanted the school to improve. In contrast, Margareth did not feel responsible for sharing knowledge. She stated that 'because I am also part of management, it is not my place to share knowledge, thus I am a bit reserved in this. I believe the other data team member, the teachers, should share this, because it is their research'.

Also, one data team member, Thomas, mentioned that he lacked the *skills* to share knowledge sometimes. Thomas stated 'it is sometimes difficult to present our result, because question can be asked. I do not have enough knowledge and skills to always answer these questions, thus I find this very difficult. Someone who has more knowledge on data use can easily blow me away'.

Organizational culture

Four of six data team members expressed that the school had a *climate of trust*. All data team members also trusted that management would act upon knowledge shared by the data team. Maria stated 'yes, I trust they will use our finding, because management is open to our suggestions'. Two data team members expressed they trusted colleagues would act upon knowledge being shared and that results would issue action and change in teachers. This was confirmed by non-data team members, Brian and Anthony. Anthony stated 'things can easily be discussed, without fear of repercussions'.

One data team mentioned that the *support of management* influenced knowledge sharing. Management ensured that he was always given time to present new findings during unit meetings, thus providing a platform for knowledge sharing.

Knowledge factors

Non-data team members expressed a certain amount of interest in the data teams' results. Anthony stated that 'in the end, we as a team must know what the plan of action should be, so it is most important to get updated, otherwise, in the end, staff will not know what to expect'. Thus, the anticipated value of the data teams' knowledge enhanced the interest of colleagues.

Unforeseen factors

In this case, one unforeseen influencing factor was mentioned by respondents. Overall, data team members expressed to *purposely share* knowledge, anticipating the importance of the knowledge they possessed. Margareth stated 'we purposely updated staff, even though we had no tentative results. Staff should know what we are doing, and that we continuously do this'. Dorothy stated that they purposely shared knowledge because they believed it to be important that staff knew what their results were, as they could issue change.

4.4 Results case D

4.4.1 Background

In case D, the data team focused on the problem of students retention rates in all educational tracks (VMBO, HAVO and VWO). The data team consisted of seven members. Three non-data team respondents participated in this study.

4.4.2 How different types of knowledge are shared

Artifacts

During the first eight to nine months of using the data team procedure, the data team formally shared their knowledge with their colleagues. The data team issued several special data team newsletters to their colleagues, signed by an individual member of the data team. In the first month of the school year, an email[9] was issued to explain the concept of data-informed decision making and data teams. Also, colleagues' participation was asked in the on-going research of the University of Twente. The first newsletter was issued only one week after the email, repeating the information shared in the email and asking staff to fill in the upcoming questionnaire of the university. The second newsletter was issued two weeks later, also reminding colleagues to fill out the questionnaire of the university. This newsletter also provided a short personal message of one of the data team members. It stated 'last Thursday, we had our first data team meeting, we were given much information on what it entails. Guided by a roadmap, we started with the first step, defining our problem. Many problems were mentioned, and everyone will further contemplate this. Also management was asked to state their preference. In our next meeting we will choose one problem'. The third newsletter, issued only two weeks after the second, was used to remind colleagues to fill out the questionnaire of the university. The fourth newsletter again included a short personal message of one of the data team members, thanking them for participating in the questionnaire.[10] The newsletter also mentioned that the data team started the data team procedure, by defining a problem in the first step. The data team would focus on the problems of disappointing student retention rates. It also stated that in the next meeting, the data team would look at absolute figures of retention, to see if this perceived problem was true and how this could be investigated.

In the second half of the school year, months after the last data team update, the data team issued another newsletter to keep staff updated. This newsletter contained detailed descriptions of the data teams' hypotheses. It stated 'we aim our research at two hypotheses: retention rates are higher for boys then for girls and students who cannot be retained in the third year, have lower Cito scores then students who can be retained'. The newsletter also announced an upcoming presentation of the results. Staff was also asked to fill out the second questionnaire of the university. The aforementioned artifacts were collected from the data team. None of the non-data team respondents were able to provide artifacts which they had received by the data team.

