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Understanding (in)formal learning in an academic development programme: A social network perspective

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Abstract Most professional development programmes provide teachers with formal and informal social networks, but limited empirical evidence is available to describe to what extent teachers build internal (within their programme) and external (with colleagues not involved in the programme) social learning relations. We triangulated Social Network Analysis with qualitative free exercise responses. Participants developed on average 4.00 internal and 3.63 external relations, and discussed teaching 128 times per year with externals. MRQAP modelling indicates group division, department, and friendships predicted learning ties. These findings indicate that research on impact of teacher education should widen its focus beyond the formal programme boundaries.

1. Introduction

Across the globe, several researchers (Author A, 2012a; Darandari et al., 2009; Ebert-May et al., 2011) have suggested that higher education institutions (HEIs) should provide adequate professional development, training and staff support for new academics. In a range of European countries, including Belgium (Stes, Min-Leliveld, Gijbels, & Van Petegem, 2010), Finland (Postareff, Lindblom-Ylänne, & Nevgi, 2007), the Netherlands (Author A, 2013b), the UK (Norton, Aiyegbayo, Harrington, Elander, & Reddy, 2010; Parsons, Hill, Holland, & Willis, 2012), and the US (Ebert-May et al., 2011), most universities have implemented some form of academic or professional development (PD) for new academics.

Recently several researchers in the US and Europe have urged for more robust research on the effects of these professional development programmes (Author A, 2013b; Lawless & Pellegrino, 2007; Stes et al., 2010). Although a large number of PD studies have focussed on learning satisfaction (for overview, see Stes et al., 2010), academic identities (Crawford, 2010), or (perceived) changes in teaching approaches by participants (Author A, 2013b; Ebert-May et al., 2011; Postareff et al., 2007), limited research has been conducted in order to assess whether

participants also learn from the experiences of other participants in their PD programme. As reflection on teaching practice and engagement in dialogues with colleagues is assumed to be of crucial importance for professional development (Author B, 2008; Moolenaar, Sleegers, & Daly, 2012; Postareff et al., 2007; Stes et al., 2010), limited studies are available whether participants indeed engage with each other and socially co-construct and share knowledge together beyond the "PD training room" (De Laat, Lally, Simons, & Wenger, 2006).

More importantly, to the best of our knowledge no empirical study is available to what extent participants engage in dialogues with people outside the formal PD programme (e.g., friends, family, partner, departmental colleagues, or colleagues at other institutions) about teaching and learning. . In line with ideas of Communities of Practice (De Laat et al., 2006; Wenger, 1998), uptake of PD may be dependent on the "external" network of participants (Akkerman & Bakker, 2011; Jones, Ferreday, & Hodgson, 2008; McCormick, Fox, Carmichael, & Procter, 2010) and/or the organisational cultures within the participants' departments (Daly & Finnigan, 2010; de Lima, 2007). As argued by Moolenaar et al. (2012), due to teachers' formal and informal interactions with colleagues and other network contacts, teachers may passively or actively engage in a dialogue with others about their teaching practice. In a study of 53 primary schools in the Netherlands, Moolenaar et al. (2012) found that cohesiveness of teacher networks in schools increased collective efficacy, and indirectly influenced children's achievement.

As argued by Daly and Finnigan (2010) and Author A (2013c), these (internal/external) professional development links cannot be easily measured by traditional educational psychology instruments. However, methods like Social Network Analysis can allow researchers to make these informal relations amongst participants and people outside the PD visible, thereby potentially improving our understanding of the impact of professional development activities. In

line with Social Network theory (Katz, Lazer, Arrow, & Contractor, 2004; Wassermann & Faust, 1994), recently several educational researchers (e.g., Daly & Finnigan, 2010; De Laat, Lally, Lipponen, & Simons, 2007; de Lima, 2007; Jones et al., 2008; McCormick et al., 2010; Moolenaar, Daly, & Sleegers, 2010; Moolenaar et al., 2012) have explored how teachers build social network relations with other teachers, and what the underlying mechanisms are for creating a cohesive community of learning professionals (De Laat et al., 2006). In different domains in education research, researchers have also explored social (student) networks by focussing on inter- and intra-group dynamics within a social network (Akkerman & Bakker, 2011; Author A, 2013a; Decuyper, Dochy, & Van den Bossche, 2010; Hommes et al., 2012) in order to explore why some learners or groups are actively looking to extend their internal and external group network, while others are primarily focussed on their own group.

In both teacher-focussed and student-focussed social network research, a consistent finding (see also section 2) is that formal and informal social network relations influence with whom people learn (Hommes et al., 2012) and build communities to effectively learn together (De Laat et al., 2006; Wenger, 1998). At the same time, not every learner benefits equally from these social networks, as some learners become central nodes in the social network (De Laat et al., 2006; de Lima, 2007; Moolenaar et al., 2010) or brokers between different groups (Author A, 2010, 2011; Daly & Finnigan, 2010), while others have limited or no professional development links.

The prime goal of this study is to understand to what extent teachers in a professional development programme develop internal (within their formal programme) and external (outside their programme) social learning and teaching relations. In this explorative case-study, we triangulated (closed and open) Social Network Analysis (SNA: Author A, 2012c; Author A,

2013a; Katz et al., 2004) with a free response exercise in order to compare and understand with whom 54 participants built and developed learning relations. SNA can be considered a wide-ranging strategy to explore and predict social structures to uncover the existence of social positions of (sub)groups within a network (Author A, 2013a; Curşeu, Janssen, & Raab, 2012; De Laat et al., 2007; Katz et al., 2004; Krackhardt & Stern, 1988). While some researchers (McCormick et al., 2010) indicate that SNA techniques provide limited insights in teachers' networks and can only be used as a metaphor how teachers develop networks, in this explorative study we aim to illustrate that SNA can be a useful method for academic developers, programme directors and researchers to obtain insights in the (in)formal learning of professional development.

2. Social network theory and analyses

A social network consists of set of nodes (i.e., participants in a professional development programme) and the relations (or ties) between these nodes (Wassermann & Faust, 1994). In social network theory, the focus of analysis is on measuring and understanding the social interactions between entities (e.g., individuals, teams, schools), rather than focussing on individual behaviour (Katz et al., 2004). A general assumption of social network theory is that people's behaviour is best predicted by the web of relationships in which they are embedded. Although historically studies in education have paid limited attention to the structure of teachers' social relations (Coburn & Russell, 2008), Moolenaar et al. (2012) argue that recently teachers' social networks are increasingly studied in order to understand to what extent teachers learn formally and informally from each other.

Research in the context of primary school teachers in the US, the Netherlands and Portugal have shown that social networks have a strong impact on trust, collective efficacy

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(Moolenaar et al., 2012), sharing of lesson materials (de Lima, 2007), teacher involvement in shared decision-making (Daly, Moolenaar, Bolivar, & Burke, 2010; de Lima, 2007), and schools' innovative climate (Coburn & Russell, 2008; Daly & Finnigan, 2010; Daly et al., 2010). For example, when comparing two different departments in the same Portuguese primary school using social network analysis, de Lima (2007) found that "teachers seemed to live in totally distinct worlds, both from a professional and from a social point of view". In a US study amongst five primary schools in an under-performing school district, Daly et al. (2010) found significant differences between schools in terms of reform-related social networks. "[R]eform goes through several layers of modification prior to teaching the classroom. The reform is first interpreted by the principal, modified at the grade level, and then finally delivered in the classroom" (Daly et al., 2010, p. 375).

2.1 Social capital theory and teacher's social network

While McCormick et al. (2010) doubt whether SNA research can be used to measure the complexity of teachers networks, numerous researchers have found that SNA networks provide robust and accurate depictions of actual learning processes and social networks (Author A, 2012c, 2013a; Curşeu et al., 2012; De Laat et al., 2007; Hommes et al., 2012; Katz et al., 2004). Recent research in higher education contexts in the US and the Netherlands highlights that social networks are a key predictor for learning (Gašević, Zouaq, & Janzen, 2013; Hommes et al., 2012). Most social network studies in education use social capital theory to explain how teachers develop and maintain formal and informal learning relations (e.g., Coburn & Russell, 2008; Daly et al., 2010; de Lima, 2007). Social Capital is a concept with probably the largest growth area in organizational network research (Author A, 2010; Borgatti & Foster, 2003; Ibarra, Kilduff, & Wenpin, 2005; Reagans & McEvily, 2003), which is concerned with the value of the resources

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that social network ties hold. Social capital can be defined as "resources embedded in a social structure which are accessed and/or mobilized in purposive action" (Lin, 2001, p. 12).

