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Social Network Analysis: An Emerging Methodology to Study Interactions within Networked Learning Communities

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Abstract

Networked Learning Communities (NLCs) are complex systems made up of course users with a shared purpose: achieving learning goals. When these communities and the online courses they take part in are supported by Virtual Learning Environments (VLEs), studying interactional patterns and the communication structure of the community is a real challenge for researchers as VLEs do not usually provide relational data. Researchers thus have to (1) produce this type of data while building the corpora they wish to analyse, and (2) resort to specific methodologies to analyse the corpora built. One such methodology is Social Network Analysis (SNA), an emerging methodology in the study of NLCs as it offers various measures and modelling tools for the analysis of relational patterns within a group. In this chapter, we show how powerful this method is through a case study on interactional competence development in English as a second language through an online course. Indeed, the sociometric analysis of the corpus built highlighted the influence of the communication tool used on the interactional load and configuration of interactions, and demonstrated the extent to which telecollaboration was successful depending on the tool used. More general conclusions are also drawn on the invaluable contribution of SNA in the study of NLCs.

I. Introduction

The rapid development of computer-based technologies has led to the growing popularity of e-learning systems, thus making web-based education more popular in recent years. The

online courses offered are often supported by Virtual Learning Environments (VLEs), also called Learning Management Systems or Courseware Management Systems. These are systems which offer a number of tools which are necessary for a course to be administered online, the most famous of these being Blackboard, WebCT or Moodle. VLEs usually support “the distribution of study materials to students, content building of courses, preparation of quizzes and assignments, discussions and distance management of classes” (Drazdilova et al., 2010, p. 299). In addition, they facilitate communication as they provide a number of collaborative learning tools. These enhanced learning environments can be considered as social networks of course users if we accept Garton et al.’s (1997) definition of a social network as “a set of people (or organizations or other social entities) connected by a set of social relationships, such as friendship, co-working or information exchange”. As these specific social networks aim at connecting course users with each other with a view to learning, they can also be termed Networked Learning Communities as they fit both of the following definitions:

Networked learning is learning in which information and communication technology (ICT) is used to promote connections: between one learner and other learners, between learners and tutors; between a learning community and its learning resources (Jones & Esnault, 2007).

A learning community is a group of individuals who come together to acquire knowledge (Dillenbourg et al., 2003).

It should be noted, however, that groups of learners do not systematically become learning communities (Chanier & Cartier, 2006): the close study of their relationships and interactions is necessary to determine whether or not a learning community has emerged from a group of learners.

Finally, in line with Holtzer’s (1995) definition of complex systems as a whole of interdependent elements (course users) organized for a purpose / a definable objective (achieving learning goals), NLCs can also be considered as complex systems. Thus the dynamic nature of these systems lies in the interactions between their components which researchers strive to examine. Still, researchers interested in studying VLE-supported NLCs might have to overcome several obstacles, one of these being the type of data provided by these new technological learning environments. Indeed, if the data usually provided by VLEs

include user profile, information about student learning habits, student results and user interaction data (mainly chat logs and posts on discussion boards), information on participation patterns and on the communication structure of the group is usually not automatically made available by VLEs (Reffay & Chanier, 2003).

As a consequence, researchers have to face two problems when working with VLE-based data:

(1) First, it is sometimes difficult to extract useful information from the data provided (Drazdilova et al., 2010); for example, connection time is the type of information that is systematically provided but is difficult to use by researchers as we all know that a course user who has logged on the VLE can always do something else (make themselves a cup of tea !) or simply forget to log off, but the system will still consider this time as connection time ; this type of tracking information is thus very unreliable and often unusable by researchers.

(2) In addition, the data provided by VLEs is centered on the individual: no relational data is usually readily available. Consequently, researchers interested in the study of interactional patterns have to produce this type of relational data while building their corpora from the raw data made available by the VLE. One methodology to then analyse relational data in the study of NLCs is that of Social Network Analysis (SNA).

The aim of this chapter is to show to what extent SNA is a valuable methodology to study interactional patterns in VLE-based NLCs. The basic principles and various applications of SNA will first be examined; then, a case study in the field of second language acquisition will be presented in which SNA was used to study the development of learners' interactional competence in English as a second language in a VLE-based NLC. Finally, conclusions will be drawn as regards the usefulness of SNA in the study of NLCs and its potential implementation within VLEs.

II. Social Network Analysis (SNA)

Social Network Analysis (also known as structural analysis) has developed from three different traditions or strands (Scott, 2000):

1) Sociometric analysts (Moreno, 1934; Lewin, 1936) whose work on small groups gave rise to a major technical breakthrough: graph theory (a combination of mathematics and social theory);

2) Harvard researchers of the 1930s (Mayo, 1933) whose work focused on patterns of interpersonal relations and the way cliques are formed;

3) Manchester anthropologists (Barnes, 1954; Bott, 1955; Mitchell, 1969) whose work was based on the first two strands and consisted in investigating the structure of community relations in village and tribal communities.