Data team members

At the individual level, only Betty and Nancy mentioned having non-scheduled informal conversations with colleagues about the data teams' activities. Of the two, only Betty could describe in detail what was mentioned during these conversations. Betty stated 'one colleague was interested in the

[9] Standard email designed by the University of Twente.
[10] Questionnaire issued by the University of Twente

differences between boys and girls, so I kept her updated on our results on this subject', referring to Donna (NDM). Betty mentioned that besides her conversations with Donna, she purposely did not mention the data team, because she believed the team should present findings as a whole.

At the team level, all six data team members mentioned using the schools' newsletter to formally share their knowledge with their colleagues. Only Karen gave a description of what was published. Karen stated 'sometimes we published something in the schools' newsletter, for example on what problem we are working on, our hypotheses and problem statement'. Mark questioned if publishing in the newsletter had any effect, because he believed colleagues were not interested in reading about the data teams' activities or even in the school newsletter. Paul believed such newsletters to be useless without further explanation.

Overall, data team members mentioned few knowledge sharing initiatives. Mark expressed there was an impending gap between what the data team does and what colleagues know about it. Only Mark expressed that knowledge sharing should be an important point on the data teams' agenda to ensure more data use in the school.

Non-data team members

Of the three non-data team respondents, two were able to identify two members of the data team, but they were unable to identify all members and expressed a certain amount of uncertainty on this subject. One respondent, Kevin, could not identify any data team member. Also, none of the respondents were able to describe what educational problem the data team was working on.

Only one non-data team member, Donna, mentioned knowledge being shared by the data team. She stated 'I had read something about the data team, so I decided to approach them with my own educational problem. I believed there was a great difference in students' results between boys and girls. The data team analysed this problem and explained their results to me in a conversation and in a report. Their results showed that there was no significant difference in students' results of boys and girls'. Donna did not state what she had read, but she did mention the data team used the schools' newsletter to publish things. According to Donna, since their start, the data team had published something approximately three times, she did not specify what was published.

When asked if the data team members had ever mentioned the data team, all non-data team members stated they never had informal conversation about the data team with the data team members. Also, all non-data team members stated that it was never mentioned during meetings. Kevin did state that Betty asked him to provide her his students' test results and that Mark observed some of his classes. He believed both were related to the activities of the data team, but did not know this for certain.

4.4.3 Influencing factors

Individual factors

Of the data team members, three respondents mentioned it was not their *responsibility* to share knowledge. Mark and Daniel mentioned that another data team member was responsible for knowledge sharing. Karen stated 'I believe that our management is responsible for sharing our results with staff. We as data team members can accompany management to help them explain the results. I do not feel responsible to do this. I could support management in sharing our knowledge. But I believe Paul is a more

appropriate person to do this'. Betty expressed that knowledge was hardly shared because they had no tentative results and did not master the steps of the data team procedure yet.

Organizational culture

Of the data team members, Karen and Daniel stated that they *trusted* management to act upon their results. In contrast, Nancy mentioned that it was unclear how management would use their results, because management had recently issued an improvement measure without acknowledging their recommendations. According to Nancy, all students of a specific grade have been moved to another location, because management believed this would improve retention rates. Nancy explained that 'if they really took the data team seriously, they would not have made this decision, they should have waited on our results on what caused our disappointing retention rates'. Karen stated that overall staff is willing to except statement made by others, stating that 'everyone is in the flow to make changes and to take action to improve things'. In contrast, Paul, Betty and Mark believed that teachers would not act upon the knowledge that was shared. Mark mentioned that teachers are busy with other things and usually place problems beside themselves and are unable to reflect on their own functioning. He stated 'this might prove to be a problem when we share are knowledge on the educational problem. Colleagues avoid knowing more on the cause of our problems, afraid to be forced to reflect on their own functioning'.

Unforeseen factors

In this case, several unforeseen influencing factors were mentioned by respondents. According to data team members Mark, Daniel and Paul, the amount of *interest* of colleagues in the activities of the data team were mentioned as a hindering factor in knowledge sharing. Daniel stated 'we have no control whether colleagues will read what we publish. We are responsible for sending the information, they are responsible for the adoption of information'. One non-data team member confirmed this. Kevin stated that he sometimes does not read his email, so even if the data team had sent him information, he would not have read it. He also mentioned that his focus was solemnly on teaching and that if something was mentioned by the data team, he could probably not remember this. It was unclear whether his lack of interest was due to the perceived value of knowledge by colleagues or due to other influencing factors.