Generally there are four explanations why sources embedded in social networks may enhance the returns on an individual's actions (Lin, 2001). The first explanation is that embedded resources facilitate *information flows* between teachers, which consequently reduces the transaction costs, such as sharing of materials, new innovative practices, or lessons-learned (Coburn & Russell, 2008; de Lima, 2007). Second, social ties have a substantial *influence* upon how teachers deal with professional development and organisational change (Daly et al., 2010; de Lima, 2007; Moolenaar et al., 2010). For example, if a teacher who wants to explore a new pedagogical approach has a strong link with the department head, this teacher may be more likely to be given support to develop this new pedagogical approach, and would be allowed more risk-taking than a teacher who has weak relations to senior management. Third, social ties may be conceived as certification of *social credentials*, as it reflects a teacher's accessibility to resources through social networks and relations, thus his or her social capital (Lin, 1999). If this teacher's innovation is successful and his/her colleagues and senior management provide (in)formal recognition, other teachers are more likely to adopt the same innovation, even when no social support is given. Finally, social networks provide substantial psycho-social support (Moolenaar et al., 2010; Moolenaar et al., 2012), a sense of belonging (De Laat et al., 2006), and *reinforces identity and recognition* (Lin, 2001). According to Coburn and Russell (2008, p. 208), "[s]ocial networks develop as individuals form network ties based on their perceptions of others, reaching out to those whom they see have similar professional values, … who appear to occupy a similar structural position, … or whom they perceive as having expertise".

Typically, in social capital theory a distinction is made between the strength of a tie and the structure of the social network. Strong social ties support the transfer of tacit, complex knowledge, and joint problem solving (Daly et al., 2010; Reagans & McEvily, 2003). Hommes et al. (2012) found that Dutch medical students develop strong learning and friendship ties with a range of students to share knowledge and expertise, which substantially improved their copying mechanisms and academic performance. According to Daly et al. (2010), weak ties are better suited to transfer simple, routine information, but research by Granovetter (1973) and our own research (Author A, 2010, 2011) indicates that weak ties can allow (new) brokerage information that is not known within the strong dense network. In line with Borgatti and Foster (2003), a combination of strong ties with a substantial number of weak ties in different social networks will allow teachers to benefit from the diversity of social capital connections, while maintaining sufficient close and strong links with network connections who can be trusted.

2.2 *Knowledge spillovers and boundary-spanning in professional development programmes*

In many professional development programmes (Author A, 2013b; Parsons et al., 2012), teachers are put into small-group settings to allow them to share and reflect on their teaching and learning experiences, and build new professional skills and networks. In line with Author A (2012c), the introduction of groups as basic learning units redefines the physical location of a professional programme as a learning space; a space in which the different agents in the learning process − facilitators, groups and participants - are together. These learning activities resemble the sharing model of boundary-crossing (Akkerman & Bakker, 2011), which refer to a person's transition and interaction across different sites. For example, when teachers as participants join a professional development programme and interact with participants from different departments

in a small-group activity, participants need to develop strategies to create a joint problem-solving space to cope successfully with transitions and to allow them to cross boundaries between individuals, groups and disciplines.

The main premise of this understanding of boundary spanning activity is that knowledge is transferred, translated and transformed between (groups of) people working in different spheres of activity (Akkerman & Bakker, 2011; Author A, 2012c; Hsiao, Tsai, & Lee, 2011). Author A (2012c, p. 160) refer to cross-boundary activities between learners and groups as "knowledge spillovers", which are defined as "the positive influence that teams receive in terms of knowledge from other teams in the classroom".

Although the idea of knowledge spillovers in small-group settings makes intuitive sense and has been verified in organisational science contexts (Author A, 2011; Borgatti & Cross, 2003; Krackhardt & Stern, 1988) and educational (student) settings (Author A, 2012c, 2013a), sharing knowledge and expertise with other participants in a professional development programme is an implicit cost to an individual participant (e.g., spending time and energy to explain another participant/group, sharing a creative solution that others may "steal"), while the expected returns of receiving relevant new knowledge and expertise from others are unknown. In particular when teachers are obliged to join a professional development programme as part of their academic probation (as in our study), the incentive to pro-actively (and perhaps altruistically) share knowledge across the boundaries of the groups may be limited. In addition, the process of social network construction may be different for participants whose home disciplines exhibit tight boundaries (e.g., physics and mathematics), compared with participants from disciplines with loose boundaries (e.g., sociology and politics), or even those who are used to working in interdisciplinary teams (e.g., healthcare).

2.3 Moving from inward to external social network interactions in professional development

Although the education literature explored here provides important insights into how teachers learn informally and formally, few studies have focussed on to what extent participants in professional development learn *beyond* the boundaries of their training programmes. In other words, most studies using SNA in education (e.g., Author A, 2012c; Curşeu et al., 2012; Daly et al., 2010; de Lima, 2007; Hommes et al., 2012) have used a so-called *closed (ego-centric) network analysis*, using a predescribed list of participants (e.g., a class list). In contrast to student-focussed studies, in teacher-focussed research it is well-documented that teachers primarily identify their own identity based upon their grade-level (Daly et al., 2010), departmental structure (Daly & Finnigan, 2010; Daly et al., 2010; de Lima, 2007; Moolenaar et al., 2012), and particularly in higher education based upon their academic discipline (Author B, 2008; Clarke & Reid, 2012). For example, after a typical small-group activity in a professional development programme, a participant will return to his/her daily practice and will again work and interact with (the same) departmental colleagues, who may have different beliefs and values towards teaching and learning than those discussed during the professional development programme (Author A, 2013b; Author B, 2008). Several researchers have found that departmental structures have a strong impact on the uptake of professional development activities (Daly & Finnigan, 2010; Daly et al., 2010).

In addition, several early-career academics have already developed substantial external social networks. For example, friendships developed during their Bachelor, Master or PhD study conducted at a different institution or working on international research projects allows (some) academics to discuss their teaching and learning practice outside the formal organisational

structure of a university. In fact, our research in an online professional development programme (Author A, 2013b) highlighted that one of the reasons for its success was the opportunities for academic staff to work with colleagues from different institutions and disciplines, who might have a different perspective towards teaching and learning. Social network researchers try to identify the intensity and type of relation of these external (outside the organisation) links by using an *open network approach* (Author A, 2010; Wassermann & Faust, 1994). Rather than a predescribed list of names, in an open network approach participants are provided with open text boxes and are asked about the characteristics of their relation(s) with network contacts.

As a result, the degree to which participants engage and interact in a professional development programme is described as a complex function of individual motivation and drives, intra-group group dynamics (Decuyper et al., 2010), inter-group group dynamics (Akkerman & Bakker, 2011; Author A, 2012c), strength of social ties (Daly et al., 2010; Lin, 2001), departmental pressures (Author B, 2008; de Lima, 2007), and external relations. This is visually illustrated in Figure 1, whereby the circles or nodes represent academics, the colour of nodes represents their respective department, and the lines between two nodes represent a learning link in terms of teaching and learning between two academics. Note that for simplicity purposes the strength of a tie between nodes is assumed to be identical.

→ Insert Figure 1 about here

In the professional development programme (illustrated as a dashed box), in our context participants worked in small-groups of five. For example, Group 1 consists of two members from Department B (grey) and Department C (white) each, and one from Department A. The five group members have six (intra) group learning links, whereby one member from Department B

is the central connector. At the same time, the participant from Department A (black) has a learning link with a fellow-participant from the same department in Group n, which we refer to as an inter-group learning link, or knowledge spillover. This knowledge spillover may originate from (a combination of) prior expertise, friendship, or disciplinary context. An important point to remember is that as a result of this knowledge spillover both Group 1 and Group n can potentially profit from cross-boundary knowledge sharing. Similarly, there are two knowledge spillovers between Group 1 and Group 2. Furthermore, two participants in Group 1 have an external (from the perspective of the professional development programme) link to a member of Department A, as illustrated by the dashed grey lines. Finally, a member of Department C in Group 2 has external links with two people outside the university (as illustrated by the two nodes with a circle in the box).

As illustrated in Figure 1, research (Author A, 2012c, 2013a; De Laat et al., 2007) has highlighted that some groups (like Group n) develop strong and cohesive learning links with all members of their group, while others (like Group 2) develop relatively loose learning links within their group. In line with social capital theory (Borgatti & Foster, 2003), some groups primarily learn within their own group (like Group 1), while others (like Group n) develop strong knowledge spillovers with academics outside the formal professional development programme. Furthermore, departmental structures and cultures may facilitate or hamper knowledge sharing of professional development of teaching and learning (Author B, 2008; Daly et al., 2010; de Lima, 2007), depending on departmental values of and attitudes towards the (relative) merits of teachings versus research. This is illustrated in Figure 1 by the relative distance of the departments towards the professional development programme, whereby Department C is positioned at greater distance in comparison to Department A and B. This could for example be

due to the strategic focus in Department C on research and grant acquisitions rather than on teaching, while in Department A and B the quality of teaching is more important than research output.

Finally, a common finding in social network theory is that not all nodes have a similar number of connections. For example, in line with brokerage theories in a longitudinal study of a Linux global open source community of 2000+ programmers, Toral, Martínez-Torres, and Barrero (2010) found that a group of 5-12 key brokers provided the bulk of the contributions in this community, while Jones et al. (2008) in an online community of school principals and school teachers found that some key participants were central in the social sharing network. This is illustrated in Figure 1 by one academic in Department A who has a relatively large number of (external) knowledge spillover connections, also from participants of different departments.