These traditions were brought together in the 1960s and 1970s at Harvard to forge contemporary SNA. It consists of a body of qualitative measures of network structure (Scott, 2000).

II.1. Principles

First, it's important to understand that SNA is an approach which does not focus on individual attributes or properties, nor on the fine-grained analysis of every network participant's contribution. On the contrary, it focuses on the level of activity of a group as a whole and on the patterns of relations – the ties (links, connections) relating one participant to another. Indeed, SNA's objectives are to study relationships between individuals and to compute representations that highlight global information invisible in raw data: formal properties of social configurations.

Although SNA is often considered as difficult to come to grips with (due to the technical and mathematical language used) (Scott, 2000), its underlying principles are relatively simple (Garton et al., 1997):

- (1) The unit of analysis is the relation (between one or more network participants);
- (2) The main feature of a relation is its pattern (and not the specific attributes of network members);
- (3) A relation is characterized by its content, direction and strength;
- (4) A link (or tie) connects two (or more) participants by one or more relations.

As noted by Drazdilova et al. (2010), SNA is more than an approach and can be considered as a full methodology for data mining in online educational research following four steps:

- 1) data collection (through the VLE),
- 2) data pre-processing: drafting matrices,
- 3) data mining application: using techniques and algorithms to obtain required information (specific software),
- 4) data interpretation and result implementation (to improve student learning processes).

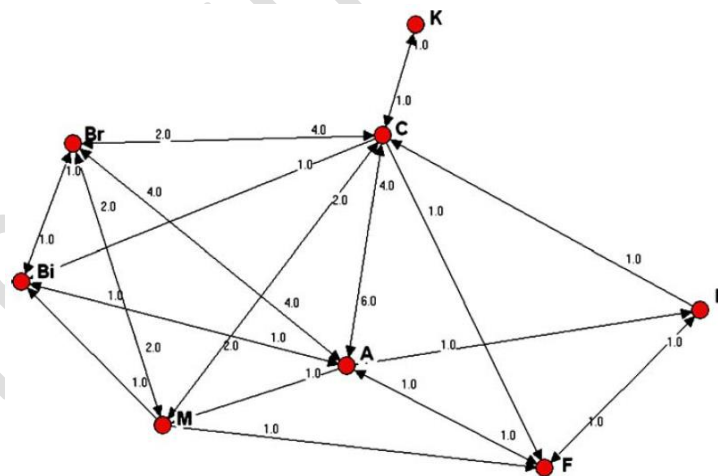
II.2. Two tools, two key indicators

Two Tools

Matrices: A matrix is a table of figures, a pattern of rows and columns where rows represent each case studied and columns correspond to variables on which attributes are measured. Matrices are extremely useful as they support mathematical manipulations.

Sociograms: SNA can be used to visualize the network through its graphical representation (node-link graph) which aims at mapping chains of connections and at indicating the strength and direction of relations. Participants are represented as nodes and their connections as lines between the nodes (Figure 1). With sociograms, SNA offers a modelling technique which is invaluable to uncover asymmetry and reciprocity, to identify groups of individuals within the network (named cliques) and to identify leaders (central – node C in Figure 1) and isolated individuals (peripheral – node K in Figure 1).

Figure 1 – A sociogram (de Laat et al., 2007)



Two key indicators of SNA

Network density provides “a measure of the overall connections between participants” (de Laat et al., 2007) and corresponds to the number of observed ties divided by the number of all possible ties. Network density ranges from 0% to 100%: the more participants are connected to each other, the higher the density of the network. The average geodesic distance of a network is defined as “the number of relations in the shortest possible walk from one actor to

another” (Hanneman & Riddle, 2005), in other words the length of the shortest path to link two nodes. This basic definition of geodesic distance is that used by the UCINet software package¹. It can be obtained “by adding distances for all the links in the path between [two people]. If there are multiple paths between people, we define the distance using the shortest path. If there are no paths, we define the distance as infinite. This definition [...] generalises the concept of *geodesic distance*” (Dekker, 2005). It is thus expressed as a number of ties and ranges from 1 to infinity: if the average geodesic distance of a network is 1 (=1), the length of the shortest path between each participant and their partners corresponds to one single link, which means that all participants are directly connected to one another (everyone is interconnected). On the contrary, if one or more participant is not directly connected to one or more of their partners, the length of the shortest path between them corresponds to more than one link, which means that the average geodesic distance of the network will be higher than 1 (>1). Consequently, the closer to 1 the average geodesic distance of a network is, the more participants are directly connected to each other.