Of the non-data team members, Donna mentioned that 'colleagues are 'allergic' to numbers, this *resistance* may hinder data team members to share their knowledge'. Donna did not explain this further, so it was not clear whether she meant knowledge on data use or knowledge on the educational problem.

5. Results: Cross-case analysis

In this section all cases are compared on each element of the theoretical framework, summarizing how knowledge is shared, what types of knowledge is shared and the influencing factors for knowledge sharing. Relevant themes and differences will be discussed.

5.1 How different types of knowledge are shared

Both formal and informal reports of knowledge sharing were found in all cases, see Table 2. Formal reports included the artifacts and the recollection of these artifacts being used. Informal reports included informal conversation during the coffee break (e.g. case A), and even after hours in a telephone conversation (e.g. case B).

In all cases, the data team used artifacts to share knowledge with staff, both on data use in general and on the educational problem. Overall, data teams used the same means to share their knowledge, namely verbally, or by means of newsletters and presentations. In three cases, the artifacts were also used to ask colleagues' feedback on what they believed to be the underlying cause of the educational problem. All cases used their artifacts, to ask colleagues 'cooperation in the research by the University of Twente by filling in the questionnaires.

Overall, knowledge was mostly shared on the educational problem (e.g. problem statement, hypotheses ad tentative results), see Table 3. In case D, respondents reported to have shared more general knowledge on the activities of the data team, like small updates during team meetings or in the schools' newsletter. Respondents in case D had poor recollection of what type of knowledge was shared in these updates. The analysis of artifacts proved that knowledge was shared on data use in general and the educational problem.

The recollection of knowledge that was shared differed between cases and between respondents. For example, in case A, five of seven data team members stated they had not shared knowledge with their colleagues, even though several artifacts were issued to do so. In contrast, in case C, the data team members were extremely accurate in recollecting how knowledge was shared.

In all cases, knowledge sharing reports of data team members differed from knowledge sharing reports of non-data team members. Only case C differences between these reports were minimal. In contrast in case B, many reports were found of knowledge sharing by the data team members, but one of three non-data team respondents claimed that no knowledge was shared by the data team.

Table 2: *How knowledge is shared*

	Case A		Case B		Case C		Case D	
	Data team members	Non-data team members	Data team Members	Non-data team members	Data team Members	Non-data team members	Data team members	Non-data team members
Formally at the team level	Email Two newsletters Pore recollection of sharing One data team member updated staff during staff meetings	Two NDM mentioned team meetings	Email PowerPoint presentation Newsletters Flap-over Verbally, during formal unit meetings	According to one NDM, no knowledge was shared Presentation during staff meeting One report of newsletter being used Updates during unit meetings	Several newsletters PowerPoint presentation Flap-over in staff room Monthly unit meeting	Unit meetings PowerPoint presentation Flap-over	Email Several newsletters Flap-over Verbally during meetings Presentation	Two NDM reported that no knowledge was shared One report of formal feedback on educational problem
Informally during non-scheduled social time	Several reports	Several reports	Several reports	One report of intensive knowledge sharing during informal conversations	Some reports of informal conversations	One report of an informal conversation	Some reports of informal conversations	Some reports of informal conversations

Table 3: *Types of knowledge*

	Case A		Case B		Case C		Case D	
	Data team members	Non-data team members	Data team members	Non-data team members	Data team members	Non-data team members	Data team members	Non-data team members
Knowledge on the educational problem	Educational problem Problem statement Hypotheses	Educational problem Overall poor recollection	Educational problem Hypotheses Overall poor recollection	According to one NDM, no knowledge was shared Updates on activities of data team	Possible causes of the educational problem Educational problem Tentative results on analysis of Cito scores Second hypothesis	Detailed recollection of problem statement	More general information, like updates on activities Educational problem Hypotheses Problem statement One report of knowledge shared on educational problem of differences between boys and girls	Two reports that no knowledge was shared One report of knowledge shared on educational problem of differences between boys and girls
Knowledge on data use	In short the data team procedure Types of data were briefly explained	One report that the use of standard deviation was explained	In detail the data team procedure Data analysis Quality of data Overall poor recollection	One report that no knowledge was shared One report of on formulating research questions Two reports of knowledge shared on data team procedure	Data-informed decision making in the school Data team procedure	Detailed recollection of steps of data team procedure	Only step 1 of the data team procedure was mentioned	Two reports that no knowledge was shared

