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Teacher educators' collaboration in subject departments: collaborative activities and social relations

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Teacher educators' collaboration plays an important role in the improvement of teacher education. Many studies in educational research focus on collaboration from 1 particular perspective. A focus on 2 perspectives, a qualitative (focusing on collaborative activities) as well as a quantitative (focusing on relations) perspective, and relating both perspectives, can add to our knowledge. Data were collected in 3 subject departments of a teacher education institute. Findings indicated that educators' collaborative networks inside the departments could gain from more coherent and dense relations, and that key players were important to support and sustain collaboration. Both perspectives were mildly related, correlations were found for "degree" and "information" ($r = .31, p < .05$), "degree" and "joint work" ($r = .38, p < .01$), and "reciprocity" and "joint work" ($r = .33, p < .05$), no correlations were found for "degree" or "reciprocity" and "discussing". At the department level, only mathematics showed significant correlations. Results indicated that, in further research, qualitative aspects as well as quantitative aspects should be included.

Keywords: collaboration; teacher educator; interdependence; network theory

Introduction

During the past decades, research has provided growing support for the assumption that collaboration is an important factor for learning (Eraut, 2004; Horn & Little, 2010; Levine & Marcus, 2010; Tynjälä, 2008; Westheimer, 2008). Compared to educators without the social support provided by collaboration, educators involved in collaborative processes are more likely to develop their teaching practice, which, in turn, may produce increases in students' achievements (Goddard, Goddard, & Tschannen-Moran, 2007). For teacher educators, collaboration is considered equally important as for teachers; next to being a role model in professional collaboration for future teachers, teacher educators' collaboration is considered important for making improvements in teacher education (Caena, 2012). Following the international debate on concerns about the quality of teachers and teacher education itself (Cochran-Smith & Zeichner, 2005) in recent years, large-scale reforms have been introduced as attempts to improve the quality of teachers and teacher education (Darling-Hammond, 2010). In order to successfully implement such reforms, teacher educators get

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involved in collaborative efforts to make the required collective changes in their instructional practices (Frank, Zhao, & Borman, 2004; Goddard et al., 2007; Wenger, 1998). Collaborative processes in teacher education need a sense of urgency or a collective goal in order to develop (Hadar & Brody, 2010). Unfortunately, and although research on teacher educators' is growing, there is little knowledge on what teacher educator collaboration in the context of educational change actually looks like.

Given this scarcity in the literature on teacher educator collaboration, in the present study, we draw on literature on teacher collaboration, when studying *teacher educators'* collaboration. Multiple studies on collaboration, especially with regard to teachers (Dopenberg, Bakx, & Den Brok, 2012; Friend & Cook, 1992; Horn & Little, 2010; Little, 1990; Mostert, 1998; Rosenholtz, 1989), use two perspectives on collaboration, (a) a *quality*-focused perspective and (b) a *quantity*-focused perspective (Scott & Carrington, 2011). Research on teacher collaboration using a quality-focused perspective has its roots in the psychological domain and focuses merely on community building via interaction and more specifically on examining types of exchange, such as types of cognitive activities performed by teachers while collaborating or the level of interdependence of these activities (Friend & Cook, 1992; Kwakman, 2003; Levine & Marcus, 2010; Little, 1990). Studies on teacher collaboration conducted from the second perspective, the quantitative perspective, provide insights into social structures which support or constrain collaboration and focus merely on the collaborative relations (Coburn & Russell, 2008; Daly & Finnigan, 2010; Penuel, Riel, Krause, & Frank, 2009; Rosenholtz, 1989). This research has its roots in studies in the domain of sociology (Burt, 2000; Scott & Carrington, 2011).

Although these perspectives might seem somewhat overlapping, each perspective has a different emphasis on collaboration (i.e., an emphasis on the type of exchange versus an emphasis on the number of relations). As a consequence, it has been argued that in research these perspectives should be related in order to develop a fuller understanding of how collaboration actually takes place and enhances learning and learning outcomes (Kreijns, Kirschner, & Jochems, 2003; Moolenaar, 2012). Also, as has been shown in previous research on collaboration, it is important to focus on subject departments as described by Stodolsky and Grossman (1995). Norms in subject departments can differ from organisational norms, since departments differ in features such as the degree of definition or the number of distinct fields included in the school subject (Stodolsky & Grossman, 1995). Such differences lead to differences between departments in perceptions on collaboration and, as a result, the actual outcomes of collaboration, such as the implementation of an innovation (Coburn & Russell, 2008; Penuel et al., 2009; Stodolsky & Grossman, 1995). In a study by Van Wessum (1997), differences in collaboration were found between (department level) as well as within subject departments (individual level), suggesting that it is important to include both the individual and the department level in research on teacher educator collaboration. Therefore, in this study we address the subject department level as well as the individual level.

Both a *qualitative* and a *quantitative* perspective are used to investigate collaboration in the present study. The aim of our study is to describe and to relate these two perspectives on teacher educators' collaboration within their subject departments, as a way to assess teacher educators' collaboration as it actually takes place during educational change. We address the lack of studies including multiple perspectives on collaboration and the need to take more closely into account the specific context of teacher educators within their subject departments. Insights provided by this study might be useful in teacher education for gaining a more comprehensive view of teacher educators' collaboration in the context of

educational changes taking into account the two perspectives (quality and quantity) and the specific features of collaboration in the departments.

In the following sections, we will first introduce the specific context of this study, before elaborating a bit more on the two perspectives as introduced above. Then, the research questions and methodological approaches are discussed, consisting of (a) quality of the exchange analysis and (b) network analysis (see Instruments section).

