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Making the most of “external” group members in blended and online environments

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Abstract

Although the importance of boundary-spanning in blended and online learning is widely acknowledged, most educational research has ignored whether and how students learn from others outside their assigned group. One potential approach for understanding cross-boundary knowledge sharing is Social Network Analysis (SNA). In this article, we apply four network metrics to unpack how students developed intra- and inter-group learning links, using two exemplary blended case-studies in Spain and the UK. Our results indicate that SNA based upon questionnaires can provide researchers some useful indicators for a more fine-grained analysis how students develop these inter- and intra-group learning links, and which cross-boundary links are particularly important for learning performance. The mixed findings between the two case-studies suggest the relevance of pre-existing conditions and learning design. SNA metrics can provide useful information for qualitative follow-up methods, and future interventions using learning analytics approaches.

Keywords: blended learning, group learning, knowledge spillovers, structural holes, social networks analysis, higher education.

Biography

Dra. Núria Hernández Nanclares is Associate Professor at the Applied Economics Department of University of Oviedo (Spain). She specialises in innovative teaching for Higher Education and Economics, both fields in which she focuses her research currently. The main working areas are forms of assessment and alternative assessment methods, active methodologies in higher education, social and learning networks. Currently, she is involved in bilingual teaching in Economics with a CLIL approach. Her main area of expertise is International Economics and most of her teaching is related to this area.

Dra. Ana Salomé García Muñiz is an Associate Professor of Applied Economics at the University of Oviedo (Spain). She received her Ph. D. in Economics from the University of Oviedo (Spain) in 2006. The topic of her dissertation was ‘The Network Theory in input-output analysis’. Her areas of interests include research on economic networks, input-output, technological diffusion and higher education assessment. She has been involved in several e-learning projects about assessment methods and blended learning. She has published several articles in international journals as Social Networks, The International Journal of Learning in Higher Education, Computers in Human Behavior. Her first contact with REAL (Regional Economics Applications Laboratory) was in September 2012 as a visiting scholar to do research about statistical network models.

Dr. Bart Rienties is Reader in Learning Analytics at the Institute of Educational Technology at the Open University UK. He is programme director Learning Analytics within IET and Chair of

Analytics4Action group, which focuses on evidence-based research on interventions of 80+ modules to enhance student experience. As educational psychologist, he conducts multi-disciplinary research on work-based and collaborative learning environments and focuses on the role of social interaction in learning, which is published in leading academic journals and books. His primary research interests are focused on Learning Analytics, Computer-Supported Collaborative Learning, and the role of motivation in learning. Furthermore, Bart is interested in broader internationalisation aspects of higher education. He successfully led a range of institutional/national/European projects and received several awards for his educational innovation projects.

Making the most of “external” group members in blended and online environments

Introduction

The power of learning in small groups in blended and online settings has been acknowledged for over two decades ([Järvelä & Häkkinen, 2002](#); [Katz, Lazer, Arrow, & Contractor, 2004](#); [Schellens, Van Keer, De Wever, & Valcke, 2009](#); [Tirado, Hernando, & Aguaded, 2015](#)). A vast body of Computer Supported Collaborative Learning (CSCL) and group research literature has found that group work using ICT tools, like chats, discussion forums, videoconferences, or WIKIs, can stimulate motivation ([Hommes et al., 2012](#); [Järvelä & Häkkinen, 2002](#)), lead to co-construction of new knowledge ([Decuyper, Dochy, & Van den Bossche, 2010](#); [Schellens et al., 2009](#); [Toikkanen & Lipponen, 2011](#)), and a shared mental model ([Van den Bossche, Gijssels, Segers, & Kirschner, 2006](#)).

Most literature in CSCL and group research focuses on learning within groups ([Lowry, Roberts, Romano, Cheney, & Hightower, 2006](#); [Lu & Churchill, 2014](#); [Schellens et al., 2009](#); [Van den Bossche et al., 2006](#)), while broader educational studies pay attention either to the individual learner, the group, or the program as a whole, potentially missing vital interactions between students that are formally and informally learning outside the boundaries of their own group ([Ancona & Caldwell, 1989](#); [Balkundi, Barsness, & Michael, 2009](#)). With the arrival of social network sites and other social media, students can create their own personal learning environments outside the formal settings of an assigned group or classroom. Informal learning tools like Facebook, Twitter, or WhatsApp extend the opportunities for students to learn new and divergent ideas from others. However, these informal interactions between students are mostly not visible for teachers and learners who are not part of these communities.