In a nutshell, SNA is an approach which “offers a method for mapping group interactions, visualizing ‘connectedness’ and quantifying some characteristics of these processes within a community” (de Laat et al., 2007). It requires the use of specific software packages to compute, represent and analyze network structure. The most popular of these are UCINet (Borgatti et al., 1999), Pajek (Batagelj & Mrvar, 2014) and NetMiner (Cyram Inc., 2014).

II.3. Applications

According to Drazdilova et al. (2010, p 301), Social Network Analysis is used in a variety of fields: from the commercial sphere in the case of viral marketing, to biology and medical diagnoses for the application of viral prevention; from law enforcement in order to investigate organized crime to the e-business sphere (online advertising, recommendations systems and auction markets). SNA has also been used to study organizational communication: for example, workplace interactions have been analyzed with SNA after the introduction of computer-mediated communication in the workplace (Garton et al., 1997). Obviously, virtual social networks have also recently been studied thanks to SNA: for example, LinkedIn (D’Andrea et al., 2010).

¹ Source: < http://www.arschile.cl/ucinet_ing/calcular.html >

Several studies in the field of educational research have also started using SNA, among which a few have attempted to study NLCs: while some researchers have studied elementary school learners' patterns of interaction during the completion of a collaborative online task (Palonen & Hakkarainen, 2000), others have studied VLE-based activities (De Laat et al., 2007; Drazdilova et al., 2010); and while some have studied postings in a discussion board, as part of an online graduate class (Russo & Koesten, 2005), others have studied the cohesion of small groups in interactions based on computer-mediated communication (e-mail, text chat, discussion board) as part of a French as a Foreign Language course (Reffay & Chanier, 2003). As we can see from these examples, SNA seems to be an emerging approach in the study of NLCs.

III. Case Study

In this section, a brief account of one case study will be given to illustrate how SNA can be extremely useful in the study of computer-mediated communication patterns within an NLC. As this is part of a larger study, only part of it will be presented here, but interested readers might want to refer to Sarré (2013) for more details.

III.1. Context and participants

Over one semester (January – June) at Orléans University (Sciences Faculty), 48 first year Master's students specializing in Biology took part in a 25-hour online module of English (as a second language) whose aim was to help them develop all five skills (reading, listening, writing, speaking, interacting), with special emphasis on interactional competence development. The online module consisted of 6 collaborative tasks that learners had to complete in groups through computer-mediated communication.

Prior to the start of the course, a computerized language skills diagnosis test was administered (DIALANG, European Commission, 2004). As taking part in interactions with more competent interactants is claimed to help develop one's interactional competence through peer scaffolding (He & Young, 1998), the results of the test were used to split all participants into 12 mixed-ability groups of 4 students. In addition, all 12 groups were then split into 3 meta-groups and each was assigned a specific computer-mediated communication tool to interact

with while completing the online collaborative tasks: a text chat tool (4 groups), a discussion board (4 groups) or a desktop videoconferencing tool (4 groups).

III.2. Research Question

The main objective of the study was to explore L2 Interactional Competence development through three computer-mediated communication modes: (1) asynchronous text-based communication (discussion board), (2) synchronous text-based communication (text chat), (3) synchronous voice-based communication (desktop videoconferencing).

The research question to answer was the following: Does the computer-mediated communication mode used have an impact on the interactional load and configuration of online interactions in a second language?

The main hypothesis consisted in considering that the computer-mediated communication mode influences the interactional load of learners' contributions, the social configuration of their interactions, their integration in their NLC and the efficiency of their telecollaboration.

III.3. Equipment and materials

The online module was based on the technical infrastructure offered by an open-source VLE: Dokeos 1.8.3 (De Praetere, 2010). It provided, among other functionalities, a text chat tool and a discussion board. However, as it did not provide any desktop videoconferencing tool, an external web-based application was used: Flashmeeting (Knowledge Media Institute, 2010).

Corpus building and analysis also required the use of several technological tools:

- Camstudio (Rendersoft, 2013): an open-source screen recording tool to capture the videoconferencing sessions;
- EXMARaLDA (Schmidt et al., 2013): a transcription and data mining software package;
- UCINet (Borgatti et al., 1999): an SNA software package.