2.4 Research questions

Based upon our theoretical framework, in this explorative case-study we anticipated that 54 academics who participated in a professional development programme after nine months of working together in small-groups would have developed substantial new teaching and learning links as well as friendship links. However, few studies have actually measured whether (or not) participants in professional development programmes develop such teaching and learning links, let alone which factors (e.g., discipline, group division methods, demographic factors) predict such social network links.

According to Daly and Finnigan (2010, p. 118) "[a] case-study approach is most appropriate when the phenomenon of interest has a level of complexity that requires multiple data sources and methods to gain an in-depth understanding". Please note that when we refer to learning we explicitly focus on learning from others about educational practices (e.g., how to prepare for a

lecture, how to create an assessment, how to provide feedback). In the first module of the course, participants were randomised into groups of five, while in the second module participants were allowed to self-select their group members. Therefore, we expected that learning relations over time would be influenced by the group division methods. At the same time, we expected that academics would continue to maintain and nurture their relations with their external contacts and colleagues from their own department or faculty. Therefore, the following research questions were formulated:

1. To what extent did academics develop teaching and learning, working, and friendship relations with other academics in the professional development programme?

2. To what extent were these social relations influenced by disciplines and group division methods, controlling for demographic factors (i.e., gender, cultural background)?

3. Finally, to what extent did academics develop teaching and learning relations with network contacts outside the formal professional development programme, and what was the basis for these relations?

3. Method

3.1 Setting

54 academics from four faculties (arts & social science, business & economics, engineering & physics, health & medical science) at a university in the south of England participated in a 18 month professional development programme called programme XYZA (name programme removed for blind peer-reviewing), consisting of four modules (i.e., theory and practice of teaching; understanding the curriculum; research in practice – part 1; research in practice – part 2). In contrast to traditional, workshop-based PGCAP or PGCert programmes in the UK where

participants follow a pre-described programme with typically a bi-weekly two hour session on topic A, B, C (Parsons et al., 2012), this programme uses a distinct approach starting from the teachers' daily practice and the educational problems teachers may face. During module 1, participants worked together on these educational problems in randomised small-groups consisting of four or five members, using principles of Problem-Based Learning and inquiry-based learning (Hmelo-Silver, Duncan, & Chinn, 2007). As a primary learning objective, participants were expected to develop greater understanding of their role as a teacher within the learning environment. After four months, each of the 13 groups presented their educational problem and possible solutions to a wider university audience.

During the second module, again in small-groups, participants had to design a new curriculum or module. Some groups redesigned an existing module, while others designed a new (fictitious) module. Participants were allowed to self-select their members, or if no preference was indicated were randomised in groups[i]. The final module design was presented to a wide university audience after eight months. With an estimated workload of 150 hours per module, the majority of hours were self-study, as only five face-to-face meetings of two-three hours were arranged per module. During the third and fourth module, participants conducted an individual piece of action research within their own teaching practice. Participants were put into groups based upon themes and formally met four times during the next eight months to share research ideas and experiences. However, most participants worked individually on their action research. Therefore, in this study we focussed on the first part of the programme, whereby participants worked intensively together in groups.

3.2 Participants

The average age of the 54 participants was 35.92 (SD = 6.29, range 26-57) and 59% of the academics were male. Participants were from 17 different departments, primarily from business (17%), electronic engineering (11%), mathematics and civil engineering (both 9%). Five participants had no other department member following the programme in their respective cohort. A large cultural diversity of 19 different nationalities was present, typical for an international science community, within which the largest group of participants (43%) were from the UK. As some participants did not have any co-nationals, in order to guarantee privacy of participants we used the GLOBE geo-cultural classification of House, Hanges, Javidan, Dorfman, and Gupta (2004). International participants primarily were from Latin-European and Confucian Asian countries (both 11%), followed by countries from Eastern Europe (9%) and Middle East (7%).

3.3 Instruments

3.3.1 Social Network Analysis of friendship, working, and learning and teaching networks

As a first step, during module 3 after participants had worked together for nine months we used a closed-network analysis (Author A, 2012c; Daly et al., 2010; Krackhardt & Stern, 1988), whereby a list with names of the 54 participants was provided and the participants answered three Social Network questions, namely "I have learned from…", "I have worked a lot with …" and "I am friends with ..." in a check-box manner. The reason for using check-boxes rather than Likert response scales of 1-5 (i.e., to measure the relative strength of a tie) was twofold. First, most participants worked with a limited number of participants, so asking them to rate the 53 participants for three separate networks (i.e., 159 questions) was considered to be too labour intensive for respondents. Second, as participants also had to complete the external network part,

the strength of the ties within the internal professional development programme was not measured to prevent questionnaire fatigue.

As a second step, we asked participants in an open network approach the following: "In addition to members of the [Programme XYZA], we are interested to know with whom you discuss your learning and teaching issues (e.g., how to prepare for a lecture, how to create an assessment, how to provide feedback). This could for example be with a colleague, a friend, family, or partner who is not following [Programme XYZA]." Participants were asked the name of each network contact, the frequency of contact (as proxy for strength of tie), the type of relation, and where each contact works. Although five rows were provided to add respective network contacts, sufficient space on the form was provided to add more than five contacts (if needed). A response rate of 89% was established for the open and closed SNA questions. The missing responses of the six participants were replaced by the transposed results from the 48 participants who also indicated their relations to the six missing respondents, as is commonly done in SNA research (Author A, 2013a; Neal, 2008). All calculations were based upon the 54 participants.

3.3.2 Qualitative reflection exercise

In line with recommendations of de Lima (2007) and Coburn and Russell (2008), we triangulated the social network analyses with qualitative techniques in order to detect, illustrate and diagnose the complex patterns in professional development. One month after the SNA questionnaire was distributed, we presented the results in the form of two social network graphs (learning & friendship network) during a face-to-face session, which was attended by 45 participants. The names of the participants were replaced by random-numbers representing each of the four

faculties (i.e., 1-4), and the nodes were coloured based upon the group division during the first module (See Figure 2-3 in section 4.1).

As a first step of the free response exercise, participants were asked to reflect individually on the social network graphs for ten minutes. That is, participants were asked to reflect on three open questions: what is the first thing that comes to mind when looking at these networks?; why are some groups closely clustered?; and can you identify yourself in the graphs, indicate why? As a second step, participants worked together in pairs and were asked to discuss their own reflections and compare notes for five minutes. Third, a 10 minute discussion with the entire group was facilitated twice (given that this session was divided over two time slots) by one of the authors of this article, whereby the emerging themes and concepts were shared in an open dialogue, and interactively stored using PowerPoint. One hour after the open dialogue exercise was completed, participants who were working on a different task with their respective facilitator were asked to share their written personal reflections. 15 (33%) participants were willing to share these reflections[ii].

3.4 Data analysis

First, a graphical analysis of the three closed (Programme XYZA) networks was conducted in order to identify the overall social network structure and to identify possible patterns of sub-group development, as recommended by Wassermann and Faust (1994). In line with Author A (2013a), two group division matrices (module 1, module 2) were constructed, a procedure similar to creating a dummy-variable for each person within the same group in "classical" statistical analyses. Furthermore, two matrices were constructed for the respective departments and faculties participants were working in, as de Lima (2007) argues that departments and faculties

in general can be characterised as distinct social worlds. Finally, we constructed a GLOBE matrix in order to control for cultural factors, in line with Author A (2013a).

Afterwards, quadratic assignment procedure Pearson correlations and multiple regression quadratic assignment procedures (MRQAP) were used to test whether group divisions, departmental or faculty networks, or culture influenced friendship, working, and learning and teaching relations. Basically, MRQAP tests are permutation tests (2000x) for multiple linear regression model coefficients for data organised in square matrices of relatedness of friendship and learning and teaching, and the interpretation of the standardised betas is similar to OLS regression analyses (Author A, 2013a; Krackhardt, 1988). As measure of fit for each model, UCINET provides a R-square adjusted score, which can be interpreted similarly as classical OLS regression analyses. Data were analysed on a network level using UCINET version 6.445.

For the open network of external relations, we measured only outgoing links to external contacts. Conducting (MR)QAP analyses in a similar manner as above is prone to lead to an overrepresentation of participants' degree of centrality in the network. That is, as the external network contacts were likely to have several links to other non-Programme XYZA participants (which we did not measure); the relative central position of the Programme XYZA participants may be an artefact of the data collection process. As we were primarily interested in the network relations of the Programme XYZA participants, all data was coded and organised in SPSS and only descriptive analyses were conducted.

All academics participated voluntarily in the SNA and free-response exercise. Participants who were not present during the session(s) were contacted via email. The participants were guaranteed that the results would be completely anonymised and participation was voluntary. Both authors (one who taught on the programme, one who had no prior

involvement with the programme) analysed the transcribed qualitative data to identify key concepts to reflect the meanings attributed to the data (e.g., Lichtman, 2013). Afterwards, notes were compared, and similar emerging themes were identified.