In order to analyse how students are using formal learning environments (e.g., Virtual Learning Environments) in conjunction with informal learning tools, several researchers ([Author A, 2012a](#); [Author C, 2014a](#); [Hommes et al., 2012](#); [Katz et al., 2004](#); [Tirado et al., 2015](#); [Toikkanen & Lipponen, 2011](#)) use the method of Social Network Analysis (SNA). This perspective considers individual students and groups as interlinked structures embedded in larger social networks. Thus, a student's position and its relationships inside the larger social network can impact how individuals and groups perform. SNA offers several methodological tools for investigating relations within a group and its external context. For example, a recent review of 37 studies using SNA techniques in blended and online courses by [Cela, Sicilia, and Sánchez \(2015\)](#) has indicated that SNA techniques combined with content analysis of discussion forum or wiki entries can provide a detailed understanding of interactions between students.

As we are primarily interested to determine whether and with whom students were learning inside and outside their formal group, we opted to gather SNA data using (pre-post) questionnaires. While one could also analyse the interaction patterns of discussion forums threads, WIKIs or chats in a Virtual Learning Environment (VLE) using SNA interaction techniques ([Author C, 2014b](#); [Cela et al., 2015](#); [Lu & Churchill, 2014](#); [Schellens et al., 2009](#); [Tirado et al., 2015](#); [Toikkanen & Lipponen, 2011](#)), these networks by definition would miss the (unobserved) informal interactions that take place outside the VLE, such as Facebook, WhatsApp or informal discussions in a café. As a result, the proposed analysis pursues to demonstrate the applicability of social network concepts in appraising the relative importance of inter- and intra-groups relations in blended environments using self-reported SNA questionnaires. Furthermore, as the relationship between social engagement and high level of cognitive engagement is not demonstrated ([Lu & Churchill, 2014](#)), this article also investigates how

effective these relations are and how structural effects in terms of network positions may influence learning outcomes. The questions concerned are then:

1. What is the relative balance between intra- and inter-group learning relations?
2. To what extent do intra-group learning relations have an impact on learning performance?
3. To what extent do inter-group relations enhance learning performance?

In the next section, a background about SNA literature in education is exposed, whereby concepts of network closure, structural holes and non-redundant relations are described. Afterwards, these concepts are applied to two case-studies, where the use of these SNA metrics help to analyse the learning networks and evaluate the effectiveness of such learning contacts in terms of learning performance. We hope that our article will contribute to recent discussions ([Akkerman & Bakker, 2011](#); [Decuyper et al., 2010](#); [Sharples et al., 2015](#); [Tortoriello & Krackhardt, 2010](#)) how researchers can conceptualise and measure the impact of the external environment on groups.

Network closure vs. structural holes: learning in and outside groups

In this article, social network analysis is proposed to assess several aspects of learning groups' behaviour. Mixed findings have been collected in the literature ([Author C, 2014b](#); [Cela et al., 2015](#); [Katz et al., 2004](#); [Tirado et al., 2015](#)). Typically, in SNA a distinction is made between the structure of the network and the relations that a student has in the classroom. Both from a network closure perspective ([Coleman, 1988](#)) and from a CSCL group learning perspective ([Decuyper et al., 2010](#); [Järvelä & Häkkinen, 2002](#); [Schellens et al., 2009](#); [Van den Bossche et al.,](#)

[2006](#)), it is well documented that groups may work better if they have generated trust and cohesion through a high number of mutual and reciprocal relations. In this case, the higher the number of relations, the better. From the point of view of this approach, dense embedded networks, with many connections between groups is seen as beneficial for groups and individuals performance and this type of network structures are regarded as advantageous ([Coleman, 1988](#)). It seems that many studies using SNA in education ([Curşeu, Janssen, & Raab, 2012](#); [Daly, Moolenaar, Bolivar, & Burke, 2010](#); [de Lima, 2007](#); [Hommes et al., 2012](#)) implicitly or explicitly regard densely connected networks with many connections as an essential factor for transfer of knowledge. Indeed, in one of the first studies on intra- and inter-group learning amongst 304 MBA students, [Baldwin, Bedell, and Johnson \(1997\)](#) found that intra-group relations strongly influenced learning performance, student satisfaction, and project performance, but inter-group relations were not predicting learning performance.