III.4. Method

Over the course of the semester, learners had to complete 6 collaborative tasks, the completion of which required the students to interact in order to solve specific problems and

make decisions as a group. The tasks were part of five subject-specific scenarios which put learners in realistic situations where they had missions to complete. The outcome of each scenario was a written language production which could only be done after the completion of the collaborative tasks: closed problem-solving or decision-making tasks and open opinion-gap tasks. For example, one of the scenarios about phytoremediation puts learners into the realistic situation of an internship that they have to carry out in Crozet, Virginia. During their internship, learners are supposed to take part in the decontamination process of the Crozet site which used to be an orchard and got contaminated with arsenic over time. At the end of their internship, they have to produce a two-page brochure about the phytoremediation procedures used in Crozet to explain them to the general public, as well as the risks of such procedures. The collaborative task they have to complete is a problem-solving task: learners notice strange phenomena during their internship (deaths of moles and voles, damage of certain types of fern, etc.) and have to come up with possible reasons for these phenomena as well as recommendations and measures to be taken to solve the problems observed in the short and long terms.

Corpus building consisted in collecting, transcribing and tagging data:

- The data collected comprised 24 chat log files in the form of text files (25 440 words), 24 discussion board files copied and pasted into text files (27 324 words) and 24 videoconferencing files which were captured video files in AVI format (521 minutes);
- Conversation Analysis-based data transcription and annotation were performed: chat files were annotated, discussion board files were annotated and videoconferencing files were transcribed, time-aligned and annotated.

Specific interactional resources were tagged in order to analyse the types of interactional resources used in each group and draw specific interactant profiles as well as conclusions in terms of interaction efficiency. The interactional resources under study (Figure 2) were all considered to be indicators of the 'interactional load' (or "*measures of interactive involvement*", Skehan 2003) of the exchanges, that is the extent to which interactants truly engage with their interlocutors through their use of specific interactional resources which enable them to negotiate meaning, coconstruct discourse and manage the interaction. An interaction with a very low interactional load often takes the form of parallel monologues, i.e. interactants talk to each other but do not take their interlocutors into consideration, so do not truly engage with their interlocutors. The resources under study thus were to show to what

extent each interactant (1) took part in the coconstruction of meaning and (2) made good use of their interactional competence.

Figure 2 – Tagged interactional resources

Resource category	Resource type	Tag	Description
Negotiation of Meaning	Routines	SCR, SCC, SST	Signal
		RMIN, RSR, RPAR, RSC, RCOMPC	Response to signal
		REAC	Reaction to response
	Negative feedback	EXCO	Explicit Correction
		QUES	Question
		RECA	Recast
		INC	Incorporation
Coconstruction	Positive alignment moves	AAP	Assessment Activity Positive
		COLCO	Collaborative Completion
		COCON	Collaborative Contribution
		FORMU	Formulation / rephrasing
	Negative alignment moves	AAN	Assessment Activity Negative
COUNTER		Counter Argument	
Turn Management		NCSSS	Non Current Speaker Selects Self
		CSSO	Current Speaker Selects Other
Interaction Management		SOCFOR	Social Formulae
		METATA, METATEC	Metacommunication about Task or about Technical aspects

III.5. Results

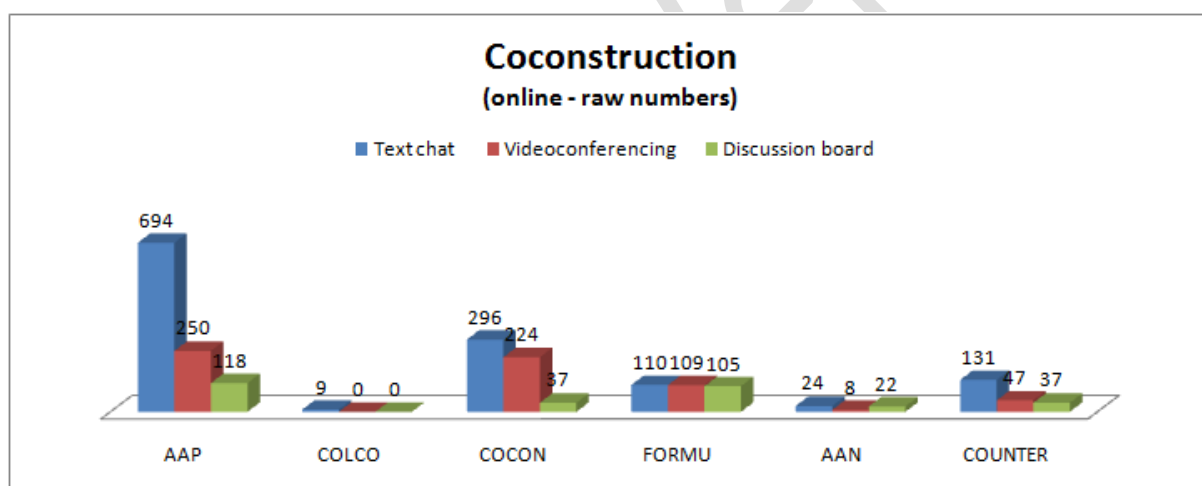
Table 1 – Interactional resources used per computer-mediated communication mode

