

Collaborative learning processes in an asynchronous environment: an analysis through discourse and social networks

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Abstract

This article analyses an experience in collaborative learning in an asynchronous writing environment through discussion forums on a WebCt platform of the University of Huelva's virtual campus, and was part of an innovative teaching project in 2007-08. The main objectives are to describe the processes of collaborative knowledge construction and the relevance of many-to-many communication in collective case resolution in asynchronous writing contexts. Two cases were selected for the experience, and two analytical approaches were adopted: discourse analysis and social network analysis. The results show that in the Case A group, where speech occurrence was less prevalent, the social network analysis markers show considerable cohesion and low levels of network centrality. By contrast, speech prevalence was greater in the Case B group and the network centrality markers were higher, although the group was less cohesive. These results lead to the hypothesis that many-to-many communication is more important in collective knowledge generation processes than dyadic or triadic communication.

Keywords: Asynchronous collaborative learning; discourse analysis; social network analysis; curricular practicals; discussion forums; many-to-many communication

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1. Introduction

1.1. Collaborative learning

Peer-to-peer learning covers a wide range of approaches, and it is important to consider it within the broadest possible context as determined by the didactic programme and the context of the centre (Coll & Colomina, 1990).

Considerable effort has been made to define collaborative learning and differentiate it from cooperative learning. According to Damon and Phelps (1989), both types of learning are defined as an action centred on the acquisition and / or application of knowledge established by a group of students. However, in cooperative learning, the skills of group members are heterogeneous within margins of proximity, while in collaborative learning the students have similar skills. In collaborative learning, Monereo and Durán (2003) state that the group's level of reciprocity, dependence and mutual interest is high, given the symmetry of skills among its components. Likewise, there is a common tendency to understand collaborative learning as the most general expression of the various dimensions of learning among equals, it being the most natural and spontaneous form of learning among peers. By contrast, cooperative learning demands a certain level of organization and planning of interaction. Collaborative learning is also recognized as appropriate for university education.

1.2. Virtual synchronous communication

The potential of virtual communication to integrate written and spoken language, together with its synchronous and asynchronous capability to be everywhere but have no base, makes it a particularly useful medium for collaborative learning. Nevertheless, its use in joint activities and the shared creation of knowledge reveals its limitations, and requires the formulation of some basic rules.

Some of these limitations are related to the difficulty of fluid exchange when taking turns in communicating, and the absence of paralinguistic complements, such as intonation and gesture, to transmit emotional aspects and more subtle meanings, which are currently described by emoticons. However, the use of virtual communication in the discussion of complex themes is especially opportune due to inherent values like asynchrony associated to the time available to think, to finding information and setting up discourse before responding, the permanence of messages that allows a more considered reflection on their content (Ramos, 2007) and the absence of social pressure, freeing participants to act in a critical way (Harasim, Hiltz, Toroff & Teles, 2000; Tirado, 2002; 2003; Schrire, 2006; García, Ruiz & Domínguez, 2007; Álvarez, 2007; Casanova, 2008). An assessment needs to be made of situations and conditions in which virtual communication is deemed appropriate, as opposed to other instances when physical contact is essential (Casanova, 2008).

1.3. Collaborative learning in virtual contexts

Collaboration has two distinct functions in virtual contexts: as a synonym of social interaction, fomenting the cooperative construction of knowledge, and, as a counterpoint to the concept of independent learning, a reference to the construction of meanings shared with others, enabling the interdependence of the participants' learning (Barberá, 2004).

From our point of view, and within the framework of this experience, we understand collaborative learning to be a communicative process directed towards knowledge construction among peers with similar skills in a virtual scenario of positive interdependence.

1.4. Many-to-many communication via forums

Differences within virtual contexts are now clearly established; computer conferencing, for example, with its three different forms – one to one, one to many and many to many – each with its own features that influence the teaching-learning processes (Hilt, 1990; Wheeler, 1997). As a forum tool, many-to-many communication enriches and socializes knowledge via the ideas, experiences and knowhow brought to it by its participants.

The idea of “collective intelligence” (Lévy, 2001) is one of several related to many-to-many communication, this being the common factor among the new forms of intelligence based on a structure of communication that is all-to-all, ubiquitous, asynchronous and enhanced by the development of information and communication technologies. Collective intelligence arises in cyberspace supported by Internet mechanisms of one-to-one, symmetrical and many-to-many communication. Computer conferencing enables a type of communication in which all the connected nodes can be broadcasters or receivers, participating collectively and on equal terms in the generation, negotiation and definition of collective knowledge (Pierre & Kustcher, 2001).

These new concepts of knowledge have their roots in the theory of conversation based on the social nature of learning proposed by Vigotsky (1978). The role of social interaction within this theoretical framework is crucial for promoting learning. The acquisition of new knowledge is the result of the interaction of students who participate

in a dialogue. So, learning is a dialectical process in which an individual contrasts his personal point of view with that of another to reach agreement. Information and communication technologies have the potential not only to reduce the isolation of distance-learning students but also to create a social environment in which learning is made easier through discussion of course content by articulating and communicating ideas, simultaneously hearing and evaluating the ideas of others.

1.5. Discourse analysis in asynchronous communication

Gone are the times when studies on collaborative learning were limited to identifying its effects on and relation to different methodological variants. Now the new generation of researchers seeks to identify the causes and mechanisms behind the positive results of collaborative learning, focusing attention on the processes of collaborative interaction among peers.