An alternative social network perspective regards the structure of the network as more important than how densely each student is connected with others ([Burt, 1992](#)). Following [Burt \(1992\)](#), having non-redundant ties linking all participants is regarded as being more efficient, as redundancy is avoided. According to Burt and colleagues ([1992, 2004; 2013](#)), in any network there could be structural holes that give some individuals the possibility to connect two or more individuals not yet directly connected. New contacts may give access to (potentially) more varied, less homogenous information and may provide opportunities to improve learning; i.e. new contacts have to be non-redundant relations ([Burt, 1992](#)). The return on their efforts accrues from their ability to “broker” this segregated flow of knowledge and information, giving them some kind of advantage over others, i.e. information breadth, timing and brokerage advantage ([Burt et al., 2013](#)). These brokers provide a bridge across the structural hole, set up connections between

individuals on opposite sides of the hole, and coordinate how knowledge in one individual or group could create value in others. Therefore, brokers are people who are exposed to diverse surrounding information and knowledge, and may be able to generate new opportunities to combine these previously segregated behaviour and opinions of different people ([Burt et al., 2013](#)).

In a collaborative learning space, students can take advantage of the interaction opportunities inside their groups ([Burt et al., 2013](#)). However, information can become stuck within the group ([von Hippel, 1994](#)), opening “holes”, missing relations in the social structure that obstruct the general flow of information ([Burt, 1992](#); [Burt et al., 2013](#)). Some students are better positioned in the network or are more able than other students to bridge alternative ways of thinking and collaborating between groups, promoting knowledge spillovers, which are defined as the transfer of knowledge between groups through the physical and online classroom ([Author A, 2012a](#)). Consequently, there could be a diverse understanding on which role inter-groups relations play in group performance, and what type of network promotes knowledge diffusion between groups more efficiently.

A realistic scenario in collaborative learning contexts is that multiple groups of learners are present at the same time in a blended environment, as depicted in Figure 1. In collaborative learning contexts, groups are not isolated elements in the learning space, but rather form part of a larger network in which they relate to other groups and individuals. [Author A \(2012a\)](#) indicate that transfer of knowledge between students occurs not only inside groups but also through the contacts all groups actively share. In Figure 1, there are three groups with different degrees of group density. For example, group 3 presents the highest group density with the strongest and most cohesive links compared to the other groups. Although, there are also several sparse areas,

structural holes, whereby some individuals in each group (group 1 and 2) are not (directly) connected with members of other groups. Thus, it is possible to establish knowledge spillovers, relations between students outside their group ([Author A, 2012a](#)), which can positively influence the amount and type of knowledge that groups receive from other groups in the classroom.

➔ Insert Figure 1 about here

Following [Burt \(1992\)](#), social relations between two students can be classified as redundant and non-redundant. Some of these relations may provide new assorted information, as illustrated by the black lines in Figure 1. Referring the students with a label indicating the number of the group and the student's number for the next explanation. The relation between individual 1.3 with individual 2.3 is a non-redundant relation, whereby individual 1.3 (and as a result the entire group 1) can obtain access to group 2's (new) knowledge. In a blended environment, individual 1.3 could obtain this new information from individual 2.3 by a variety of options: talking in/outside the classroom, using the affordances of the VLE, or using social media. These relations may spread knowledge between groups, and they can be considered as high quality relations with newly connected individuals. Similar (non-redundant) links are established between group 2 and group 3 through the relation between 2.5 and 3.5.