5.2 Influencing factors in knowledge sharing

Several influential factors have been identified by respondents, see Table 4. They will be further discussed in the following paragraphs.

5.2.1 Organizational culture

The reports of the influence of management differed between cases. In case A, management did not facilitate the time needed to share knowledge, which hindered data team members. In contrast, data team members in case C were very satisfied with the support of management. Sufficient time was given to share knowledge, which promoted knowledge sharing by the data team members. In case A, B, and C mixed results proved that in fact the openness to discuss data and trust influenced knowledge sharing. Respondents differed in their perception on whether it promoted or hindered knowledge sharing in case A and B. Results of case C proved that it promoted knowledge sharing, as data could be openly discussed. In terms of trust on whether the knowledge would be used, respondents (e.g. case A and C) trusted that management would act upon their results. In case D mixed reports mixed reports were found on the trust of management, one extremely negative report was found by a data team member, stating that management had issued improvement measures, without waiting for the data teams' results or recommendations. Data team members also expressed trust in staff to act upon their results in case A and C. Case D also reported mixed results on this matter. The influence of the use of technology was only mentioned in case A, wherein data team members and a non-data team member believed it could promote knowledge sharing. They stated that technology systems were already in use and that they were easily accessible for the entire staff, messages of the data team could be placed within this system.

5.2.2 Individual factors

Of the hypothesized individual factors, several respondents mentioned a sense of responsibility to influence knowledge sharing. Both in case A and D, two data team members believed it was not their responsibility to share knowledge, stating it was either the responsibility of another data team member or of management. Whether the task of knowledge sharing was not appointed to them by management or whether this was due to other factors was unclear. It was stated that the lack of responsibility did hinder their knowledge sharing. In case C, mixed reports were found of the feeling of responsibility influencing knowledge sharing. Both statements of feeling responsible and not feeling responsible for knowledge sharing were found in this case. Respondents who felt responsible for knowledge sharing stated that they did so because they believed the purpose of knowledge sharing was to improve the school.

5.3.3 Knowledge factors

In case A reports were found wherein data team members stated that it was hard to share knowledge on data use with colleagues, because they lacked the knowledge in statistics, claiming that the results of a chi-square test would not be understood by most colleagues. Thus claiming that the gap between data teams' knowledge and the existing knowledge base was too significant. Thus, according to the data team members, the existing knowledge base hindered knowledge sharing by the data team. The results of interviews with non-data team members could not confirm this, as all respondents mentioned having experience in using data to make informed decisions. In case B, C and D, reports were found of the lack of skills hindering data team members to share knowledge. Stating that, if they were asked to explain data use in more detail, the lacked the skills to do so.

5.2.4 Unforeseen factors

In case B, two non-data team members stated that personal relationships promoted knowledge sharing. Stating that personal relations made it easier to talk about things and have discussions. Also, reports were found that the amount of interest of colleagues influenced knowledge sharing by the data team. In case C, data team members stated that the amount of interest and curiosity promoted them to share more knowledge. Also in this case, non-data team members expressed a certain amount of interest in the data teams' activities. In contrast, data team members of case B and D reported that their colleagues were not interested in the data teams' activities, which hindered them to share their knowledge with them. Data team members in both cases stated that 'colleagues do not read documents, people are tired of change, so they are not receptive of new information'. In case D, this was confirmed by a non-data team respondent. In case C data team members expressed to purposely share knowledge, anticipating the importance or *value of the knowledge* they possess. The non-data team members also expressed a certain amount of interest in the data teams' results due to the anticipation of the value of knowledge. Anthony stated that 'in the end, we as a team must know what the plan of action should be, so it is most important to get updated, otherwise, in the end, staff will not know what to expect'. In other cases, the anticipated value of knowledge was not mentioned to promote knowledge sharing.