Context

The context for this study is a large-scale educational reform in Dutch teacher education institutes: a nationwide implementation of common goals and standardised tests for (future) primary teachers in all 14 subjects in teacher education (HBO-raad, 2012). This innovation has some resemblance to the Common Core State Standards Initiative in the US (Porter, McMaken, Hwang, & Yang, 2011), in a way that it involves the introduction of common goals and tests in order to establish consensus on expectations for, in this case, (future) teachers' knowledge and skills. The innovation implies for teacher educators in their subject departments the need to review their courses and possibly adapt the curriculum, for example, by explicating and changing learning goals, lesson materials, or student tests. This implementation therefore implies a collaborative effort of teacher educators in their subject departments. This provides an opportunity to study teacher educators' collaboration within subject departments, but also to look at differences between departments. Teacher educators from one large primary teacher education institution in The Netherlands participated. Teacher educators in the subject departments worked collaboratively at five different locations. The subject departments covered all five locations.

Framework

Given the gap in the literature on teacher educators' collaboration (see Introduction section), here literature on *teacher* collaboration is used as a starting point in order to grasp the concept of collaboration and quality and quantity thereof. We assume that, although the contexts and the type of respondents are different in teacher education, the central assumptions and tenets found for teacher collaboration will also hold here.

Tynjälä (2008) found in her review study that teachers learn at work by participating in various working practices, for example, collaborating with colleagues. Collaboration between teachers takes place by interaction (Friend & Cook, 1992; Little, 2003; Mostert, 1998). For the purpose of this study and in line with previous studies (Friend & Cook, 1992; Mostert, 1998), *teacher educators'* collaboration is seen as *a form of interaction by which resources like knowledge, information, or experience are exchanged*.

The quality-focused perspective

Many researchers who have studied collaboration in a context of educational change emphasise the quality of the exchange by studying types of collaborative activities or levels of interdependence in these activities (Doppenberg, Bakx, & Den Brok, 2012; Friend & Cook, 1992; Horn & Little, 2010; Kwakman, 2003; Little, 2003; Meirink, Imants, Meijer, & Verloop, 2010). Most of these studies show that the exchange of experiences is a common activity, whereas collaboration referred to as "joint work" is less common (Kwakman, 2003). These studies point at the importance of interdependence in collaborative activities in order to be effective in terms of learning or making changes in

Table 1. Categories of collaborative activities (cf. Little, 1990).

Categories of collaborative activities	Examples of each category
1 Story-telling and scanning	Venting stories about one's own teaching practice or listening to information
2 Aid-and-assistance	Asking a more experienced colleague for help or advice
3 Sharing	Mutual exchange of ideas or opinions, exchange of materials
4 Joint work	Collectively developing lesson materials, or evaluating students results

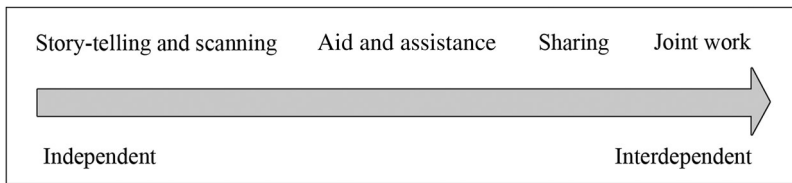


Figure 1. Teachers' collaborative activities on a scale of in(ter)dependence (cf. Little, 1990, developed by Doppenberg, Bakx, & Den Brok, 2012).

practice (Little, 1990, 2002; Meirink, Imants, Meijer, & Verloop, 2010). In addition, Shank (2006) in her study showed the importance of collaborative activities referred to as “story-telling” for developing a culture of trust and, among other things, to help teachers imagine new possibilities for adapting their courses. These findings illustrate that different types of collaborative activities are important for collaborative learning.

According to Little (1990), collaboration can be placed on a continuum that ranges from independent (working more autonomously) to interdependent (working in a highly collaborative manner). These levels of in(ter)dependence give an idea about the quality of collaboration. In this study, these levels of in(ter)dependence are used to assess teacher educators' collaboration from a qualitative perspective. Little (1990) distinguishes four categories of collaborative activities on a scale of in(ter)dependence. These categories are presented in Table 1.

Following Little (1990), these forms of collaboration constitute more than a simple inventory of activities. They are phenomenologically discrete forms that vary from one to another on a dimension of mutual interdependency between the people involved. The category “story-telling” entails low mutual interdependence, whereas “joint work” is an example of collegiality that involves high interdependence (Little, 1990), see also Figure 1. In her study, Little concludes that “the various forms of exchange that pass as collaboration comprise fundamentally different conceptions of professional relations” (1990, p. 531). When people collaborate more intensively, indicated by high levels of interdependence, they contribute more to the implementation of innovations, effectiveness of education, and their colleagues' professional development (Little, 2002).

The quantity-focused perspective

The quantitative perspective adds to a more quality-focused perspective in such a way that the structure of the relations involved in collaboration is taken into account. Social network

studies on collaboration focus on relations between actors (Borgatti & Cross, 2003). Following recent literature, networking theory is based on three key assumptions: (a) Resources such as information and knowledge are exchanged in the relationships between individuals; (b) individuals are not independent but interdependent because they are embedded in a social structure; and (c) social networks provide opportunities for, but also constraints on, the actions of individuals and organisations (Scott & Carrington, 2011).

In a social network, individuals (e.g., teacher educators) are embedded in dyadic relationships (referred to as *ties*), and dyadic relationships are embedded in larger sub-groups of three or more actors that eventually shape a network (Moolenaar, Slegers, Karsten, & Daly, 2012). Social network analysis (SNA) provides opportunities to identify the distribution of access to and exchange of resources within teacher educator networks. In the context of educational change, having access to and exchanging resources is important for reaching collective goals and developing an innovative climate (Moolenaar, Daly, & Slegers, 2011; Witterholt, Goedhart, & Suhre, 2015). Studies indicate that having a dense and coherent network supports sustainable innovations (Burt, 1997; Daly, 2010).