Other external relations (i.e., knowledge spillovers) will be redundant, as they provide the same type of information and will not be so powerful in transmitting assorted information and promote learning ([Burt, 1992](#)). For example, the additional tie connecting 2.4 with 3.5 is redundant, because any new information that could spread between these two groups has already been bridged through previous connections. So, the knowledge obtained by individual 2.4 from individual 3.5 is redundant, as individual 2.4 already established a relation with 2.5, which

simultaneously maintains contact with individual 3.5. In other words, structural holes in the network can be indicators of the possibilities to access diverse information ([Burt, 1992](#)).

Other studies mixed theoretical perspectives (e.g., [Daly & Finnigan, 2010](#); [Giuliani, 2013](#)) and highlighted that a combination of strong intra-group ties (network closure) with sufficient inter-group ties (structural holes) leads to better performance. In this line, [Reagans and McEvily \(2003, p. 245\)](#) argued that “an optimal network combines elements of cohesion and range ... The most productive teams are internally cohesive, but have external networks full of structural holes”. Also, [Ahuja \(2000, p. 426\)](#) stated it can be effective to develop networks based mainly on indirect ties as a way “to enjoy the benefits of network size without paying the costs of network maintenance associated with direct ties”, depending on the relative value of direct versus indirect ties.

SNA approaches to unpack intra- and inter-group learning

In this article, a graphical representation of learning networks are represented to get an initial identification of the overall social network structure and patterns of sub-group development, as recommended by [Newman \(2003\)](#) and [Wassermann and Faust \(1994\)](#). SNA quantitative analysis tools measure the inter- and intra-groups relations from different points of view ([Author C, 2014b](#)). Afterwards, we will explore four different SNA metrics to identify inter- and intra-group learning.

First, the relative level of relations in a group or overall network, so-called *density*, is calculated as the ratio of number of relations present divided by the number of possible pair connections, and varies between 0 and 1. A density of 0 means that nobody is connected with anybody else; while 1 means that everyone is connected with everybody else. Density, as a

metric of interaction quality, usually appears in empirical network research, although one has to carefully consider the interpretations of this index.

A second inter-group metric, *the External – Internal index*, developed by [Krackhardt and Stern \(1988\)](#), determines the position of each student within their group (intra) relative to other students (inter) in the (dichotomised) social learning network. Basically, the External – Internal (E-I) index takes the number of links of members of the group to students outside the group (EL), subtracts the number of links to members within the group (IL), and divides by the total number of links:

$$E - I = \frac{EL - IL}{EL + IL} \quad (1)$$

The resulting index ranges from -1 (all ties are only with own group members) to +1 (all ties are to students outside the group). The values of E-I index highlight if a group develops strong and cohesive learning links within a group (values near to -1) or present strong knowledge spillovers outside the group (values near to +1). While this metric has intuitive appeal, it does not distinguish between whether external relations are non-redundant or redundant.

Methodologically, the determination of structural holes requires, firstly, the identification of the level of non-redundant knowledge spillovers generated in the network. Burt (1992) defines the effective size as the difference between network size and level of redundancy

$$TE_i = \sum_j \left[1 - \sum_q p_{iq} m_{jq} \right] \quad (2)$$

where index q reveals the remaining individuals that are related to individual i, p_{iq} shows the proportion of direct links and m_{jq} represents the marginal intensity of individual j in relation to individual q:

$$p_{iq} = \frac{x_{iq} + x_{qi}}{\sum_{j=1}^n (x_{ij} + x_{ji})} \quad (3)$$

$$m_{jq} = \frac{x_{jq} + x_{qj}}{\max_k (x_{jk} + x_{kj})}$$

where x_{ij} represented the relation between the individual i and j collected in the studied network.

The knowledge obtained by an individual i is described as redundant if individual i has a relation with another individual q , which maintains simultaneous contacts with individual j .

The relative non-redundant index measure as the effective size divided by the observed size, it is called efficiency index ([Burt, 1992](#)):

$$E_i = \frac{TE_i}{N} \quad (4)$$

The Efficiency index ranges between zero and one. Values near to one indicate a high efficiency level in the ability to access to new information, that is, a high number of non-redundant contacts measured by a low redundancy degree. Numbers close to zero show a low efficiency in the access to new information and, therefore, a low number of non-redundant contacts indicated with high redundancy degree.