Resource Category	Resource Type	Text Chat	Videoconferencing	Discussion Board
Negotiation of Meaning	Negotiation routines	54	102	14
	Negative feedback	61	58	0
Coconstruction	Positive alignment moves	1 109	583	260
	Negative alignment moves	155	55	59

Interaction Management	Social formulae	345	154	165
	Metacommunication	242	230	25
TOTAL :		1 966	1 182	523

The interactional resources used per computer-mediated communication mode presented in Table 1 show that learners almost consistently used more interactional resources in the text chat groups, with the exception of negotiation routines which were more numerous in the videoconferencing groups: this can probably be explained by the fact that learners interacting with videoconferencing experienced more technical glitches which gave rise to more negotiation routines (as non-comprehension, whether because of a technical problem or a language problem, is what usually sets off a negotiation routine). The data can be even finer-grained, as shown in Figure 3.

Figure 3 – Coconstruction resources used per CMC mode



As we can see in Figure 3, the number of interactional resources used to coconstruct meaning follow the global pattern mentioned above: text chat groups consistently used more than the other groups. We could, in turn, examine the other types of interactional resources under study with such detail. Still, however interesting they may be, these quantitative analyses do not account for how the various interactional resources are used within the NLCs. This is where SNA comes into play to provide a more qualitative analysis of the data. As previously mentioned, the first thing we need to perform SNA is relational data.

Figure 4 – Extract of tagged data

[1]	117	
MAM [v]	so in few months i think we will determine a new biosafety	
MAM [INTERAC]	NCSSS	
MAM [NOM]	TCONT	
[2]	118	119
MAM [v]	leveldo you agree ?	
MAM [INTERAC]	CSSO (ALL)	
MAM [NOM]		
LAU [v]		can you explain please ?
LAU [INTERAC]		CSSO (MAM)
LAU [NOM]		SCR (MAM)
ADE [v]		yes mistake like
ADE [INTERAC]		NCSSS AAP (MAM)
[3]	121	122
MAM [v]		a man who
MAM [INTERAC]		NCSSS
MAM [NOM]		RPAR (LAU)
ADE [v]	that should not occur	
ADE [INTERAC]	COCON (MAM)	
COR [v]		yes, i agree with you MAM.
COR [INTERAC]		NCSSS AAP (MAM)
[4]		
MAM [v]	walk in the coridor without safety with dangerous cultures i	
MAM [INTERAC]		
MAM [NOM]		
[5]		
MAM [v]	think there is a big problem	
MAM [INTERAC]		
MAM [NOM]		

This extract of the annotated data shows that each participant is potentially assigned three separate tiers: tiers coded [v] (v for verbal) correspond to the orthographic transcription of the exchange, the other tiers [NOM] (for Negotiation Of Meaning) and [INTERAC] (for Interactional resources) are devoted to the tagging of the specific interactional resources under study. During the tagging phase, interpersonal links between participants were also coded on resource-specific tiers. For example, on line 2, when LAU asks MAM to clarify what she just said, this particular interactional resource (a clarification request – coded SCR on the [NOM] tier as this is a signal used in negotiation of meaning routines) was tagged as well as the participant it was addressed to (the SCR tag is followed by (MAM) to identify the

participant). Another example can be seen on line 3 when COR says she agrees with MAM: on the [INTERACT] tier, the AAP tag has been used to identify the type of interactional resource used (a Positive Assessment Activity), as well as the (MAM) tag to indicate who the link is made with. Thanks to this specific tagging of interpersonal link from the raw data, which is a way of producing relational data, matrices were drafted.

Figure 5 – Group 1 Matrix

	A	B	C	D	E
1		HAY	JUM	KHE	CEL
2	HAY	0	14	11	44
3	JUM	18	0	15	25
4	KHE	13	10	0	25
5	CEL	47	27	17	0

The matrix shown in Figure 5 represents all the links made by the members of group 1 during the completion of their 6 collaborative tasks. Column A and line 1 show sets of three letters which are used to identify participants, the convention commonly used being to indicate the origin of the link on the line and the destination of the link in the column. Each cell presents the number of connections made between the different participants as coded on the [NOM] and [INTERACT] tiers. For example, line 3 column B shows that JUM made direct interactional contact with HAY 18 times. As connections between participants can be two-way (reciprocal ties) and as the intensity of each tie does matter (number of connections made), the sociograms drafted were both valued and directed. Thanks to these matrices, density and geodesic distance measures were conducted using the UCINet software package.