SNA is used to study the structure of collaborative relations at the *individual* level, referred to as the ego level, and at the *whole-network* level (Hanneman & Riddle, 2011). Both levels can provide relevant information related to collaboration; therefore both will be briefly discussed.

Whole-network level

At the *whole-network* level (i.e., the department level), *size* and *density* in the network and *connections* are important indicators. The *size* of the network (referred to as *degree*) is critical for the structure of social relations because of limited resources and capacities that each actor has for building and maintaining ties. The *density* of a network refers to the number of existing ties in a network in relation to the maximum number of possible ties (Hanneman & Riddle, 2011). In a dense network, many educators are connected to one another, while in a sparse network, there are only a few relationships among the educators in the network. The density of a network may give insights into phenomena such as the speed at which information diffuses among the educators and the extent to which educators have opportunities for collaborating with others (Hanneman & Riddle, 2011). The lack of sufficient relationships (ties) can impede or constrain the network's capability to facilitate collaboration and achieve desired goals such as making changes in teaching practice (Daly & Finnigan, 2010; Hite, Williams, & Baugh, 2005). Although literature does not agree on what exact amount of relations is desirable, a dense network is considered desirable for facilitating collaboration since dense networks reflect a high level of trust, which, in turn, is an important condition for collaboration (Finnigan & Daly, 2012). This means that, in order to enhance or sustain teacher educators' collaboration, a network (e.g., in a subject department) benefits from dense relationships.

Where density gives an overall sense of the range of possible social structures, the texture of these connections is what really matters (Hanneman & Riddle, 2011). In order to gain insight into teacher educators' collaboration and especially the more quantitative aspects thereof, the strength and direction of ties are interesting measures. Strong ties, indicated by, for example, mutual exchange, are important, especially for exchanging complex or tacit knowledge (Krackhardt, 1992). *Reciprocity* addresses the mutuality of the exchange: If two people indicate that they are connected to one another, a relationship between them is reciprocal. The reciprocity of a teacher educators' network gives an idea of interdependence and stability in the network (Hanneman & Riddle, 2011).

Reciprocity is especially of interest when studying collaboration since in a more reciprocal network a deeper exchange of resources, such as tacit knowledge, can be realised (Krackhardt, 1992).

Ego-network level

Next, collaboration can be studied at the *ego level*, a bottom-up approach focusing more on individuals and their connections (Hanneman & Riddle, 2011). “Ego” is an individual “focal” node in a network, for example, an individual teacher educator. An ego network in this study refers to an individual teacher educator (ego) and all colleagues in the subject department he or she collaborates with during the innovation (alters). Several characteristics of ego networks are of interest when studying teacher educators’ collaboration. SNA uses *centrality* to measure the existence or absence of positional advantages of actors (i.e., educators) inside their network. For example, a teacher educator who has many relations has relatively easy access to knowledge of others compared to an educator with only few relations. Centrality refers to an educator’s position in a network being central (connected to many others), peripheral (connected to few others), or isolated (not connected at all) (Hanneman & Riddle, 2011). Centrality is measured by means of an educator’s *degree* (number of relations) or by means of *betweenness*. *Degree* centrality captures an educator’s immediate ties (relations) to an alter. Multiple studies have found evidence that homophily, “the principle that a contact between similar people occurs at a higher rate than (between) dissimilar people”, plays an important role (McPherson, Smith-Lovin, & Cook, 2001, p. 416). In schools, homophily often expresses itself as educators reaching out to colleagues with similar structural positions in the network, for example, teacher educators that collaborate more with colleagues teaching the same grade or same course (Coburn, Choi, & Mata, 2010). Another strong predictor of tie formation (building relations) is *proximity*. Proximity is the physical distance separating educators in the school organisation, for example, working in physical distant classrooms (Coburn et al., 2010). *Betweenness* measures both the direct and indirect ties between an educator and others in the subject department (Hanneman & Riddle, 2011). For example, when Teacher A collaborates with Teacher B, this is referred to as a direct relation. When Teacher C collaborates with Teacher B but not with Teacher A (e.g., because Teachers B and C both teach the same course and Teacher A teaches a different course), the relation between Teachers A and C is indirect (namely, through Teacher B). Educators with a high in-degree or betweenness play an important role in sharing knowledge or information in a collaborative network, since they are apparently considered as a source of knowledge or information by others. These educators are *central* in the network.

Key players

Actors with relatively high scores on degree and betweenness in a network are more central than others and can be considered as *key players* in collaboration (Borgatti, 2006). These key players, being more connected than others, have more opportunities to collaborate (Granovetter, 1982). Having a favoured (i.e., central) position in the network means that an educator may have better bargains in exchange, a greater influence, and may be a focus for defence and attention from those in less favoured positions (Hanneman &

Riddle, 2011). These educators having a favoured position in the network are often referred to as key players (Borgatti, 2006; Spillane, 2005). With regard to developing and sustaining collaboration, key players are important, since they are in a position to connect otherwise not connected educators in less favoured positions (Gould & Fernandez, 1989). An interesting question is whether or not functional positions (such as chair of the department) match with key players. We assume that there will be some mismatch, since informal leaders might play a role in collaboration in the context of the implementation of an innovation next to the more formal leaders (Moolenaar et al., 2011; Spillane, Halverson, & Diamond, 2004).

Differences between subject departments

Recent studies on *teacher* collaboration show large differences in collaboration between schools or departments or (sub)teams, due to different features like the degree of definition or the number of distinct fields included in the school subject, the degree of sequence, the subject matter being perceived as being static or dynamic, and the required or elective status of the subject (De Lima, 2007; Siskin, 1994; Stodolsky & Grossman, 1995; Van Wessum, 1997). Studies also show variety in network measures among and within schools, such as among subject departments (Coburn et al., 2010; De Lima, 2007; Frank et al., 2004; Moolenaar et al., 2012; Siskin, 1994). In previous studies on collaboration, it has been argued that it is important to focus on differences between subgroups, such as departments, while studying collaboration, since subgroups might develop norms that differ from the school culture, which in turn might affect perceptions on collaboration (Coburn & Russell, 2008; Penuel et al., 2009) and as such the actual results of collaboration, such as the implementation of an innovation. In order for teacher education to adaptively support their teacher educators' collaboration inside the departments, it is important to study the nature of differences in collaboration at the subject department level.