As our fourth and final index, it is interesting to determine the constraints of the network through the so-called *Constraint index* ([Burt, 1992](#)):

$$C_i = \sum_j c_{ij} \quad (5)$$

where

$$c_{ij} = \left(p_{ij} + \sum_q p_{iq} p_{qj} \right)^2; \quad q \neq i, j \quad (6)$$

p_{ij} is the relative intensity links between i and j and p_{iq} (p_{qj}) are defined analogously.

Constraint refers to how dependent an individual is to access the network. If a person connects to the network only through one partner or a small number of them, this person is (relatively) restricted in his/her conditions to access as (s)he depends heavily on a few connections to get contact with other parts of the network. Similarly, students with higher levels of constraint have a higher risk of exclusion from the classroom's learning dynamics. In contrast, students with a lower restriction degree are much more flexible and have a higher adaptability to the context. Following [Burt \(1992, p. 51\)](#), the constraint index "measures the extent to which an individual's time and energy are concentrated in a single group of interconnected colleagues which means no access to structural holes". Constraint is affected by the size, the density and the hierarchy in the network. It is lower in larger networks, but it increases with density and hierarchy ([Burt, 1992](#)).

Research methodology

Data collection

This research selected two case-studies in Spain and the UK to apply the four metrics described above to illustrate how researchers and teachers can use these SNA tools to better understand how students connect within and between groups in a blended learning environment. Case-study 1 is situated in an elective third-year course in International Economic Relations at University of Oviedo (Spain). This module was followed by 57 students who met twice a week during a two-hour class session in a 14 weeks period. 26 males and 31 females students were divided into eleven groups, which consisted of four to seven members per group (5.40, SD = 0.84), who self-selected their members. In case-study 1, most students were unfamiliar with each other before working on several authentic economics group tasks over a period of fourteen weeks.

During the fourteen weeks, the eleven groups had to solve five authentic tasks related to international economics that were highly inter-related. These activities include the creation of a conceptual map of globalisation, writing a comment from an economic blog by a famous economist or organisation and preparing and participating in a final conference about globalisation. The instructional design offered the groups several opportunities to share knowledge and the students used several intra-and inter-group interaction tools both in the face-to-face and in the VLE provided by the university and supported by Moodle (i.e., blogs, discussion forums, videos, WIKIs). Learning performance was based upon group work and students were graded on five authentic tasks related to international economics. ([Author A, 2012a](#)).

Case-study 2 took place in a second semester of a post-graduate program of hospitality at a British university, whereby 69 students were able to self-select their members of the group on the first day of the module. In contrast to case-study 1, students had already worked together for four months in different modules and were asked to work in self-selected groups on implementing an authentic project. During the 14 week course period, students met formally once a week during a three-hour interactive class session. At the same time, students were expected to meet with the peers of their group throughout the module in order to work on three group processes/products using the VLE (i.e., discussion forums, peer assessment). 87% of participants were female and the average age was 24.31 (SD = 2.23). The 69 students were divided into eight groups. Groups worked and were assessed on a group level on three authentic group products, one of which was organising a large event at the end of the module. Learning performance was measured as a combination of the final event, a reflection report, and peer-

assessment scores. A detailed description of the design principles of the module has been published elsewhere ([Author C, 2014a](#)).

Measurement

In order to capture the formal and informal learning interactions between students and groups, we used questionnaires following Social Network Analysis techniques, whereby students answered the question stem “I have learned a lot from...” using a list with all students’ names as is commonly done in SNA ([Author A, 2012a](#); [Hommes et al., 2012](#)). In case-study 1, students had to mark on a Likert response scale of 1 (Totally disagree) – 5 (Totally agree) whether they learned a lot from each respective student or not. For all measurements a 100% response rate was established. In case-study 2, students marked on a check-list (yes-no) whether they learned a lot from each respective student. A response rate of 77% and 73% was established.

From these data, two networks are formulated. The network associated to case study 1 consists of 57 nodes (students). The network for case the case study 2 consists of 69 nodes (students). In these networks, the learning interactions are denoted by links. The learning link between two students can be reciprocal, null or asymmetric.