4. Results

4.1 Power of Social Network Analysis to understand (in)formal learning and teaching

In order to illustrate the power of SNA in understanding how learning and teaching, working, and friendship networks of the 54 participants in the professional development programme after nine months developed and to address research question 1, Figure 2-4 are presented. Seven aspects can be distinguished from these figures. First of all, Figure 2 illustrates whom participants considered as their friends. The colour and shape of the node represents the respective faculty of each node (i.e., participant)[iii]. For example, on the left of Figure 2, two groups of academics from Business and Economics (black, diamond) were friends, while another cluster of Business & Economics was present on the bottom right. Second, some participants were on the outer fringe of the friendship network and were not well-connected to other learners, while two participants had no friends after nine months in this program.

➔ Insert Figure 2 about here

Third, friendship seemed to be related to faculty and departmental (not illustrated) structures. For example, participants from the top-left black diamond group in Figure 2 were all from the same Economics department, while the bottom group on the left were all from the Business department, while participants of the bottom group on the right were all from the

Hospitality department. Fourth, several friendships were based upon group-divisions during the first module, such as groups 22, 24 or 27. Note that four participants who did not join module 1 (e.g., switching universities, maternity leave) were labelled with 0.

Fifth, in terms of the learning and teaching network in Figure 3, the group-divisions during the first module seemed to have a more profound effect on the structure of the learning and teaching (sub) groups than on friendship relations. In addition to three friendship groups (i.e., 22, 24, 27) already identified in Figure 2, also a clear group learning and teaching structure can be identified for seven groups (i.e., 21, 23, 25, 26, 28, 30, and 32) in Figure 3, in line with our initial visualisations in Figure 1. In two groups (29, 33), one or more members of the group were only linked with one connection, indicating a less cohesive group structure.

→Insert Figure 3 about here

Sixth, as illustrated in Figure 4 three separate clusters were present in the working network, whereby group 22 and 26 indicated to have worked only with their respective group members, while the eleven groups worked also with other non-group members. Finally, three of the participants who did not join module 1 were on the outer fringe on all three networks, and network links were primarily out-going, mostly without receiving reciprocal links. This seems to indicate that late-comers in the programme developed fewer reciprocal learning and teaching relations with other participants.

→ Insert Figure 4 about here

4.2 Predicting learning and teaching, working, and friendship ties within Programme XYZA

Although network visualisations give important first impressions of the social network patterns, follow-up quantitative analyses are needed to determine whether these patterns were statistically significant in order to answer research question 1 and 2. In Table 1, the descriptive statistics of the group divisions in module 1 and 2, the participants' respective specialisation and the social networks are illustrated. On average, participants developed 3.37 friendship relations within the professional development programme. Of these friendships, 1.52 friendships were based upon the initial group division during module 1, while 1.85 were based outside their first group. Participants had on average 4.00 learning and teaching relations, of which 2.56 were based upon the initial group division during module 1, while 1.44 were based outside their own group. A similar distribution was found in terms of the working network.

➔ Insert Table 1 about here

Follow-up QAP correlations in Table 1 indicated that the initial group division in module 1 was significantly related to friendship, learning and teaching and working networks after nine months. The discipline specialisation and cultural backgrounds were unrelated to the initial group division, as participants were randomised during module 1. However, the group division in module 2 was significantly related to the department and faculty participants were working with in order to co-design their module. As participants were allowed to self-select the members of their group in module 2, (some) participants seemed to have selected participants from their own disciplines. Furthermore, the rhos of the group division in module 2 with the three social

friendship, work, and learning and teaching networks were substantially larger than those of the group division in module 1, in particular for friendships.

→ Insert Table 2 about here

In order to identify the (relative) magnitude of the group divisions, specialisation and cultural backgrounds on friendship, learning and teaching, and working networks and to address research question 2, we used multiple regression quadratic assignment procedures, as illustrated in Table 2. In Friendship Model 1, friendship ties were significantly predicted by the group division in module 2 ($\beta = .39$; $p < .01$), followed by same department ($\beta = .29$; $p < .01$) and group division in module 1 ($\beta = .15$; $p < .01$), whereby β represent standardised betas. This indicates that the group division in module 2, when participants were allowed to self-select their group members, was the best predictor for friendship, directly followed by the proxy of the same department. Neither the matrix for same faculty, cultural background nor gender was a significant predictor for friendship. In Friendship Model 2, learning and teaching and working networks were added in order to determine whether the learning and teaching, and working social interactions during the programme influenced friendships, whereby the learning and teaching network ($\beta = .26$; $p < .01$) and same department ($\beta = .24$; $p < .01$) primarily predicted friendships, followed by the working network ($\beta = .21$; $p < .01$) and group division in module 2 ($\beta = .17$; $p < .01$). The beta of group division in module 1 was negative, though small in size. Separate analyses (not illustrated) indicated that this was primarily a result of the addition of the working network, which had a strong overlap with the group division in module 1.

In Learn Model 1, the learning and teaching network was primarily predicted by group division in module 2 (β = .46; p < .01) and group division in module 1 (β = .35; p < .01), followed by same department (β = .11; p < .01). Adding the working and friendship networks further improved the fit of Learn Model 2, whereby the working network was the most powerful predictor for learning and teaching. As the group division proxies remained significant, this indicates that the learning and teaching network was primarily predicted by whom participants worked with in their small groups.

Finally, as indicated by Work Model 1, both group divisions were strong predictors of the working network, which is a rather straightforward finding when participants are "forced" to work in groups. Adding the learning and teaching and friendship networks to Work Model 2 further confirms that group divisions were primarily predicting work relations. For all six Models, a good fit in terms of R-square adjusted was found, as 36-70% of the variance was explained by the models. In other words, a substantial amount of variance was explained by the group divisions in the programme and the departmental structure. Neither gender nor nationality (GLOBE culture) significantly predicted any of three social networks, indicating that social interactions were not influenced by cultural backgrounds or differences in gender. Furthermore, working at the same faculty did not significantly predict the social networks when the proxy for the same department was included. This indicates that when participants were from a different department within the same faculty, this did not positively predict social interactions.

4.3 Qualitative free response exercise

Analyses of the qualitative data highlighted five categories within the responses, with subsequent analysis revealing two key emerging themes: 'friendship' as a factor within the networks that may contribute to the strength of links; and 'persistence' of initial groupings as a factor that

seemed to inhibit the formation of new links, particularly with peers from different faculties. One month after completing the SNA exercise, in the open dialogue the first thing mentioned by participants was that friendship networks seemed to be related to the same faculty. Although participants were not provided with the detailed information about each department (given that five participants were the only representatives of their department and could be easily identified), some participants explicitly indicated that friendship relations were related to departments.

> *Fig. [3] is clustered because we all definitely worked with each other (except the burgundy group) [eds. participants with number 0 in Figure 2-3, who were not enrolled in module 1] & I hope it means most groups identified that they all learned from each other (two-way areas, each cluster member links to all the others). Fig. [2] has greater mix of colours (groups "swapping"), but more clustering by number (friendships within faculties)* (#104, UK, Female, group 30 in module 1, Business, 39 years old)

One of the reasons why the friendship network is relatively based upon disciplines was explained in the following ways. Participants indicated that this might be related due to a shared language, as many academics identify themselves according to their own discipline or specialisation (Author B, 2008). Interestingly, a specific specialisation mentioned during one of the sessions was engineers, who were in relative large numbers in the programme, but at the same time may not be interested in developing friendships outside their own discipline. Furthermore, some participants indicated that personalities might (partially) influence the results, whereby some people are more outgoing and have stronger social skills than others.

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A second emergent theme was the relatively strong group structures in the learning and teaching network, as indicated by participant #140. These interactions were related to the initial group division according to several participants. At the same time, the self-selection processes in module 2 might have resulted in some groups switching members, as indicated by participant #147.

Most groups tend to interact mostly within, but a few groups seem to branch out and interact with other groups as well --> when looking at interactions between groups, it also seems that the interactions mostly take place between members of the same faculty. There appears to be lesser interaction across faculties and a reluctance to mix (#140, Eastern European, Female, group 24 in module 1, Arts & Social Science, 31 years old).

One participant indicated that the reason why some groups were interacting more with other groups was a result of how relationships developed during the first module. Although no specific data were presented about the group structure of module 2 (which according to section 4.2 was a better predictor for the three social networks), many participants indicated that the group division methods strongly encouraged learning and teaching within their own group, rather than potentially looking for learning and teaching links outside the formal group structure.

4.4 External learning and teaching relations

In Table 3, the descriptive statistics of external learning and teaching relations are illustrated. In total 174 network contacts outside Programme XYZA were used to discuss learning and teaching issues, whereby 149 unique names were provided, indicating that some (external) network contacts provided support for multiple Programme XYZA participants at the same time. Ten

participants indicated not to discuss their learning and teaching practice with external relations. On average, participants had 3.63 learning and teaching-related relations to people outside the professional development programme, leading to a total of 7.63 network relations (including participants from Programme XYZA) from whom an average participant was learning in terms of his/her teaching practice. In a study by Daly et al. (2010) in primary education, "only" 1.8 links per participant were found within a school, while in a Dutch study (Moolenaar et al., 2012) 4.5 links per participant within a school were found.