Research questions

The national implementation of common goals and tests in teacher education programmes provides the context for studying teacher educators' collaboration in subject departments. Teacher educators' collaboration is studied by using a qualitative perspective, focusing on collaborative activities, as well as a quantitative perspective, focusing on collaborative relations, both at the individual (ego) and at the collective (department) level.

This leads to the following main research question:

(RQ) How are the quality and quantity of teacher educators' collaboration related?

In order to answer the main question, the following subquestions are stated:

(RQ 1.1) How can the quality of teacher educators' collaborative activities during innovation be described, in terms of "story-telling and scanning", "aid and assistance", "sharing", and "joint work", both at the individual and at the aggregated (department) level?

(RQ 1.2) How can the quantity of teacher educators' collaborative relations be described, both at the individual level in terms of degree, betweenness, and key players and at the network (department) level in terms of density, centrality, and reciprocity?

Table 2. Participating teacher educators per department.

Department	Number of participants	Years of experience in education Mean	Years of experience as teacher educator Mean
Mathematics	16	20.6	8.5
Dutch language	14	21.6	9.0
Environmental science	21	24.0	14.3
Total number of participants	51	22.5	11.3

Method

Procedure and participants

This study was performed in a large primary teacher education institution in The Netherlands. In The Netherlands, teacher education for both primary and secondary school teachers takes place in higher education institutes. In universities of applied science, a 4-year trajectory leads to a bachelor degree in primary or secondary education. The particular institute in this study is organised in five different locations and employs 150 teacher educators. Each location is responsible for the education of a group of future teachers, including guidance of workplace learning and assessments. Teams vary in size, ranging from 8 to 46 teacher educators. Subject departments¹ are responsible for the development and implementation of the curricula. The institute's curriculum consists of 14 different subjects, with pedagogy, Dutch language, and mathematics as the main subject areas. All 60 teacher educators in three subject departments, (a) mathematics, (b) Dutch language, and (c) environmental science, were included in this study. Mathematics and Dutch language were chosen because they are core subjects in Dutch primary school curricula and are tested in a national knowledge test. Environmental studies was chosen because of the Dutch government's emphasis on better preparation of children for a career in science (Programmaraad Verbreding Techniek Basisonderwijs, 2004).

Of the 60 invited teacher educators, 51 agreed to participate in this study (a response rate of 85%). Of these, 57% were male. The age of the teacher educators varied between 31 and 64 years old ($M = 48.5$; $SD = 9.2$). Years of experience in teacher education varied between 1 and 35 years ($M = 11.0$; $SD = 8.2$). Table 2 presents the number of participants for each department and some background characteristics.

To measure interdependence, a survey was used for collecting data on the collaborative activities. Although it is common to study interdependence using qualitative methods, given the large group of respondents a survey was deemed more feasible. Moreover, such an approach has been successfully used before in student interdependence studies (Blaney, Stephan, Rosenfield, Aronson, & Sikes, 1977). To measure the networks, a network survey was used, as is common in network research (Scott & Carrington, 2011).

All 51 participants completed the two questionnaires during a teacher educator meeting where two researchers were present to assist the data collection process. Teacher educators completed the questionnaires individually and anonymously. Before completing the questionnaires, the participants were informed about the nature and goals of this study.

Instruments

First, in order to map and categorise the collaborative activities of teacher educators, an interdependence questionnaire was developed consisting of 30 items, based on Little's

four levels of interdependence (Little, 1990) and one open question for adding collaborative activities that were not covered by the 30 items. For each of Little's (1990) four categories for teacher collaboration, items were constructed by the researchers. Respondents were asked to indicate the frequency of a certain activity that was mentioned in the item, using a 5-point Likert scale varying from 1 (*never*) to 5 (*very often*). An exploratory factor analysis² was conducted to investigate construct validity of the questionnaire. This analysis revealed three underlying factors (instead of Little's [1990] four categories), explaining 67.6% of the total variance with an eigenvalue above 1.0. Factor loadings suggested that these factors could be labelled as: (a) "joint work"; (b) "exchange of information and exchanging experience", referred to as "information and experience"; and (c) "discussing work": Cronbach's alpha for the resulting scales varied from 0.92 to 0.94. The constructed scales differed somewhat from the four categories used by Little. Little's categories "story-telling" and "aid" refer to exchanges with a low level of interdependence; the category "information and experience" in our study also refers to exchange with a low level of interdependence, but – as factor analysis showed – could not be seen as two different categories. Our scales "discussing work" and "joint work" show some resemblance with Little's categories "sharing" and "joint work", although "discussing work" more explicitly refers to sharing ideas regarding points of view, whereas Little's "sharing" also refers to sharing student outcomes.

Pearson correlation coefficients were calculated in order to investigate overlap between the three scales. Correlations between scales were high. The scales "joint work" and "information and experience" correlated 0.70; the scales "joint work" and "discussing work" 0.72; the scales "information and experience" and "discussing work" 0.70. Table 3 presents the scales, descriptions, and item examples.

Second, to map teacher educators' collaborative networks whole network data were collected by means of an open-ended questionnaire in which respondents were asked to report with whom they shared a particular relation regarding collaboration on the innovation

Table 3. Scales of the interdependence instrument, reliability, number of items, description, and item examples.