Results

As a first step, we conducted a graphical analysis of the social networks in order to identify the overall social network structure and to identify possible patterns of development, as recommended by [Wassermann and Faust \(1994\)](#). As a second step, we determined the position of each student within the networks using density, E-I, efficiency and constraint index. Finally, the dependence between learning performance and the SNA metrics was studied. UCINET version 6.445 was used to analyse data on a network level.

Graphical illustration of learning networks

In order to unpack research question 1, Figures 2-5 illustrate the power of SNA in understanding the learning networks in the two case-studies. The social network graphs show the position of individual students as well as their respective group. Additional information is attached to the nodes -students- in Figure 2-5: the shape of the nodes indicates the group in which students were enrolled and their size illustrates the constraint index for each student. In Figure 2, the larger the node, the more constrained the student is, offering a measure of the brokerage opportunities for each student. Besides, each node is annotated with a label indicating the group and student number. For case study 1, Figure 2 illustrates whom the participants consider as their learning contacts after fourteen weeks. At the end of the module most groups have developed strong group ties.

➔ Figure 2.about here

The level of the relations in the overall network and in each group can be observed. In order to detect if there are connections between groups, it is useful to compare the group densities with overall network density. For case-study 1, Table 1 describes the group density, whereby the overall network density is 0.177. In case-study 1 all group densities are larger than the overall one, meaning that group members have developed knowledge spillovers with other groups and established connections with colleagues beyond their own group.

➔ Table 1.about here

➔ Figure 3 about here

The circle-type graph in Figure 3 clearly illustrates the extent of knowledge spillovers in case-study 1, as lines from one part of the circle to another indicate knowledge spillovers. Students on average have developed 3.94 (SD = 0.80) intra-group learning links and 3.54 (SD = 2.82) inter-group learning links after fourteen weeks, providing support for that students have developed many knowledge spillovers.

For case-study 2, Figure 4 represents learning connections measured at the end of the course. Figure 5 clearly illustrates that learning relations are concentrated mainly inside of the groups, particularly for groups 1, 4, 6 and 8. Students on average developed 4.75 (SD = 2.53) intra-group learning links and 1.83 (SD = 1.92) inter-group learning links after fourteen weeks, confirming the higher difficulty to establish and keep inter-group relations. As students had already worked together for four months in different modules and were allowed to self-select the members of their group, most students selected members with whom they already established previous learning relations. Table 2 describes group density with an overall network density of .072. In this network, 50% of groups had lower densities than the overall network. These results indicate different balances in inter- and intra-group relations in the two case studies.

➔ Insert Figure 4-5 about here

➔ Insert Table 2 about here

Quantifying network measures

Network visualisations and density measures give important first impressions of the social network patterns in the two case-studies. Nevertheless, density may not be very useful in studying learning networks ([Toikkanen & Lipponen, 2011](#)) as these tools do not inform about the

quality or the type of information (redundant/non-redundant) these connections are providing to the group and students. Therefore, the research measures E-I, constraint and efficiency metrics for both case-studies are computed in order to complete the analysis and to detect structural holes as indicators for access to diverse (non-redundant) information.

The minimum, maximum, and group average values of each index by groups are represented in the stocks charts (See Figure 6). When comparing these stocks charts, different structures of the learning networks emerge for both case studies. Students in case-study 1 have a relatively high level of efficiency (average: 0.68) and a low level of constraint index (average: 0.20). The variability of these levels between groups (and students) is low. The negative E-I index (average: -0.17) indicates a larger number of relations inside their own group. However, groups 3, 6, 8 and 11, with positive values of the E-I index, have relatively more inter-group relations. The combination of this E-I index together with low values of constraint index indicates that in case-study 1 there is sufficient unrestricted potential access to new information through the spillovers generated in the learning space.

→ Insert Figure 6 about here

In contrast, in case-study 2 the E-I index indicates that most of the relations are developed within the group (average: 0.48), with relatively scarce inter-group relations. The level of efficiency (average: 0.58) is lower than in case-study 1, while the level of constraint (average: 0.40) is higher. The dispersion of results between individuals and/or groups is also higher than in case-study 1, showing that students have developed different types of learning relations. In case-study 2, the combined information from the metrics reveal that students tend to share much less varied knowledge across the boundaries of their group. There are dense groups but with high dependence, which may not facilitate the spread of new ideas across groups. The different

learning network structures illustrated by the three metrics in case-study 2 may be due to students' previous familiarity with each other, or the (potential) competitiveness amongst groups to reach the best performance during the final event.