→ Insert Table 3 about here

As participants could indicate multiple relations with each network contact (e.g., colleague, supervisor & friend), the subdivision in Table 3 does not add up exactly to 100%. Most of the external learning and teaching relations were based upon colleagues from the same discipline and same department. This is also highlighted in Figure 5, whereby the formal and informal network relations of the 54 participants with the 149 externals towards learning and teaching are illustrated.

→ Insert Figure 5 about here

In Figure 5, most external contacts were from the same Faculty (as illustrated by the same shape of the participant's node). Interestingly, 40 (24%) network contacts were from outside the participants' institution, primarily colleagues at other universities from the same discipline, their partner, or their (former) supervisor. Although the majority of participants had more network

contacts from the same institution than from outside the institution, five (9%) participants had more learning and teaching links with network contacts outside their institution.

Conducting a conversion of frequency of contacts (daily = 200, weekly = 40, monthly =12, quarterly = 4, yearly = 1), on average participants indicated to discuss learning and teaching 128.40 (SD = 106.37) times per year with network contacts outside Programme XYZA. In terms of frequencies, eight participants had daily contact with in total eight external contacts (5%) to discuss learning and teaching, 38 participants had weekly contact with in total 72 contacts (41%), 29 participants had monthly contact with in total 76 contacts (44%), eight participants had quarterly contact with in total eleven contacts (6%), and six participants had yearly contact with in total seven contacts (4%).

In other words, two thirds of the participants discussed learning and teaching with external contacts at least on a weekly basis. Although this number may overestimate the actual number of times participants discussed learning and teaching practices, due to known issues of self-reporting and problems with recalling interactions (Neal, 2008), this number does highlight an important issue frequently ignored in teacher education research. Participants in professional development programmes formally and informally discuss their learning and teaching experience frequently with several people outside their formal programme. Focussing only on what happens in the training programme "in the classroom" may fundamentally underestimate the true impact of professional development.

5. Discussion and conclusion

Whilst across the globe teachers undertake teacher development programmes as individuals, it is important to recognise the social element of such programmes (Daly & Finnigan, 2010; de Lima, 2007). This is commonly recognised by PD participants, and is often exploited deliberately by

course organisers to encourage participants to share their professional experiences with peers within their Community of Practice. In other words, PD programmes may facilitate social interaction with peers from other (academic) departments with whom they may otherwise never have any direct contact, and so work across 'structural divides' of university departmentalism (Clarke & Reid, 2012). This is often with the intention of promoting the development of greater insight to the generic issues of learning and teaching (Author B, 2008; De Laat et al., 2007; De Laat et al., 2006; McCormick et al., 2010). However, whilst it may be assumed that participants within such programmes are making "new" learning and teaching links with their peers, it is rarely tracked or documented (Jones et al., 2008; McCormick et al., 2010), let alone modelled or specifically triangulated with qualitative reflections from participants of such programmes in order to explore which factors contribute to internal and external learning and teaching knowledge sharing.

In line with previous findings (Daly & Finnigan, 2010; Daly et al., 2010; De Laat et al., 2007), using principles of social capital theory we found that the majority of the 54 participants in an internationally diverse professional development programme developed a range of internal and external friendship, learning and teaching and working relations after nine months. Participants had on average 4.00 learning and teaching relations within the professional development programme, of which 2.56 were based upon the initial group division during module 1, while 1.44 were based outside their own group (Research Question 1). In other words, 36% of the learning and teaching relations within the professional development programme were characterised as knowledge spillovers (Author A, 2012c), which are positive influences that groups of learners receive from other groups in the course. As highlighted by recent research (Akkerman & Bakker, 2011; Author A, 2013c), most research in educational science and teacher

education in particular often ignore the informal learning and teaching processes within the formal training programme.

A first new contribution is that we were able to model the social network structures how some academics develop strong learning and teaching links within professional development programmes, while others primarily learn outside the formal course (Research question 2). QAP correlations and MRQAP regression modelling and triangulations with the free response exercise indicate that social network relations were primarily related to the group division in the programme and the respective departments participants were from. As participants were allowed to self-select group members in module 2, a positive experience during module 1 seemed to have led to continued work-relations. Cultural backgrounds and gender were not significant factors in explaining the three social networks. In other words, in line with previous findings (Author A, 2013a) when participants work together for a substantial period of time, learning and teaching and friendship links develop across cultural boundaries or gender due to intensive small-group work, although the organisational culture (i.e., departments) remain important facilitators for knowledge spillovers.

A second new contribution is that we also explored the extent to which academics developed and maintained learning and teaching links outside the formal professional development programme (Research question 3). The results indicate that participants had on average 3.63 external learning and teaching-related relations to people outside the professional development programme, with an average intensity of dialogue of 128 times per year. The majority of external contacts were from participants' departments or faculties, while 24% of contacts were from outside the boundaries of the respective university. Although the majority of participants had more internal learning and teaching links with fellow-participants, 9% of the

participants had more external learning links outside the formal learning programme. Four of these five participants were positioned on the outer fringe in the learning and teaching and working network (see Figure 3-4). This is not surprising and reflects the situation that exists where formal support systems are not well-developed and informal communications with (external) colleagues can provide an important source of support in teaching-related matters (Remmik, Karm, Haamer, & Lepp, 2011). Perhaps these participants already had strong external relations to discuss their learning and teaching practice, and therefore the need to develop strong internal relations with other participants might be less outspoken? Or alternatively due to a lack of internal connections, some of these participants used external networks to discuss their teaching practice outside the formal Programme XYZA.

Whilst we can visualise, calculate and model the numbers of links that our participants were forming inside and outside of the programme, the data do not tell us about the relative importance of these links (in terms of the influence of the information shared on developing practice), or the exact type of information that is being shared. Furthermore, any pre-existing relations not based upon working in the same department (e.g., friendships developed during PhD, member of same sports club, children attending the same school) were not controlled for. These learning and teaching links inside the professional development may also been based or strengthened outside the professional development programme. One might surmise that colleagues within departments are sharing information that would be closely tied to the departmental teaching context (the practical knowledge that comes from experience), whereas the programme may be a site for discussion of some of the more conceptual/theoretical understanding of the principles that underpin teaching that are less tied to disciplinary context. In order to examine this possibility, future research needs to analyse and compare the structure of

the discourse taking place within the programme and between the professional development programme participants and their (external) colleagues (as discussed by Shay, 2012).

Overall, in this explorative case-study in a UK context we found support for the notion that the method of social network analysis, when used appropriately, can provide researchers and professional development some useful new tools to visualise and to understand the informal learning and teaching interactions in formal training and professional development. Both within the professional development programme as well as with colleagues and network contacts outside the programme, all 54 participants intensively engaged in discourse outside the formal group structure they participated as part of the programme, echoing the findings by Crawford (2010, p. 196) that "externality is significant in shaping professional development".

5.1 Limitations

A crucial limitation of our findings is that both closed and open social network analyses of learning and teaching networks were self-survey instruments, whereby socially desirable behaviour might influence the results. However, a large body of research (Borgatti & Cross, 2003; Curşeu et al., 2012; Daly & Finnigan, 2010; Daly et al., 2010; de Lima, 2007; Hommes et al., 2012) has found that SNA techniques provide a robust predictor for actual social networks and professional development programmes, in particular given the high response rates (89%) and the triangulation of the results with participants one month after their initial contributions. Furthermore, given that we used multiple regression quadratic assignment procedures to predict the social learning and teaching networks, which is a conservative technique (Krackhardt, 1988) given that 2000 random permutations of alternative models were conducted, we found strong and robust findings (with adjusted R-squares explaining 36-70% of variance) that primarily group-divisions and departments are predicting learning and teaching relations.

A second limitation is that this study only considers the social interactions during the progress of the professional development programme. It would be interesting to see if the internal connections remain active after the programme has ended, and if those at the centre of the network maintain their links for longer than those on the fringes. This might be offered as a measure of the effectiveness of such programmes: their ability to forge lasting multidisciplinary networks of academics with an active engagement in learning and teaching. Finally, the context of professional development in higher education in the UK (Norton et al., 2010; Parsons et al., 2012) may be substantially different from other contexts across the globe. Therefore, we encourage researchers to explore the formal and informal interaction patterns in professional development programmes using similar social network analyses within their own (cultural) context.

5.2 Future research and practical implications

The intensity and amount of external (from a programme perspective) contacts that participants used to further improve their learning and teaching practice is perhaps one of the most interesting findings of our study. In particular with declining budgets for training and increased focus on impact of such programmes, ignoring an important impact of social networks of academics on their professional development seems to require an urgent rethink of teacher education research (Daly & Finnigan, 2010; Daly et al., 2010; Moolenaar et al., 2012).