Table 4: *Factors influencing knowledge sharing*

	Case A		Case B		Case C		Case D	
	Data team members	Non-data team members	Data team Members	Non-data team members	Data team Members	Non-data team members	Data team members	Non-data team members
Management support	Several reports that management did not provide sufficient time	Several reports that management did not provide sufficient time	One report of time being facilitated by management to share knowledge		One report of time being facilitated by management to share knowledge			
Climate of trust	All members trusted that their knowledge would be used by management	One report of openness, honesty and transparency One report of units not openly sharing knowledge	Several reports of trust that their knowledge would be used by management		All members trusted that their knowledge would be used by management Two reports of trust that colleagues would use knowledge	Two reports of climate of trust	Several reports of trust that their knowledge would be used by management Conflicting reports on whether staff would use their knowledge	
Use of technology		Two reports of technology promoting knowledge sharing						

	Case A		Case B		Case C		Case D	
	Data team members	Non-data team members	Data team Members	Non-data team members	Data team Members	Non-data team members	Data team members	Non-data team members
Motivation								
Sense of responsibility	Two members did not feel responsible				One member did not feel responsible One member felt responsible		Three members did not feel responsible	
Skills			One report of lack of skills in data use		One report of lack of skills			
Articulability of knowledge								
Existing knowledge base	Several reports of significant gap between existing knowledge base on data use and the data teams' knowledge							
Value of knowledge								

	Case A		Case B		Case C		Case D	
	Data team members	Non-data team members	Data team Members	Non-data team members	Data team Members	Non-data team members	Data team members	Non-data team members
Unforeseen			One report of tension between transparency and sensitivity of data Two reports of close personal relations Several reports of the amount of lack of colleagues hindered knowledge sharing	One report of tension between transparency and sensitivity of data One report that communication in the organization is sometimes faulty		All members expressed to be interested in the data teams' knowledge	Several reports of the lack of interest of colleagues hindered knowledge sharing	One report of lack of interest in artifacts One report of resistance to numbers

6. Conclusions and discussion

This section includes conclusions and discussion of the results. This is followed by a critical reflection of the present study. Finally, implications for practice and recommendations for future research will be given. On a critical note, the result of this study or mainly based on statements of respondents. Therefore, it is important to acknowledge that although reports were found of how knowledge was shared, this does not mean that other ways or means of knowledge sharing did not occur in the real-life context. Also, there may be other influential factors in the knowledge sharing process that respondents failed to mention during the data collection, due to poor recollection or bias.

6.1 How knowledge is shared

The first research question was: 'how is knowledge shared between data team members and their colleagues?'. Results show that data teams were comparable in the types of medium used to share knowledge, overall they used newsletters and presentations. Still, a difference can be found between the amount of informal and formal knowledge sharing. In case C, more knowledge sharing took place in a formal setting (e.g. during meetings). Only some reports were found of informal knowledge sharing during non-scheduled social time. Case C was also an exception, as it was the only case wherein knowledge was formally shared during non-scheduled, social time, namely in the staff room on a flap-over. Data team members in case C also reported more on the importance of knowledge sharing, unlike other cases. In this case, non-data team members were also most successful in accurately recollecting the knowledge that was shared by the data team.

Surprisingly, overall the non-data team respondents mentioned more informal, non-scheduled moments wherein the data team shared their knowledge, whereas the formal, scheduled types of knowledge sharing were less mentioned. Some could not even recall these formal types of knowledge sharing (e.g. artifacts, meetings, presentations). Also, when non-data team members were asked to send the formal artifacts they had received of the data team, wherein knowledge was shared, none of the non-data team members could provide us with such an artifact.

Also, the frequency of knowledge sharing differed between cases. Overall knowledge was shared more frequently in case C, wherein respondents could give more examples of knowledge sharing and recall more moments wherein knowledge was shared (e.g. during every monthly meeting). Non-data team members in this case had more overall knowledge on the educational problem and the process of data analysis. Still, no conclusions can be drawn on the intensity of knowledge sharing during these moments. For example, in all cases, evidence was found of knowledge sharing by the data team that were not confirmed by the non-data team members. Unfortunately, we cannot conclude if this is due to characteristics of the receiver, characteristics of the organization, or if the receiver did not incorporating this new information or attach meaning to it (Davenport & Prusak, 2000).