Linking network indicators with performance

In order to address research question 2 and 3, we analysed whether there are any causal relationships between the SNA metrics and learning performance measure. With this aim, linear regressions are conducted with learning performance as dependent variable, and E-I index, constraint and efficiency as independent variables. The level of analysis is the student, as aforementioned results point to differences in individual behaviour, especially in case-study 2. Table 3 reports for case-study 1 and case-study 2 (in standardised betas) the results of the regression analyses. In case-study 1, the three metrics are significant predictors of learning performance. The positive value of the regression coefficient associated to E-I index indicates a positive impact of spillover relations on learning performance. Increments of knowledge diversity through non-redundant relations have a positive influence as well. However, the constraint index does not have the expected sign according to structural hole theory. The characteristics of students related with previous learning experiences may explain this result as students were learning how to work in a group for the first time. They created their first new contacts inside and outside the group with lower constraints, and over time may have been able to obtain access to new learning knowledge. In this context, they seem to establish a net of dense relations to improve learning performance, although it may also imply constraints.

In case-study 2, learning performance is significantly predicted by constraint and efficiency, but not by the E-I index. In this learning space, low constraint levels may have promoted the possible benefits of relations as predicted by [Burt \(2004\)](#). The diversity of relations

has a negative impact on grade. In line with [Coleman \(1988\)](#), students and groups who are relatively strongly connected to each other with limited external links had better learning performance. In case-study 2, more non-redundant relations does not imply better learning performance.

➔ Insert Table 3 about here

Discussion

A large body of CSCL and group research literature has found that group work can stimulate both individual and group-level learning ([Author C, 2014b](#); [Järvelä & Häkkinen, 2002](#); [Schellens et al., 2009](#)). Yet, most research literature seems to ignore students and groups frequently cross the boundaries of their group in order to learn from others outside the group. Although the importance of boundary-spanning is widely acknowledged in organisational science literature ([Ancona & Caldwell, 1989](#); [Balkundi et al., 2009](#); [Burt, 2004](#); [Giuliani, 2013](#); [Tortoriello & Krackhardt, 2010](#); [Vasudeva, Zaheer, & Hernandez, 2013](#)), most studies devote relatively limited attention to the external environment of the group ([Akkerman & Bakker, 2011](#); [Decuyper et al., 2010](#)).

Using a social network analysis perspective, we explored whether four SNA metrics (i.e., density, E-I, efficiency and constraint metrics) can be useful proxies of effective boundary spanning for researchers to conceptualise and understand intra- and inter-group learning. We selected two distinct case-studies in Spain and the UK, whereby we found that on average students developed four intra-group learning links and two to three inter-group learning links over time (Research Question 1). In line with previous findings ([Author C, 2014a](#); [Daly et al., 2010](#); [Tortoriello & Krackhardt, 2010](#); [Vasudeva et al., 2013](#)) and common practice in blended

and online learning, our results indicate that students and groups do cross the boundaries of their groups. In particular, by using SNA questionnaires researchers and teachers can start to unpack how students are developing formal and informal learning relations in and outside formal VLEs and social media. The visualisation of knowledge spillovers using circle diagrams seems to be an intuitive approach for researchers to discover whether students are developing inter-group learning ties or not, although when substantial knowledge spillovers are developed this approach may become too complex.

In terms of whether these knowledge spillovers and intra-group relations matter in terms of learning performance (Research Question 2-3), a mixed picture was found in the two case studies, thereby highlighting that SNA and the metrics provide some useful indicators for researchers to unpack the complex boundary spanning of groups. Both structural hole and closure perspective theories can explain the case-studies analysis. In case-study 1, the brokerage role of students and the spillovers between groups were fundamental for the diffusion of learning and better learning performance. In case-study 2, the development of relations inside the group was emphasised. The difference in learning designs and previous developed learning relations might explain the different findings. In both case-studies, students faced complex cognitive tasks and “structuring knowledge shared among individual members is a key challenge to improve the performance” ([Huang & Cummings, 2011](#)). The main difference between both settings was how students were equipped to learn in collaborative context. The students (groups) of case-study 2 had previous experience in working in groups and while case-study 1 students were relatively inexperienced in group learning.