Scale and reliability	Number of items	Description	Item example	Mean	SD
Joint work ($\alpha = 0.94$)	13	Joint evaluation of the programme and making adaptations on methods, lessons, tests, etc.	Adaptation of didactic approach	2.92	1.02
Information and experience ($\alpha = 0.94$)	10	Seeking information or giving information to colleagues and sharing experiences of asking questions concerning the knowledge base	Listening to information of a colleague	3.42	0.96
Discussing work ($\alpha = 0.92$)	7	Discussing the knowledge bases, the presentation of knowledge in the curriculum, discussing student goals, and tuning on teaching and guiding students	Discussing the way to teach knowledge	3.38	0.98

within the subject department. Background characteristics were used from the first questionnaire on collaborative activities. Three types of collaborative relations were included in the social network questions: (a) joint work, (b) seeking information, and (c) asking for advice. These three types of exchange are considered relevant for studying collaboration within networks and were used in other recent network studies as well (Daly, 2010; Moolenaar, 2012). Table 4 presents an overview of the social network questions to assess these types of exchange within the social networks of teacher educators. *Joint work* refers to work that teacher educators employ (while implementing the national knowledge standards) in collaboration (Little, 1990). *Seeking information* refers to social relationships for acquiring information (Granovetter, 1982; Wenger, 1998) and refers to Little's (1990) category of story-telling. *Asking for advice* resembles Little's (1990) category of aid and assistance and is of interest since receiving advice may be part of an on-going development and may facilitate the adoption and implementation of reform and innovation in institutions (Moolenaar et al., 2011).

In order to assess to what extent the three networks of a subject department were related, a test to reveal statistically significant correlation scores between relations in different networks was performed³ (Hanneman & Riddle, 2011). Results on the networks at the department level were aggregated to obtain an overall picture of the relations between the networks (*information, joint work, advice*). In general, all three subject department networks were weakly to moderately correlated. Correlation coefficients were: *information – joint work*: $r = .47$; *advice – joint work*: $r = .36$; and *information – advice*: $r = .43$. These findings suggest that all networks measured different facets of teacher educators' collaboration, and none of the networks showed extensive similarity with other networks.

To elicit reliable network information, we used a name generator technique described by De Lima (2010) to measure the network relations: Respondents of each department were asked to indicate the people with whom they had established a specific kind of relationship by free recall. The total number of relationships a respondent could elicit was free of choice but was restricted to actors within the department in order to get a complete image of each department's collaborative networks. Additionally, to measure the strength of relationships, ratings varying from 1 (*occurred only once*) to 5 (*occurred every week*) were used.

Third, in order to characterise the network structure at both the ego level and the whole-network level, network measures, for example, network density⁴, were calculated using UCINET, specialised software to analyse network data (Borgatti, Everett, & Freeman, 2002). Network descriptive measures were calculated both at the ego level (individual) and at the network level (subject department).

At the individual level, the following variables were established. The *degree* was measured by scores on *in-degree* and *out-degree* and *betweenness*. *In-degree* was calculated by numbering teacher educators by whom the respondent was nominated. *Out-degree* was calculated by numbering the teacher educators the respondent had nominated. Also,

Table 4. Social network questions to assess teacher educators' networks.

Scale	Question (translated in English)
Information	If I need information on the national knowledge base of my subject domain I turn to:
Joint work	If I want to work collaboratively on (developing) lessons or tests in my subject domain I turn to:
Advice	If I need advice concerning the implementation of the national knowledge base in my subject domain I turn to:

normalised scores were calculated as a percentage of the relationships of the whole network. Standard deviations for in- and out-degree and also for the normalised scores were calculated.

Betweenness was measured by locating the shortest paths between all pairs of actors, and counting up how frequently each actor fell in each of these pathways (Freeman's betweenness; cf. Borgatti et al., 2002). The proportion of times that actors were "between" other actors for the sending of information was added for each actor to get a measure of actor centrality. This measure was normalised by expressing it as a percentage of the maximum possible betweenness that an actor could have had (Hanneman & Riddle, 2011). In order to calculate the individual measures, the department network data were aggregated into one large network.

At the subject department level, referred to as the network level, the network was defined through the measures *density*, *centralisation*, and *reciprocity*. The *density* of a network was measured by dividing the total number of ties that individuals report by the total number of possible ties. The networks' *centralisation* was captured by the proportion of possible ties with others that were realised (reported in the survey). Scores ranged from 0 (no variability – all members of the network are chosen for information as frequently) to 1 (maximum variability – most educators in a network only nominate a single person in the network, while these teacher educators themselves are not nominated at all).

Reciprocity was calculated as the number of reciprocal relationships in a department, divided by the total possible number of reciprocal relationships. The reciprocity of a teacher educators' network may range from 0 (none of the relationships in the network are reciprocated or mutual) to 1 (all of the relationships in the network are reciprocated or mutual).

Analysis

To characterise collaborative activities and network structure (subquestions RQ 1.1 and RQ 1.2), descriptives means and standard deviations were calculated. To answer the first and second subquestions, referring to differences between subject departments, analyses of variance (ANOVA) were conducted, with collaborative activities (scales) and network attributes as the dependent variables and department (network) as the independent variable. Possible differences in network size between the three departments must be considered since size is critical for the structure (Hanneman & Riddle, 2011). Normalised scores are used to reduce the effects of difference in size.

Key players in the department networks were identified by calculating centrality measures per ego, using degree centrality and Freeman's betweenness centrality in UCINET (subquestion RQ 1.2). To find out if any relationship existed between the qualitative perspective and the quantitative perspective (RQ), scores of variables of both perspectives at the individual level were correlated using Pearson's correlation coefficient.

Results

The quality of teacher educators' collaborative activities

To assess the quality of the collaborative activities, as reported by teacher educators, on a scale of interdependence (RQ 1.1), mean frequency scores on each of the three scales, as derived from the questionnaire, were compared. Mean scores on the activity scales varied from 3.42 ("information and experiences" and "discussing work") to 2.92 ("joint

Table 5. Scale scores per department.