Future research needs to investigate how individual participant's personal/disciplinary knowledge structures (Donald, 2002) may influence the likelihood of developing, and 'success' of potential knowledge spillovers with peers on a professional development programme. Furthermore, taking into consideration the relatively strength of a social tie in future research may provide a more in-depth understanding of the complex roles of key brokers inside and

outside the professional development programme. Given the positive effects of knowledge spillovers found in student-learning and organisational behaviour settings (Akkerman & Bakker, 2011; Author A, 2011, 2012c; Borgatti & Cross, 2003; Hsiao et al., 2011; Krackhardt & Stern, 1988), academic developers may pro-actively encourage knowledge spillovers between individuals and groups, thereby potentially minimising the outlier effects identified in our context. For example, by organising frequent inter-group knowledge exchanges (e.g., brainstorm sessions, mutual group presentations of interim results) rather than a final group presentation (in our context) may encourage more opportunities for groups to build knowledge spillovers. Alternatively, redesigning the task structure and assessments (e.g., peer-reviewing of group processes and outcomes) may encourage further knowledge spillovers across groups.

From a methodological perspective, several barriers need to be overcome by educational researchers in terms of measuring the relative strength of social network ties as well as and transforming open-network data. Measuring the strength of social ties (e.g., 1 = less than once a year, 5 = daily; or 1 = weak, 5 = strong) requires a valuation for each social network relation for a participant. In SNA analyses with more than 30-40 questions (i.e., 40 participants, or asking two SNA questions about 20 participants), this may rapidly lead to questionnaire fatigue and/or recall issues (Neal, 2008). One option for large social networks may be to ask participants to list the five or ten most strong or frequent relations in a social network (Wassermann & Faust, 1994). Alternatively, a combination of checkbox and a valuation of the strength of tie when selected could be adopted. Furthermore, most SNA programmes prefer to work with dichotomised data (i.e., 0 or 1), thereby requiring researchers to make a value statement where to cut the response into a strong or weak tie.

In contrast to a closed-network analysis, whereby the number of participants are known and constructing a matrix of social interaction patterns is relatively straightforward (i.e., 54*54= 2916 connections in our context), in an open-network analysis the actual size of the network is technically unlimited. In practical terms, most SNA researchers (Borgatti & Cross, 2003; Wassermann & Faust, 1994) define the boundary of the network by the number of external contacts mentioned by participants, who in contrast to the closed-network analyses are (of course) not listed alphabetically by participants. In our study this led to (149+54)*203= 41209 possible connections. Although SNA software programmes like UCINET provide some useful features to fill zeros and missing data, substantial manual labour is needed to construct such open networks in order to visualise the informal learning and teaching processes of professional development.

Finally, using similar SNA analyses of external networks, academic developers may actively include external academics who already play an informal brokerage role in knowledge sharing for several participants, e.g., by giving guest-lectures or workshops. The nodes in the networks depicted in this study did not differentiate between participants in terms of power. Some of the nodes may represent Heads of Department or other senior managers who may hold more influence over a particular participant, as they are also involved in the management and appraisal of the individual. Other peer-to-peer links may be more collegial than managerial. Enhanced understanding of the quality of links depicted would offer insights to the role of links in helping to 'break isolation' or to promote 'withdrawal', characterised by Hadar and Brody (2012, p. 6) by "resistance to adopting new ideas while constructing various protective mechanisms to prevent significant learning". In other words, we encourage further research in the informal social learning and teaching relations in professional development, but more

importantly to also pro-actively use the external and informal contacts in professional development to further improve the (informal) impact of professional development.

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Author A 2010 (Rienties, Tempelaar, Pinckaers, Giesbers, & Lichel, 2010)

Author A 2011 (Bohle Carbonell, Rienties, & Van den Bossche, 2011)

Author A 2012c (Hernandez Nanclares, Rienties, & Van den Bossche, 2012)

Author A 2013a (Rienties, Hernandez Nanclares, Jindal-Snape, & Alcott, 2013)

Author A 2013b (Rienties, Brouwer, & Lygo-Baker, 2013)

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Table 1 Descriptive statistics of group divisions, specialisation, friendship, learning and teaching, and working networks and (QAP) correlations

	M	SD	1	2	3	4	5	6	7	8
1. Group division in module 1	4.17	0.71								
2. Group division in module 2	3.31	1.01	.58**							
3. Same department	3.18	2.21	.00	.15**						
4. Same faculty	13.50	8.35	.03	.06*	.41**					
5. GLOBE culture	6.00	7.75	.00	.07**	-.01	.05				
6. Friendship	3.37	1.66	.37**	.52**	.35**	.17**	.06*			
7. Learning & Teaching network	4.00	1.63	.62**	.68**	.17**	.08**	.05*	.57**		
8. Working	4.00	1.59	.68**	.70**	.14**	.07**	.05*	.55**	.77**	
9. Gender	27.00	7.07	.04	.05	.03	.04	.02	.05*	.05*	.04*

$*p < .01.$ $**p < .001.$

Table 2 (MRQAP) Regression analyses of social friendship, working, and learning networks, specialisation and cultural differences (standardised beta coefficients)

	Friendship Model 1	Friendship Model 2	Learn Model 1	Learn Model 2	Work Model 1	Work Model 2
1. Group division in module 1	.145**	-.038*	.353**	.140**	.430**	.275**
2. Group division in module 2	.385**	.174**	.458**	.205**	.435**	.212**
3. Same department	.288**	.242**	.107**	.025*	.084**	.010
4. Same faculty	.023	.024	.000	.000	-.008	-.011
5. GLOBE culture	.031	.021	.021	.006	.022	.011
6. Gender	.014	.011	.011	.008	.002	-.004
7. Learning & Teaching		.264**				.393**
8. Working		.209**		.444**		
9. Friendship				.156**		.110**
R-Squared adjusted	.359	.430	.550	.661	.609	.700

*p < .05, ** p < .001

Table 3 Descriptive statistics of external learning and teaching network (outside Programme XYZA)

	M	SD	Max	Sum
Total contacts outside Programme XYZA	3.63	2.21	10	174
Same discipline	2.79	1.99	8	134
Colleagues	2.58	2.11	10	124
Same department	2.54	1.90	8	122
Externals outside the University	0.83	1.00	4	40
Friends	0.65	1.58	9	31
Supervisors	0.54	0.68	3	26
Partners	0.38	0.49	1	18
Family	0.04	0.20	1	2

n = 48 (6 participants did not respond to questionnaire)