Table 2 – Density and average geodesic distance

		Density	Average Geodesic Distance
Text Chat	Group 1	22,1667	1
	Group 2	26,7500	1
	Group 3	36,1667	1
	Group 4	29,9167	1
Videoconferencing	Group 5	7,1667	1
	Group 6	14,5000	1,083
	Group 7	27,9167	1
	Group 9	4,5833	1,250

Discussion Board	Group 14	12,4167	1
	Group 15	9,3333	1,111
	Group 16	3,8333	1,167
	Group 17	2,0833	1,167

In addition, weighted (or valued) directed graphs were produced using UCINET to show who interacted with whom during the completion of the online tasks (interactional patterns and communication configuration). An additional attribute was added to the graphs: the amount of participation (number of turns) was represented by the nodes themselves (the bigger the diameter of a node, the more the learner participated in the interactions).

Figure 6 – Text chat (group 1)

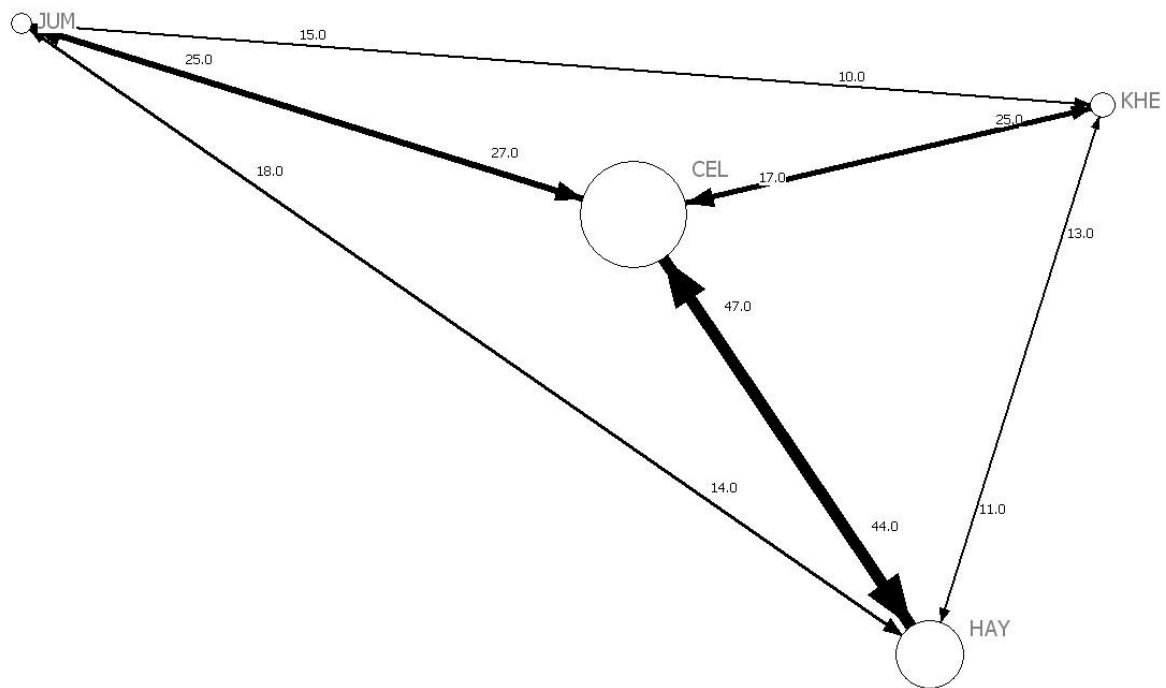


Figure 7 – Videoconferencing (group 9)