6.2 Types of knowledge shared

The second research question was: 'what types of knowledge are shared between data team members and their colleagues?'. Results show that in general both types of knowledge were shared. Overall, more knowledge was shared on the educational problem than on data use. Knowledge on the educational problem included, for example, explaining what educational problem was researched by sharing the problem statement or explaining results on investigated hypotheses for causes of the

educational problem. Knowledge on data use was also shared, such as how to collect and analyse data and the steps of the data team procedure. Still, respondents were less able to recollect this knowledge. These results indicate that although data team shared both types of knowledge, they tend to recollect more knowledge on the educational problem. A reason for this, might be found in the acknowledged influencing factors. For example, that respondents perceived they lacked the skills to share knowledge on data use. Also, when asked what knowledge was shared, some respondents could not recall exactly what was shared. Based on the results, no conclusions can be made to what may have caused this.

6.3 Influencing factors

The third research question was: 'what factors influence knowledge sharing between data team members and their colleagues?'. Several conclusions can be drawn based on the data about the hypothesised influencing factors. First, of the hypothesized influencing factors, several were not mentioned by respondents as factors that influenced knowledge sharing. This could be due to poor recollection or bias, but could also mean that respondents were unaware of possible factors that might influenced them to share knowledge, or that these factors were non-existent. Second, several factors have been found to both promote and hinder knowledge sharing. Several reports were found of management support, the climate of trust, and a sense of responsibility both hindering and promoting knowledge sharing. Third, one promoting factor was found, namely the value of knowledge. Anticipating the importance of knowledge promoted data team members to purposely share this knowledge. Fourth, also one hindering factor was found, namely the gap between the knowledge base of data team members and the knowledge base of colleagues. Reports were found wherein data team members stated that it was hard to share knowledge on data use with colleagues, because they lack the knowledge in statistics, claiming that the results of a chi-square test would not be understood by most colleagues, thus this was not shared.

In addition, results also provided unforeseen influencing factors, such as the interest of non-data team members in the data teams' knowledge. For example, in case C, non-data team members expressed clear interest in the data teams' activities. They were also able to recollect more overall knowledge that was shared by the data team than in other cases. This may prove that the interest of knowledge promoted knowledge sharing by the data team. It was unclear if this interest of the non-data team members was evoked by the knowledge that was already shared, the perceived value of knowledge, or if this interest evoked more knowledge sharing activities by the data team members. Another unforeseen influential factor, was personal relationships between the sharer and the receiver of knowledge. In the theoretical framework personal relations were mentioned as part of external motivation, but respondents did not mention these relations motivated them to share knowledge, mainly that relations made it easier to do so.

Also, knowledge on data use was more frequently shared using formal artifacts (e.g. emails, presentations). One might argue that artifacts were used due to the articulability of knowledge on data use, claiming that because this knowledge is more difficult to explain. Artifacts might also be used for this type of knowledge sharing, because of the gap between the knowledge base of data team members and the knowledge base of their colleagues is too large. One might argue that artifacts can help to guide the knowledge sharing process. For example, when using a PowerPoint presentation, you not only explain something verbally but you can also use examples and pictures as a contribution. Also, several reports were found of data team members claiming they lacked the skills to explain data use to their colleagues.

Next to cross-case differences in influencing factors, differences were also found within cases.

Respondents differed in their perception on whether factors promoted or hindered knowledge sharing. For example, non-data team members differed in whether they perceived the climate to be open to discuss data. Three respondents believed the climate was not open enough and hindered knowledge sharing. This was contradicted by another respondent who believed the climate promoted knowledge sharing, stating that he believed the organization to be 'honest, transparent and open'. This indicates that all the influencing factors are subdue to personal perspectives and beliefs.