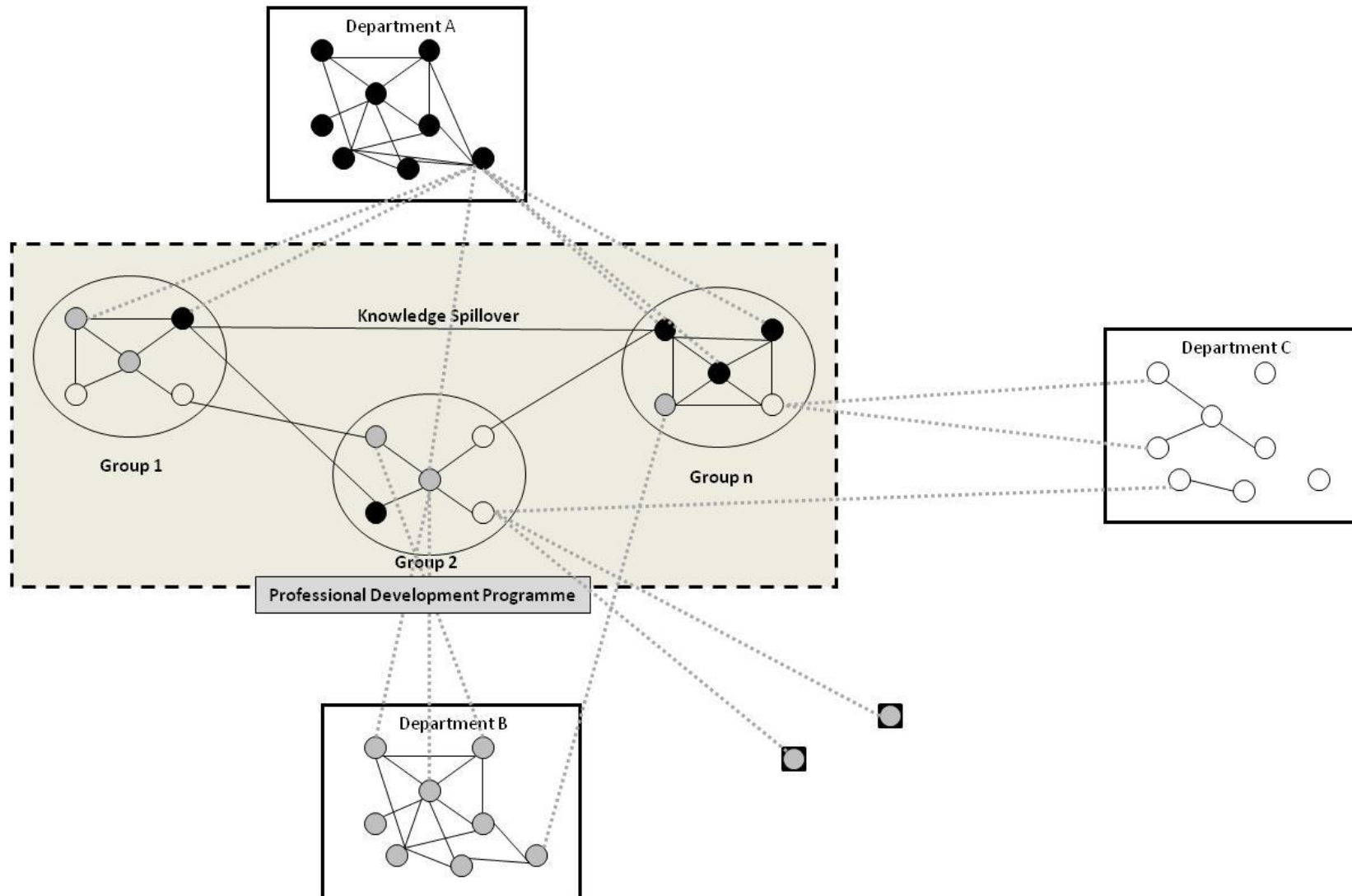**Figure 1 Internal and external knowledge spillovers in professional development programme**
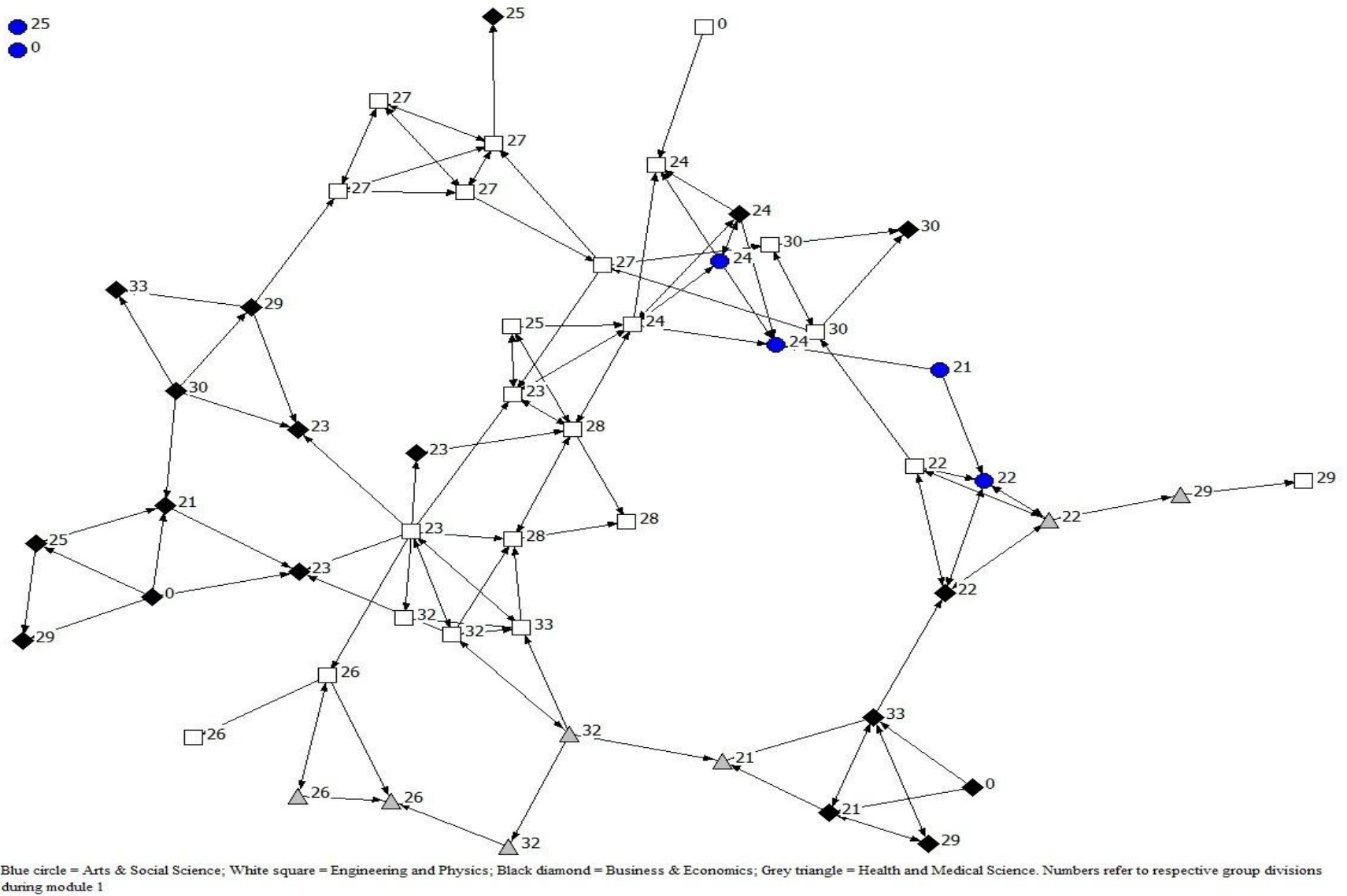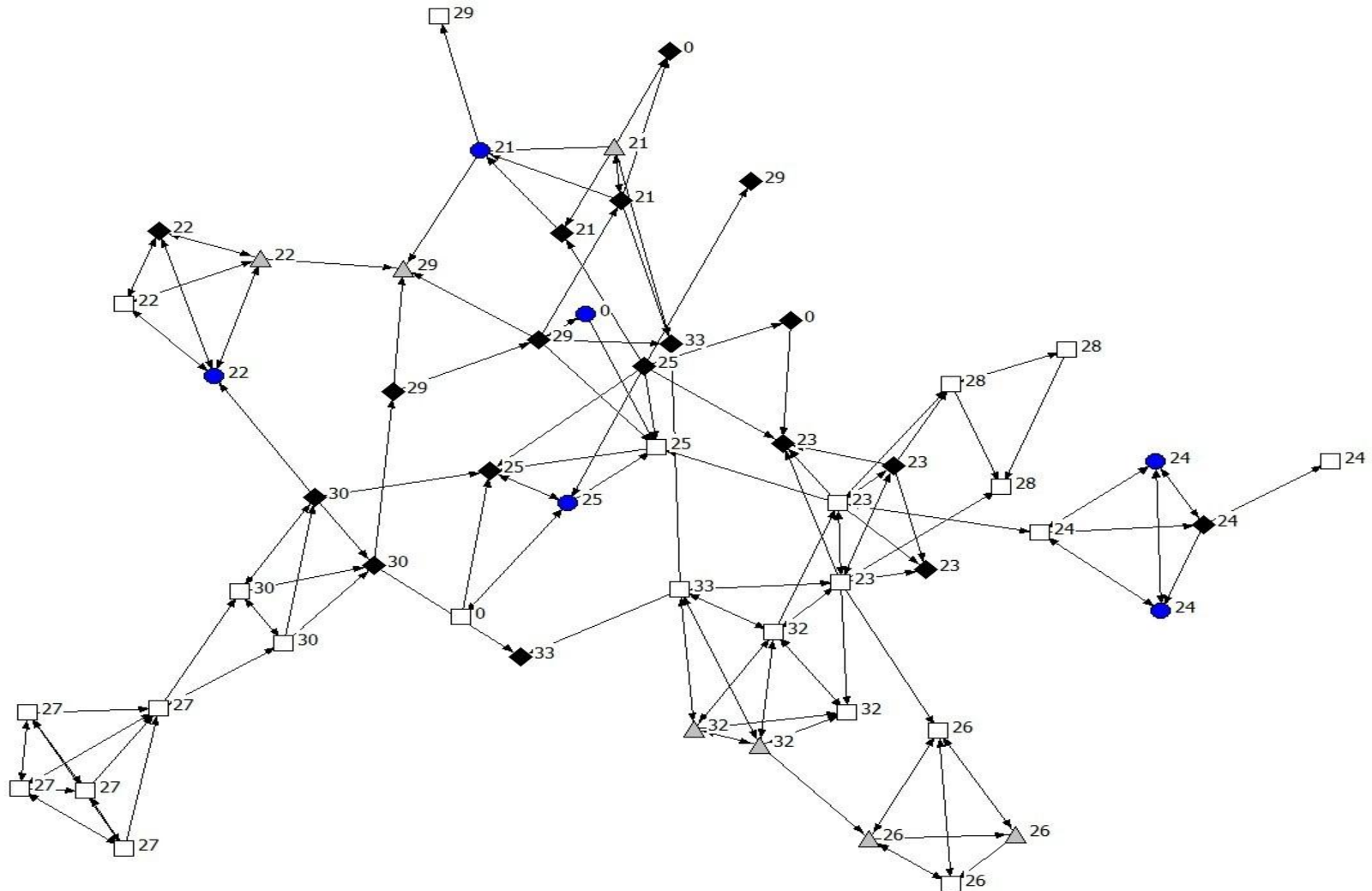
Figure 2 Friendship network after nine months