Scale	Department	Mean (range 1–5)	<i>SD</i>	<i>F</i> (<i>p</i>)
1 Joint work		2.9	1.02	5.8 (0.06)
	Mathematics	3.2	1.23	
	Dutch language	3.4	0.59	
	Environmental sciences	2.3	0.76	
2 Information and experiences		3.4	0.96	0.8 (0.77)
	Mathematics	3.3	1.15	
	Dutch language	3.7	0.73	
	Environmental sciences	3.3	0.97	
3 Discussing work		3.4	0.98	0.2 (0.81)
	Mathematics	3.5	1.09	
	Dutch language	3.5	0.84	
	Environmental sciences	3.1	0.99	

work”) on a scale from 1 to 5. Thus, collaborative activities with a low to medium level of interdependence occurred reasonably often, while highly interdependent activities (i.e., joint work) were perceived to a slightly lesser degree.

The ANOVA that was performed to find possible relations between interdependence and belonging to a specific subject department showed that belonging to a specific subject department explained the variance for the scale “joint work” ($F = 5.8$) with a significance of $p = 0.06$. Table 5 shows means and standard deviations per scale at the department level. While most differences between departments were not statistically significant, when looking at the standard deviation, it appeared that within the Dutch language department perceptions differed least, while differences in perceptions were largest for the mathematics department, meaning that mathematics teacher educators seemed to differ most from one another in the way they perceived their collaborative activities. Dutch language appeared to have the highest scores on each of the three scales, meaning that educators in this department perceived to collaborate more frequently, followed by the mathematics department and the environmental science department, with slightly lower scores.

The quantity of teacher educators’ collaborative relations

With regard to teacher educators’ collaborative relations at both the ego level and the whole-network level (RQ 1.2), results showed variation, both between individual teacher educators and between subject departments.

Table 6. Individual-level network descriptives: degree and betweenness.

Network	In- and Out-degree					Betweenness	
	<i>M</i>	<i>SD</i> /In*	<i>SD</i> /Out*	Max**	Min**	<i>M</i>	<i>SD</i>
Information	2.0	1.6	2.4	8.0	0.0	7.2	16.7
Joint Work	1.8	2.1	2.8	16.0	0.0	5.9	14.3
Advice	1.7	1.7	2.9	14.0	0.0	4.3	12.3

**SD*/In refers to the standard deviation of all incoming relationships; *SD*/Out refers to all outgoing relationships; **Max refers to maximum values; Min refers to minimum values.

At the ego-network level, results on *degree* and *betweenness*, as calculated in UCINET, are presented in Table 6, with descriptive statistics for each of the three networks, “information”, “joint work”, and “advice”. Mean scores on *degree* varied only little between the three networks, meaning that, on average, teacher educators used only slightly more relations in the information network compared to their joint work and advice networks. The QAP procedure (see Instruments section) showed that these different networks only partially overlapped. Standard deviations showed differences between actors (see Table 6), meaning that educators differed in their network sizes. Some educators even showed a minimum score of zero relations (see Table 6), indicating that they were not participating at all in the collaborative network. The ANOVA, used to assess the variance in degree between individual educators, indicated that belonging to a specific subject department explained the variance in *degree* ($F_{\text{outdegree}} = 4.3$; $F_{\text{indegree}} = 5.8$), with a significance of $p = 0.02$ for out-degree and $p = 0.007$ for in-degree. A comparable pattern as for *degree* was found for *betweenness*, with the “information” network as the most centralised. The mean number of times that an actor was found “between” other actors for exchanging information was 7.2.

Regarding the key players, the standard deviation for betweenness showed differences between educators (see Table 6), indicating that some educators were more central in their collaborative networks than others. These central educators are referred to as key players in the collaborative networks. A striking result was that the key players in each of the departments were located in one and the same location. This is an interesting result since it points at differences between locations in their conditions for collaboration. This result was not found for betweenness centrality. Some of the key players occupied functional leading positions (chair of the department network), but this did not apply to all central actors, meaning that not only formal leaders are key players in the collaborative network. Key players differed in age and years of experience.

Results at the network level (subject department) are presented in Table 7, with descriptive statistics for the three network questions in each of the three departments.

At the network level, results showed an overall density that varied between .05 and .49, indicating that most networks were not very coherent (see Table 7), since the maximum density is 1.0 when everyone is connected to everyone else. Taking the size of the networks into account, a density of .49 is reasonably dense and .05 is not dense at all.

Table 7. Network level descriptive statistics: density, centralisation, and reciprocity.

	Density		Centralisation		Reciprocity
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>
Mathematics ($N = 19$)					
1 Information	.39	1.23	.23	10.7	.33
2 Joint work	.49	1.32	.36	14.9	.38
3 Advice	.38	1.15	.34	13.5	.25
Dutch language ($N = 12$)					
1 Information	.30	1.07	.20	8.8	.29
2 Joint work	.29	1.06	.19	9.3	.29
3 Advice	.28	0.98	.31	10.9	.16
Environmental sciences ($N = 20$)					
1 Information	.10	0.57	.09	5.9	.13
2 Joint work	.08	0.55	.09	5.9	.25
3 Advice	.05	0.40	.07	4.9	.09

Variation between the departments in density was found. Standard deviations in the mathematics department were relatively high (see Table 7), indicating that there was much variation between teacher educators within the department in the number of relationships they had. Results indicated that the networks of teacher educators in the mathematics department had the highest density (.39, .49, and .38, respectively), with the “joint work” network the most dense: Of all possible relationships in the department, 49% were formed around “joint work”. Teacher educators in the environmental science department had the lowest network density. In their advice network, only 5% of all possible relationships in the department were formed. The Dutch language department showed network density levels slightly below the levels seen in the mathematics department. Department-level centralisation findings suggested that the networks were least centralised in the environmental science department and most centralised in the mathematics department. This means that in the environmental science department, relationships were more evenly distributed among teacher educators, whereas in the mathematics and Dutch language department, relationships were more centred on a few teacher educators. Findings for reciprocity reflected more or less the same pattern as found for the centralisation and density measures, with higher levels of reciprocity in the mathematics department and lower levels in the environmental science department. These findings indicate that in the collaboration network 40% of all relationships in the mathematics department were reciprocal, but this was only 21% in the environmental science department.