6.4 Reflection

Even though this study used triangulation of instrumentation (e.g. using interviews and artifacts). Several limitations of this study can be mentioned based on our instrumentation. The limitations of the interviews include: response bias, bias due to the articulation of the questions, and inaccuracies due to poor recall by the respondent (Yin, 2008). Response bias could have affected our results, as respondents could have answered questions according to what they believed the interviewer wanted to hear, instead of according to their true beliefs. Bias due to poorly articulated questions during interviews could have occurred as the interviewer had no prior experience in data analysis by means of interviewing. Also, inaccuracies in respondents' statements could have occurred, as the interviews were only snapshots of what respondents could recall. The recollection of knowledge that was shared differed between cases and between respondents. For example, in case A five of seven data team members stated they had not shared knowledge with their colleagues, even though several artifacts were issued to do so. In contrast, in case C, the data team members were extremely accurate in recollecting what means were used to share knowledge.

Moreover, results showed that several unforeseen factors influenced knowledge sharing, such as non-data team members' interest in knowledge and personal relations. Thus, this study was limited in hypothesized influencing factors. A more extensive literature could provide additional factors that might influence this process.

Also, in all cases only several non-data team members were interviewed, who may not provide a full representation of staff. Moreover, the results of this study are limited as they only describe results from four different organizations. Furthermore, our analysis was conducted eight to nine months after the data team had started using the data team procedure. Data collection after a longer period of time may provide other results, as a result of other factors influencing the knowledge sharing process. For instance, when data teams have concrete results on the cause of the educational problem, the value of their knowledge can increase, which can promote knowledge sharing.

Another limitation is the fact that from one case (B) not all interviews with data team members were transcribed, due to time limitations. This deviated from the protocol that was used for the data collection method. These interviews had to be coded by listening to the audio file. Thus, this case lacked thorough planned analysis compared to other cases.

6.5 Implications for practice and recommendations for future research

The present study recognized that knowledge sharing is a bilateral process (Cumming, 2004; Hendriks, 1999). Thus, both knowledge owners (e.g. data team members) and knowledge receivers (e.g. non-data team members) were interviewed. Results showed that their perceptions on knowledge sharing differed in terms of whether knowledge was shared, indicating that knowledge sharing was not successful.

For example, even though artifacts proved that the data team shared their knowledge, several non-data team members did not confirm this and could not recollect receiving this knowledge. Although this study recognized several influencing factors in the knowledge sharing process as whole, results provided little insight into why knowledge sharing was sometimes not successful, as influencing factors were only stated to hinder or promote knowledge sharing. Results could indicate that knowledge receivers were unable to attach meaning to the newly received knowledge provided by the data team members (Achterbergh & Vriens, 2002). Still, one case proved to be extremely successful. In case C, non-data team members were most successful in accurately recollecting the knowledge that was shared by the data team. Data team mentioned more purposeful knowledge sharing and non-data team members showed interest in the data teams' activities, which could have led to the internalization of knowledge and thus successful knowledge sharing. This study was conducted based on the perception that successful knowledge sharing by the data team may lead to the increase of data-informed decision making (Schildkamp & Handelzalts, 2012) and the improvement of education by solving educational problems. Further research should explore the success of knowledge sharing by analysing in detail the internalization of knowledge by receivers. Other research also stressed that even though knowledge can be provided, this knowledge should be internalized by attaching meaning to it (Achterbergh & Vriens, 2002; Cummings, 2004; Cumming & Teng, 2003; Hendriks, 1999), ensuring successful knowledge sharing.

To our knowledge, knowledge sharing has not been researched in the context of data teams and data-informed decision making. Therefore, the present study focused on providing insight into the process of knowledge sharing between data team members and their colleagues in Dutch secondary schools. This insight might be of use to schools with a data team, as it will provide them with insight into the knowledge sharing process and the influencing factors for successful knowledge sharing. Schools may use this insight to their advantage to achieve successful knowledge sharing. For example, having the skills to share knowledge promotes more knowledge sharing. If schools are aware of this fact, they might ensure that all data team members possess the right skills to share knowledge. In contrast, some factors might not be as easily adjusted as the aforementioned example. Changing the culture of the school, or ensuring more support of management is not easily established. Still, results of the present study might influence schools to ensure that their specific influential factors will be adjusted to promote knowledge sharing.

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