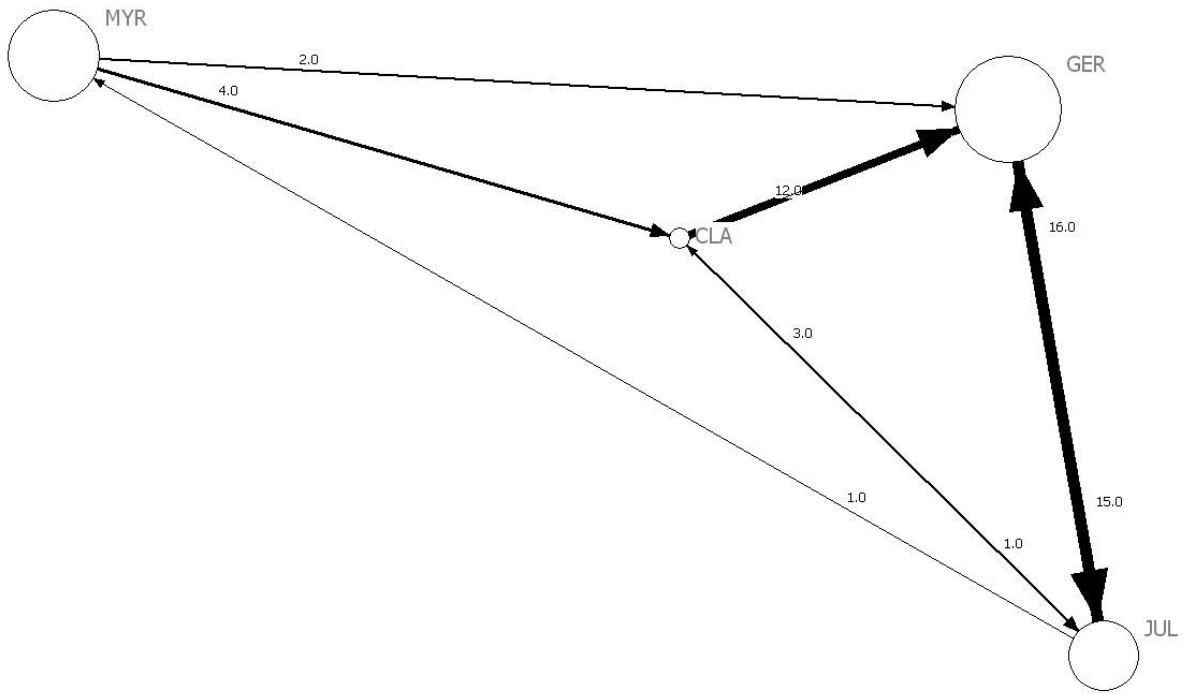


Figure 8 – Videoconferencing (group 7)

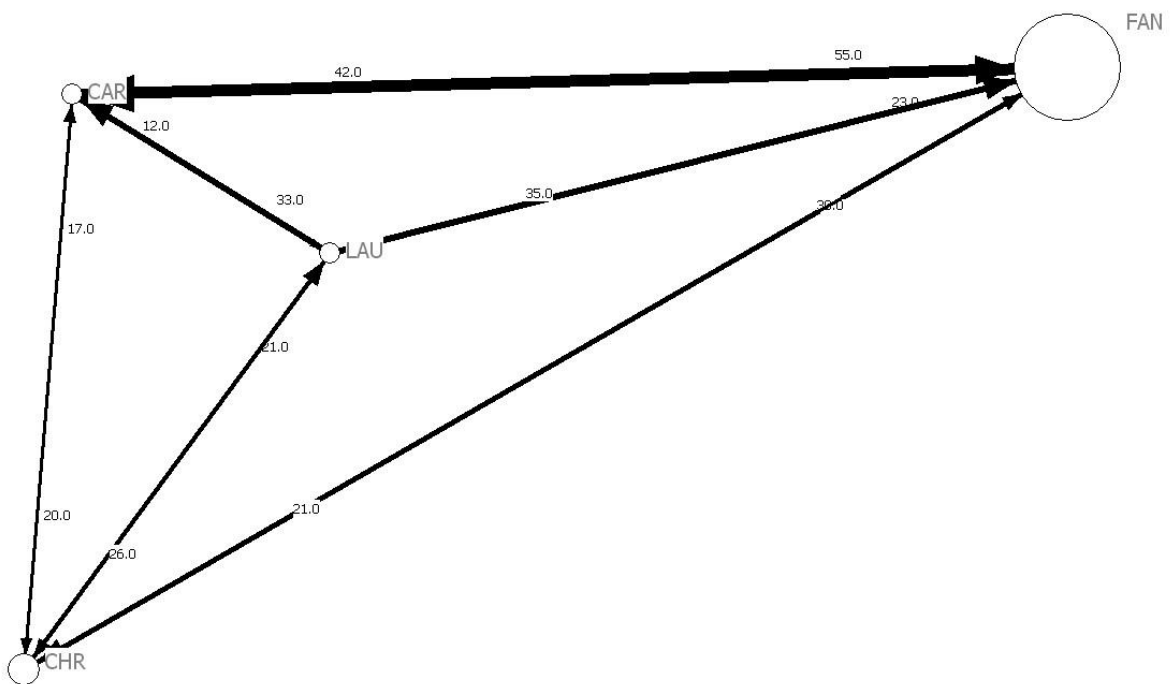
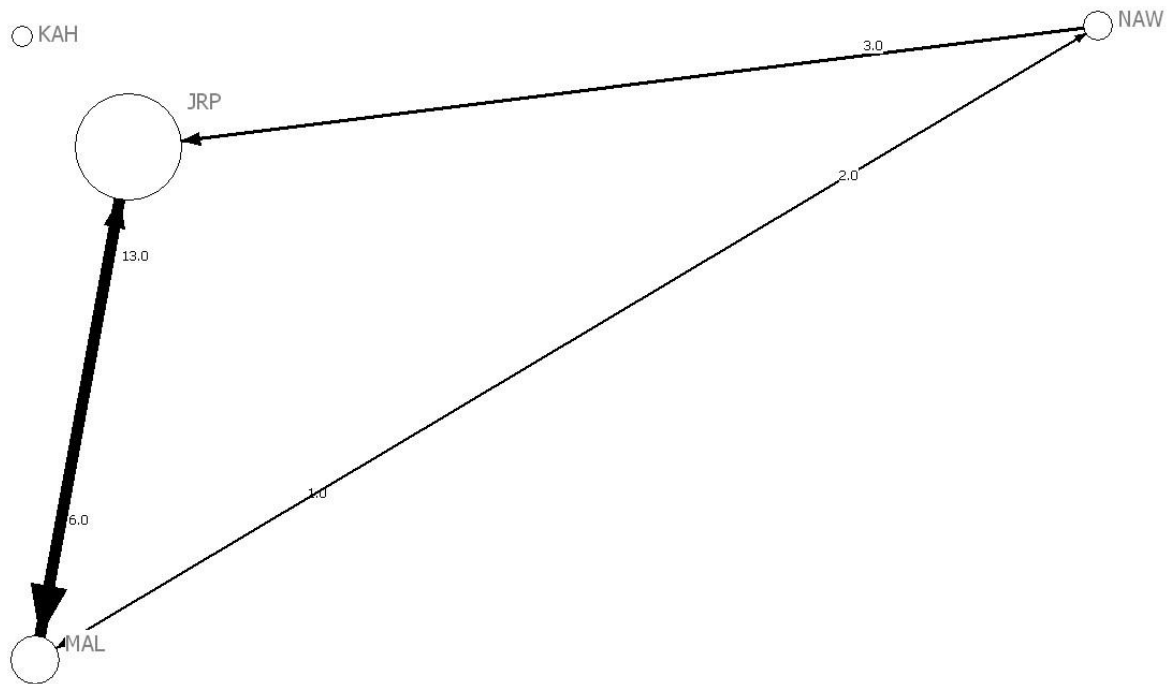