Blue circle = Arts & Social Science; White square = Engineering and Physics; Black diamond = Business & Economics; Grey triangle = Health and Medical Science. Numbers refer to respective group divisions during module 1
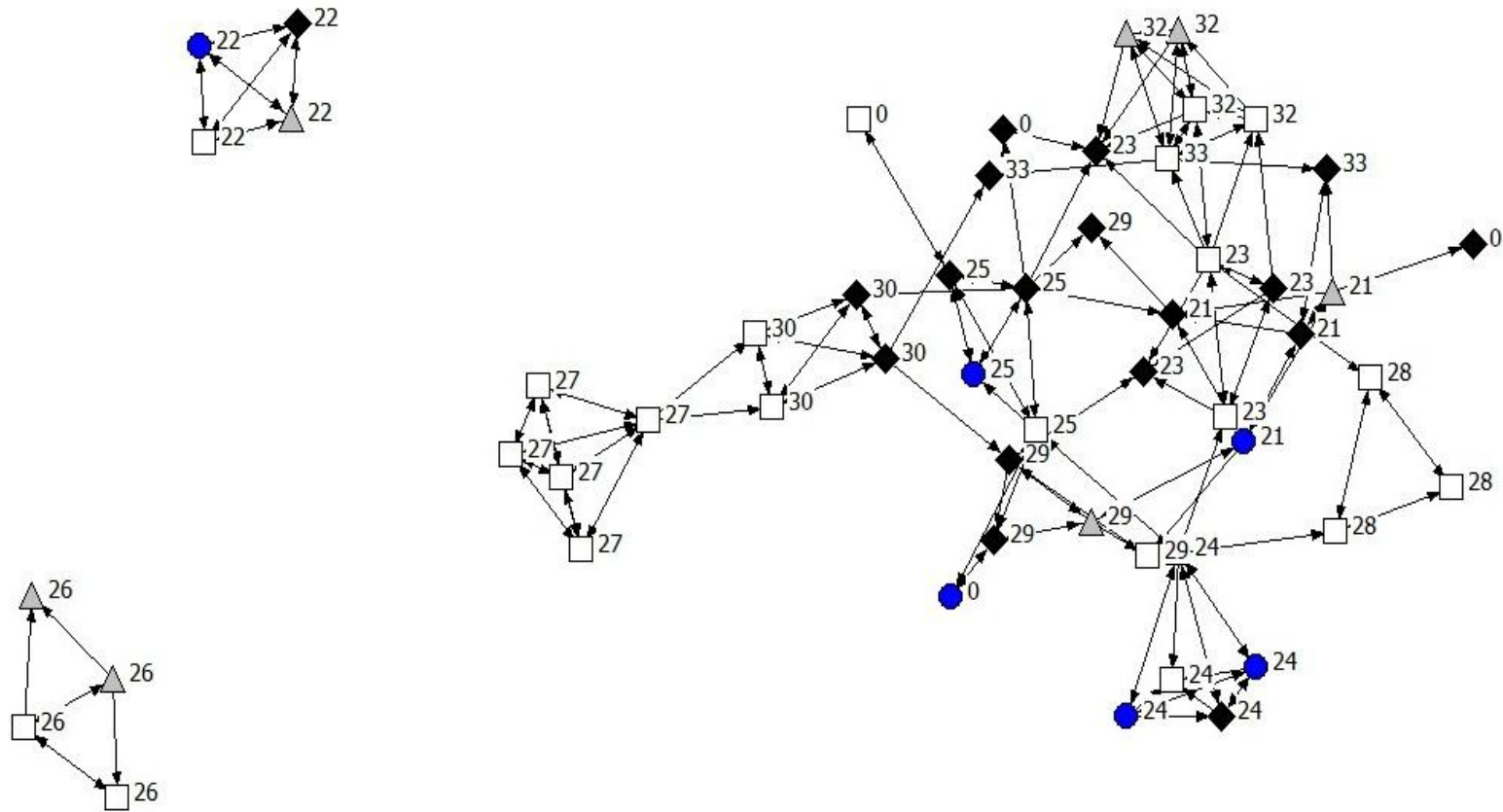
47

Figure 3 Learning & teaching network after nine months

Blue circle = Arts & Social Science; White square = Engineering and Physics; Black diamond = Business & Economics; Grey triangle = Health and Medical Science. Numbers refer to respective group divisions during module 1

Figure 4 Working networks after nine months

Blue circle = Arts & Social Science; White square = Engineering and Physics; Black diamond = Business & Economics; Grey triangle = Health and Medical Science. Numbers refer to respective group divisions during module 1

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Figure 5 External and internal learning and teaching network
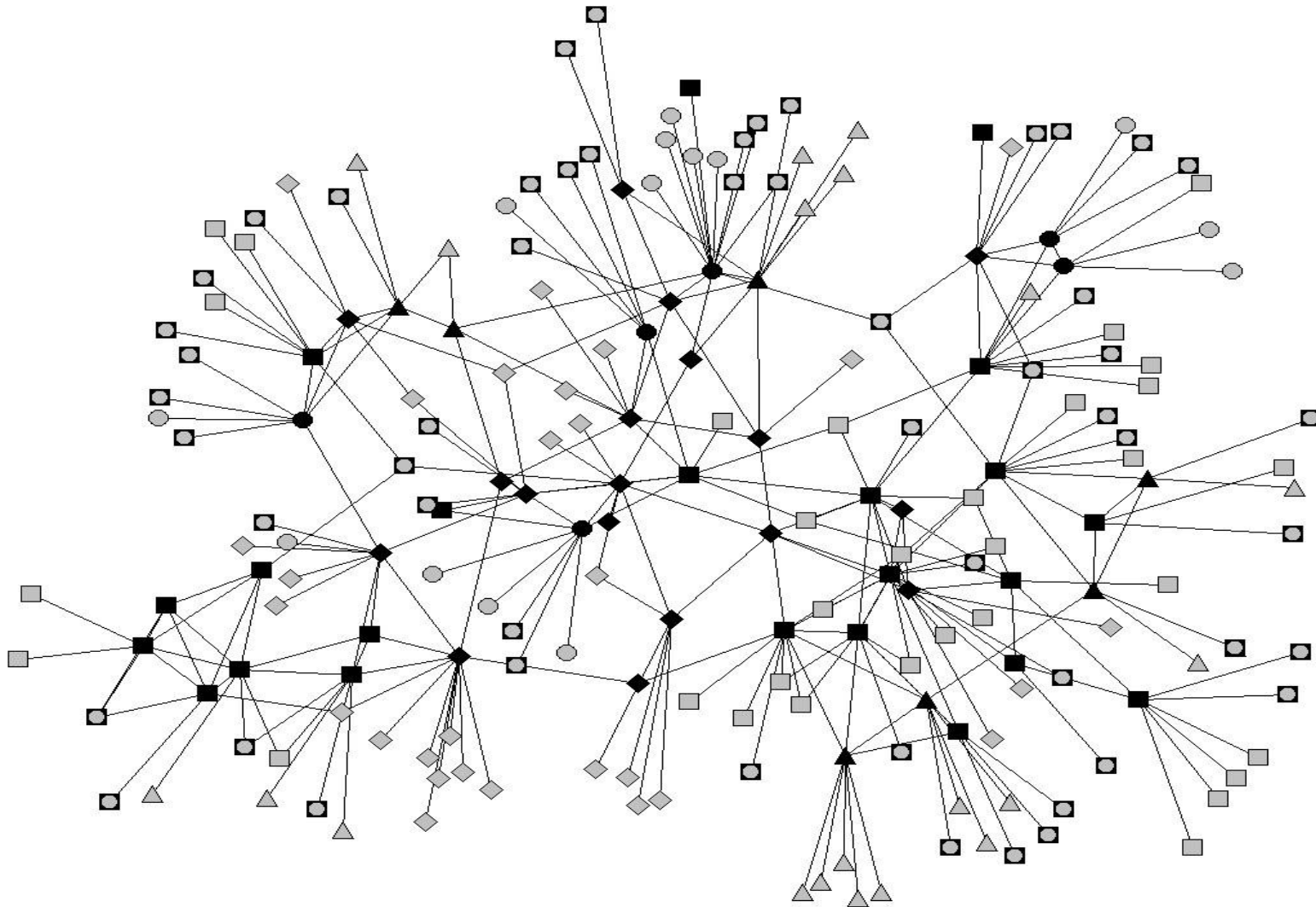
Black = Program XYZA participant, grey = External network contact. Circle = Arts & Social Science; square = Engineering and Physics; diamond = Business & Economics; triangle = Health and Medical Science; grey circle in black box = external network contact outside participants' institute.

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[i] 43 participants self-selected their group members (28 continued with the same group as module 1, 15 formed discipline-specific groups)

[ii] This was artificially lowered as one of the two facilitators did not ask participants to return the forms.

[iii] Please note that participants in free response exercise received an adjusted version of Figure 2-3, whereby the colours were representing the 12 groups and the numbers represented the faculties (without mentioning which faculty corresponded to which number). In order to make the patterns visible in black & white for this journal, we switched the colours and the number of the nodes, although technically the social network graphs are the same.