Relations between the quality and quantity of collaboration

Regarding the relation of both perspectives (RQ), Pearson’s correlations coefficients are presented in Table 8. Results showed a statistically significant positive correlation between ego-network descriptives *degree* and *reciprocity* and each of the teacher educator collaborative activities “information” and “joint work”, indicating that on an aggregated level the number of relationships as well as the direction of the relationships contributed to the frequency of activities employed, with a medium effect size (ranging from 31% to 47% explained variance). This was also the case for in-degree in relation to the activity

Table 8. Correlations between networking aspects and activity-related aspects.

		Information	Joint work	Discussing
<i>Overall</i>	NrmOutdegree ¹	.31*	.47**	.17
	NrmIndegree ²	.36*	.45**	.29*
	Reciprocity	.38*	.33*	.18
<i>Department</i>				
Mathematics network	NrmOutdegree	.66**	.43	.30
	NrmIndegree	.55*	.69**	.70**
	Reciprocity	.59*	.65**	.39
Dutch language network	NrmOutdegree	-.21	-.26	-.05
	NrmIndegree	.18	.37	-.41
	Reciprocity	.57	-.54	.05
Environmental science network	NrmOutdegree	.22	.50*	.11
	NrmIndegree	.07	-.28	-.04
	Reciprocity	.29	.02	.09

¹NrmOutdegree refers to the normalised scores on Outdegree; ²NrmIndegree refers to the normalised scores on Indegree; **Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

“discussing”, although the effect size was somewhat smaller (29% of explained variance). However, no statistically significant relations were found between out-degree and reciprocity and the activity “discussing”. At the department level, statistically significant correlations were only found in the mathematics department and in one case in the environmental science department. In the Dutch language department, negative correlations were found between out-degree and teacher activities, indicating that having more outgoing relationships diminished the number of activities; however, these correlations were not statistically significant, and the effect sizes were rather small.

Conclusion and discussion

This study investigated teacher educators’ interactions while working collaboratively, using a qualitative and quantitative perspective. The aim of the study was to describe and to relate these two perspectives on teacher educators’ collaboration inside their subject departments, to assess teacher educators’ collaboration as it actually takes place during educational change. In the next subsections, we will discuss the most important findings regarding each of the research questions.

The quality of collaboration and variance per department

Different from Little’s (1990) four forms of collaborative activities, three different forms of collaborative activities of teacher educators could be distinguished in our data: “joint work”, “exchanging information and experiences”, and “discussing work”. Teacher educators reported forms of collegiality with low levels of interdependence (such as exchanging information) relatively more often compared to activities with a high level of interdependence. This finding was also reported in previous studies on teacher collaboration (Bakkenes, Vermunt, & Wubbels, 2010; Doppenberg, Bakx, & Den Brok, 2012; Doppenberg, Den Brok, & Bakx, 2012; Kwakman, 2003; Van Wessum, 1997). This indicates that teacher educator collaboration, as was assumed in our framework, can be compared to teacher collaboration with regard to the quality of the collaborative activities during educational change. Given the differences found between the three subject departments, our findings can add to the discussion regarding the meaning or nature of these differences. It appeared that teacher educators working within the environmental science department reported working collaboratively less often than teacher educators within the other two departments. This can be seen in relation to the implementation of a new teaching method, in which the specific content of the subject matter appears to matter (Deng, 2007; Grossman & Richert, 1988; Shulman, 1986). In line with our findings in the underlying study, Stodolsky and Grossman (1995) reported more collaboration within departments that are well defined, static, and sequential in nature, such as mathematics, compared to subjects without these features, such as English language and science. On the other hand, Witziers, Slegers, and Imants (1999) reported that English teachers were more willing to collaborate with colleagues within the department than teachers in math or environmental science departments. In line with our own findings, De Lima (2007) reported on differences in interaction between departments, such as density and centrality, in his study of two anonymous departments (A and B) in secondary education. Given the differences that were found in all of these studies, evidence is accumulating that collaboration differs per department due to their specific features. This implies that for supporting collaboration a different approach per department might be required, for example, focusing on norms regarding collaboration both within the department and across departments

(Coburn & Russell, 2008). More study is needed to further define these differences and find adaptive approaches that support collaboration as it presents itself within the departments.

The quantity of collaboration and variation per department

Results for teacher educators' relations were studied at the network level (department) and at the ego level (individual teacher educators). An overall trend in the results for the second subquestion (RQ 1.2) was the difference between the collaborative networks (i.e., information, advice, and joint work network), as shown by the results of the QAP test. This is an interesting result because it indicates that teacher educators interact with different colleagues for different purposes. This finding was also reported in studies of *teacher* networks (Daly, 2010b13; Moolenaar, 2012) and indicates that, in order to get a complete picture of teacher educators' collaboration, it is important to ask different network questions.

With regard to the network characteristics (degree and betweenness at the ego level and density, centrality, and reciprocity at the network level) in general, results indicated low to medium coherence in the networks. This indicates that conditions for collaboration, such as a dense and coherent network with strong ties between educators, as described in network studies (Finnigan & Daly, 2012; Krackhardt, 1992), were not fully met. Since trust and proximity are considered important conditions for forming relations (Daly, 2010), our results might imply that for teacher education institutes it is important to do more to build trust inside the departments and make improvements with regard to proximity in order to increase collaboration.