An explanation why these studies led to different outcomes may be related to prior social network relations, the respective learning designs, and the specific group tasks that students had

to do. As students/groups in case-study 2 were essentially competing with each other over potential customers for their events, the incentives to pro-actively share knowledge might have been subdued, but those who were able to form one or two non-redundant knowledge spillovers might have substantially benefited from this new knowledge. In contrast, the design of case-study 1 actively encouraged inter- and intra-group learning, whereby students/groups had to build on each other's' work. Students seemed to be more interested in creating learning relations, especially inside of the group.

Our results indicate that SNA metrics can provide researchers some useful indicators for a more fine-grained analysis how groups and students developed these inter- and intra-group learning links inside and outside formal VLE systems, and which cross-boundary links may be particularly important. The different findings in the two case-studies amplify the usefulness of these SNA approaches to unpack formal and informal learning using questionnaire approaches. Using only trace-data of VLE interactions within groups might have substantially underestimated the formal and informal interactions that occurred in the two case-studies. The opposite directions of some of the SNS metrics indicate that these metrics are sensitive to differences in learning design and context. When aggregating these SNA metrics on a group level, researchers can easily identify which individuals and groups are more inward/outward focused, which may provide useful information for qualitative follow-up methods, or future interventions using learning analytics approaches ([Author C, 2015a](#)). As indicated by [Tirado et al. \(2015\)](#), “[t]his underlines the need for reinforcing participations that are directed to the group as a whole, and the importance of the fact the network central and intermediate members”. For example, for some researchers it would be interesting to compare the learning processes and experiences of groups, who seem to have opposite strategies for cross-boundary spanning.

Alternatively, comparing the SNA metrics on a module at various points of time might allow researchers a new perspective how learning processes of groups develop over time ([Author C, 2014b](#); [Lu & Churchill, 2014](#); [Tirado et al., 2015](#); [Toikkanen & Lipponen, 2011](#)). Finally, although we caution for simplistic comparisons across modules, these metrics might allow researchers, teachers and managers to determine how successful their designs are to encourage cross-boundary learning.

Conclusion

This methodological contribution highlights that using questionnaire-based social network analyses index) can give researchers some tools and approaches to start to explore the external and informal online environments of groups. In particular, our approach seems to suggest SNA can provide a more nuanced discussion of the merits and drawbacks of boundary crossing. If other researchers adopt similar approaches in their contexts, in particular in non-Western contexts, in next two-five years researchers may be able to better determine the optimal design for learning tasks that encourage strong inter-group learning links, or strong intra-group learning links, or a combination of the two.

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Tables

Table 1. - Case 1. Group densities

Group	1	2	3	4	5	6	7	8	9	10	11
Density	.667	.800	.750	.800	.833	.720	.560	.800	.778	.720	.800

Table 2.- Case 2. Group densities

Group	1	2	3	4	5	6	7	8
Density	.057	.104	.096	.037	.090	.064	.085	.040

Table 3.- Regression analyses of learning performance

	<i>Case-study 1</i>			<i>Case-study 2</i>		
	Beta	t	P	Beta	t	P
Intercept		-12.027	.001		23.272	.001
E-I index	.239	2.524	.002	-.074	-.629	.531
Constraint	1.647	10.973	.001	-.466	-4.038	.001
Efficiency	1.045	7.979	.001	-.193	-1.741	.086
R-squared	.757			.258		

Note: N case-study 1 = 57, N case-study 2 = 68

Figures

Figure 1. Sharing of (non-)redundant information in a classroom.

Figure 3. Case-study 1: Constraint in the Learning Network after 14 weeks (circle-shape).

Figure 4. Case-study 2: Constraint in the Learning Network after 14 weeks.

*Figure 5.*Case-study 2: Constraint in the Learning Network after 14 weeks (circle-shape).

Figure 6.- Stock charts: E-I, efficiency and constraint