Figure 9 – Discussion board (group 17)



IV. Discussion and Conclusions

In all 3 computer-mediated communication modes, SNA has made it possible to identify one (or more) key player(s), the “virtuosos” (Perkins & Newman, 1996) who are “highly skilled practitioner[s] of e-discourse”, in other words, a participant who “serves as a guide, gentle teacher and exemplar” (1996 : 163).

SNA also showed that text chat interactions are the most symmetrical ones as their characteristics include: (1) balanced participation and strength of ties, (2) reciprocal ties only (geodesic distance = 1), (3) interactional load is high and well distributed (high density).

At the other end of the scale, the sociometric analysis also highlighted the fact that discussion board interactions are the most asymmetrical ones as their characteristics include: (1) unbalanced participation and weak ties, (2) few reciprocal ties (geodesic distance >1), (3) one (or more) peripheral participant(s), the “lurkers” (Perkins & Newman, 1996) who are participants who do not actively take part in the exchanges but simply read/listen to other participants’ contributions, (4) interactional load is low and unevenly distributed (low density): there are many “parallel monologues” (House, 2002).

As for Desktop Videoconferencing interactions, SNA showed that they are the most difficult ones to map as half seem fairly symmetrical, and half asymmetrical. It is hypothesized that this may be due to the videoconferencing tool itself: indeed, Flashmeeting – like most desktop

videoconferencing applications to date – does not allow for multiple speakers to speak at the same time when using their webcam (audio and video feeds), which means that a queuing system has to be used to be given the floor. This probably explains why certain participants rush and say everything they need to say without really engaging with their interlocutors as they are afraid they might not get to talk again later in the exchange. Whatever the interpretations, this type of qualitative analysis would not have been possible without using a methodology like SNA. As previously mentioned, this sociometric analysis is part of a larger study which includes in-depth quantitative analyses and qualitative micro-analyses based on the tagged interactional resources presented here in order to uncover the interactional patterns at work when participants truly engage in a computer-mediated exchange and display their interactional competence in a second language.

Clearly, there is a growing need today for new ways of analyzing NLCs as social interactions are now central to online learning communities and not “simply scaled-up individuals and ties” (Garton et al., 1997). This is where the SNA approach provides real added value, especially when studying computer-mediated communication, as it (1) is a valuable complementary analytical tool in NLC research, (2) can be an answer to the need for data triangulation, (3) has a role to play in mixed-method research. It seems necessary indeed to study NLCs as complex environments in rich ecological settings both from a quantitative and a qualitative point of view. For all these reasons, SNA is definitely a promising approach in the study of networked learning communities.

Finally, in an ideal world, we could go as far as to imagine that future VLEs will make the most of SNA and start implementing monitoring functionalities which will automatically make relational data available to tutors and researchers as these are often a lot more relevant and interesting than connection time, for example!

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