Key players in the networks

Network results indicated that some teacher educators occupied a more central position than others within their department, which might indicate them as key players (Atteberry & Bryk, 2010; Ferligoj, Doreian, & Batagelj, 2011). Two findings were of special interest in this respect. First, although one might expect that the central positions were occupied by educators with a formal structural position, such as department leaders, this was not always the case. Apparently, others than formal leaders are central to the network. This is an interesting result from a more organisational perspective, because leadership might be distributed among teacher educators, instead of being concentrated in formal leadership positions (Spillane, 2005). It also means that teacher educators in formal roles do not always enact their intended advisory role (Coburn & Russell, 2008; Moolenaar et al., 2011; Penuel, Frank, & Krause, 2010).

Second, all key players were located in one and the same location, of five locations of the teacher education institute. This might indicate that, next to departments, locations differed in their conditions for forming relations, and, as a result, for collaboration. Further research is needed to gain more insight into a possible relation between location characteristics and centrality of individuals.

With regard to differences between departments, again, some interesting findings became clear, indicating that collaboration is perceived differently by different departments. The mathematics department differed from the other departments with respect to density and centrality. The collaborative relations in this department were more coherent, meaning that resources were exchanged more easily and more members were involved in the collaborative process, with positive implications for sustaining innovation (Moolenaar et al., 2011). Possibly, this occurred as a result of their history in collaboration in national and regional mathematics networks (e.g., WC-bel, a former regional mathematics

network in the south of The Netherlands, and Panama, a national mathematics conference), but also aspects like a well-defined subject content (Stodolsky & Grossman, 1995) or department culture (De Lima, 2007; Siskin, 1994) may play a role in this coherence.

Relations between the quality and quantity of teacher educators' collaboration

Results showed few relations between activity-related aspects (interdependency) and networking aspects (degree, reciprocity), except for the mathematics department, where associations were found between all three forms of collaboration and degree. Especially the association of high interdependent collaborative activities like “joint work” with reciprocity and degree in this department were relatively strong and statistically significant at the 0.01 level. Given the absence of further statistically significant relations between the two perspectives in the other networks, this is an interesting result. It means that it *is* important to include both perspectives in further study of teacher educators' collaboration. Also, by relating both perspectives a more comprehensive view on teacher educators' collaboration can be obtained. For example, as was shown in this study, collaboration among teacher educators can gain not only from enhancing the quality of collaborative activities in general or “joint work” activities in particular, but also from forming more relations inside the departments, especially in the environmental science domain, and from developing the strength of ties.

Limitations

Like all research, this study had its limitations. In this baseline study, we focused on teacher educators of specific subject domains within five different locations of one primary teacher education institute. Due to the level of analysis, the response group for each of the subject departments was relatively small. Therefore, caution is needed in generalising results. Additionally, in future research, a more qualitative investigation of interdependence-related and networking aspects of teacher educators' collaboration may provide a deeper understanding of teacher educators' collaboration.

Although several techniques were used to explore teacher educators' interactions, another limitation is that data were collected at one single moment. A longitudinal design would open possibilities to follow the participants during a longer period of time, while passing through several phases within the innovation. Since the implementation of the national knowledge bases can be considered a large-scale educational innovation, it may be assumed that over time, changes in interactions and collaboration might occur.

Implications

The results of this study might be useful when aiming at enhancing the quality and quantity of teacher educators' collaboration during educational change. Increasing awareness among teacher educators regarding their own collaborative behaviour in terms of quality and quantity might be an important first step. Results of this study can be used by teacher educators or administrators to reflect on quality and quantity of their collaboration and to set goals for further developing collaboration within the departments. Such goals should be related to both qualitative and quantitative aspects, for example, encouraging teacher educators' “joint work” collaborative activities inside the department to increase interdependence in the relationships. Also, supporting exchange of experiences and successes related to the innovation (story-telling) as a means to build trust might help to develop forming

relationships and increase interdependence in the relations. Next, improving accessibility or reachability of teacher educators, for example, by using digital communication tools or aligning educators' lesson schedules across locations can be used as a means to support educators in forming and maintaining relations despite geographical distance. For reaching such goals, this also involves a critical review and prioritising of all department activities. The findings regarding key players imply that acknowledging and supporting informal leaders within the department in their role might help sustaining and increasing coherence in the networks. Finally, in order to prevent undesirable differences in implementation, it might help departments to regularly tune their approach with one another.

For further study of teacher educator collaboration, the results imply a need for using the two perspectives on collaboration, since each perspective provides its own unique insights. It might be interesting to investigate how these perspectives, being unique or (partly) overlapping can explain collaboration or possible changes in collaboration. To confirm our results, it is important to repeat this study in other (international) teacher education institutes.

Notes

1. Subject departments in teacher education involved in this study differ from subject departments in secondary education in that they cover more than one location.
2. "Factor analysis is any of several methods by which the researcher attempts to relate the calculated factors to theoretical entities (scales). This is done differently depending upon whether the factors are believed to be correlated (oblique) or uncorrelated (orthogonal)" (Vogt, 1993, p. 91). In this study, Oblimin rotation was used since factors were believed oblique.
3. In SNA, this test is referred to as the Quadratic Assignment Procedure (QAP).
4. In this study, strategies of extracting both ego-network and whole-network characteristics were used (Hanneman & Riddle, 2011). First, matrices were constructed for each network question, for each subject domain separately. Every matrix was built in the same way: If a Teacher educator *i* nominated Teacher educator *j* as a relationship, 1 was entered in the matrix cell *X_{ij}*. If Teacher educator *i* did not indicate a relationship with Teacher educator *j*, 0 was entered in cell *X_{ij}*. The procedure resulted in asymmetric matrices for every subject department for every network question asked, summarising all direct relationships among teacher educators. In order to analyse the networks, networks were made symmetrical by including only subject department members in the matrices. These matrices were necessary to calculate possible relations with actor characteristics.

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