Henri (1992) is especially relevant for specifying five dimensions: participative, social, interactive, cognitive and metacognitive. Guanawardena, Lowe & Anderson (1997) centre on the cognitive dimension relative to the process of the social construction of knowledge by establishing the following stages: a) sharing and comparing information; b) discovering and exploring dissonance and inconsistency between ideas, concepts and principles; c) negotiating the meaning and mutual construction of knowledge; d) testing and modifying the synthesis or co-construction proposed; e) declaration of agreements and application of new meanings. Similarly, Rourke & Anderson (2003) propose a specific model for case studies in virtual collaborative contexts: a) learning and experimenting with the platform; b) planning group work; c) finding solutions individually; d) finding solutions collaboratively; e) preparing the final result individually and collectively; f) drawing up the final document.

Garrison & Anderson (2005) propose a three-dimensional system: a) cognitive presence; b) social presence; c) teaching presence. Marcelo & Perera refer to the social, cognitive and didactic dimensions. Recently, a doctoral thesis by Casanova (2008: 80-81) revised these models and identified three analytical categories:

- The psychosocial relations of help, assistance, support, encouragement and reinforcement among group members. These have a positive influence on motivation and affectivity, and on the group social dynamic.
- The construction of meanings through language. This presumes the devising of goals, plans, ideas and concepts by the group; offering and asking for explanations and proposals; negotiating, coordinating and regulating contributions, points of view and roles in the interaction.
- Positive interdependence between members in the development of the learning activity. This can be based on the objectives, the task, the resources and / or the reward (Johnson & Johnson, 1999). It involves considerable responsibility and commitment on the part of each group member to the learning process and to the rest of the group.

These contributions establish category systems that help us to understand the processes of knowledge construction. But, as Gros & Silva (2007) point out, it is impossible to use a valid, universal reference system given the diversity and uniqueness of each experience.

1.6. Analysis of social networks

Since virtual learning contexts are supported by the creation of social networks, any study of the processes of psychosocial relationships requires the analysis of the general structure of the network and the position of its components within it in order to examine the social structures that underlie the flow of knowledge, information, exchange and learning. Some of the markers used in the analysis of our experience are the following: size is one of the main structural determinants of the level of possible participation in a

network; group size is also important in the calculation of other parameters of network definition, such as density (Ridley & Avery, 1979). If certain students are not members of a particular network (because they opted for another communication network, for example), their absence must be noted in the size value (Fahy, Crawford & Ally, 2002).

Density is a measure of the breadth of the social experience of the individuals in a group (Berkowitz, 1982), and it can also be seen as a calculation of connection with the network, connection being the links between pairs of network members that occur as a result of the initiative taken by any member of its constituent parts.

Various methods have been proposed to calculate density (Ridley & Avery, 1979). We can take it to be the proportion between the number of links between group members and the number of total possible links among all colleagues.

Density can be useful for determining the quality of interaction but it needs to be treated with caution. Values for density could be high due to the efforts of a few “connectors” (subjects). If this occurs, we would be left with inflated density figures while the mean number of connections for all network members remained low. That is, a relatively small number of participants would account for a large chunk of the interaction (Fahy, Crawford & Ally, 2002).

Another reservation is that network density is closely related to size, and density data from larger networks are predictably lower than in smaller networks. So, density value comparisons ought not to be made between groups of different size as a way of deducing network connection (Rytina, 1982).

Another concept that helps explain a group’s properties is centrality. This is generally associated to the relative centrality of the points on a graph, and also occasionally refers

to another completely different aspect, which is the network's degree of centralization as a whole. In this sense, Freeman (1978) makes a difference between point centrality and graph centrality. Scott (1991) proposes clarification by using centrality to refer only to the centrality of the points, and centralization as a reference to the problem of the internal cohesion of the graph taken as a whole; that is, the centrality of the graph.

With this in mind, centrality studies those participants who are the most prominent, influential and reputable. Markers deployed in the asymmetric networks provide specific information on these aspects, with outdegree and indegree markers indicating outgoing and incoming contact respectively. Outdegree indicates each participant's social activity and the extent of access to other participants. Indegree reveals the most influential participants, the ones most referred to by the rest.

The centralization index refers to the participant who acts as the centre, connected to all the nodes which have to pass through this central node in order to connect to the others.

A network's degree of centralization indicates how close it is to being a star network, in which a participant or an object acts as the centre that controls or channels all activity in the network.

2. Study objectives

This study is based on the supposition that many-to-many communication within a group via computer conferencing is better suited to speech construction in collaborative learning contexts than dyadic and triadic communication, for example, as revealed by markers of communication density in the social network for which they were created. Although these other forms of communication can play an important role in the initial stages of the group's collaborative learning process, they are not as essential in the

generation phase of collective knowledge as many-to-many communication, as measured by centrality and network centralization markers.

Based on these suppositions, the aims of this study are:

- 1) To describe processes of the collaborative construction of knowledge based on the resolution of practical cases with regard to the following: socio-affective relations, positive interdependence and shared construction of meaning.
- 2) To note the relevance of many-to-many communication in the shared construction of knowledge compared to other forms of communication such as the dyadic or triadic options.

3. Description of the experience

The project is based on the organization of groups of students on the Social Education diploma course who are doing curricular practicals (related to minors at risk, drug addiction, local development, social services...) but who are designated to different institutions and centres, with different programmes. Each group has to study two real cases at the centres where the students are doing their practicals.

Each working group is given the following resources:

- A protocol on how to resolve cases and problems in a cooperative form in virtual contexts, based on the Rourke-Anderson model (2002).
- On-site evaluation of practicals by a teacher-supervisor who will take the student through the protocol on resolving cases and problems.
- This project's main instrument is the WebCt virtual training platform, which has three basic areas: content and material, communication and work assessment.

Each group also has a forum where team work can be discussed and carried out, and an area for uploading and downloading files.

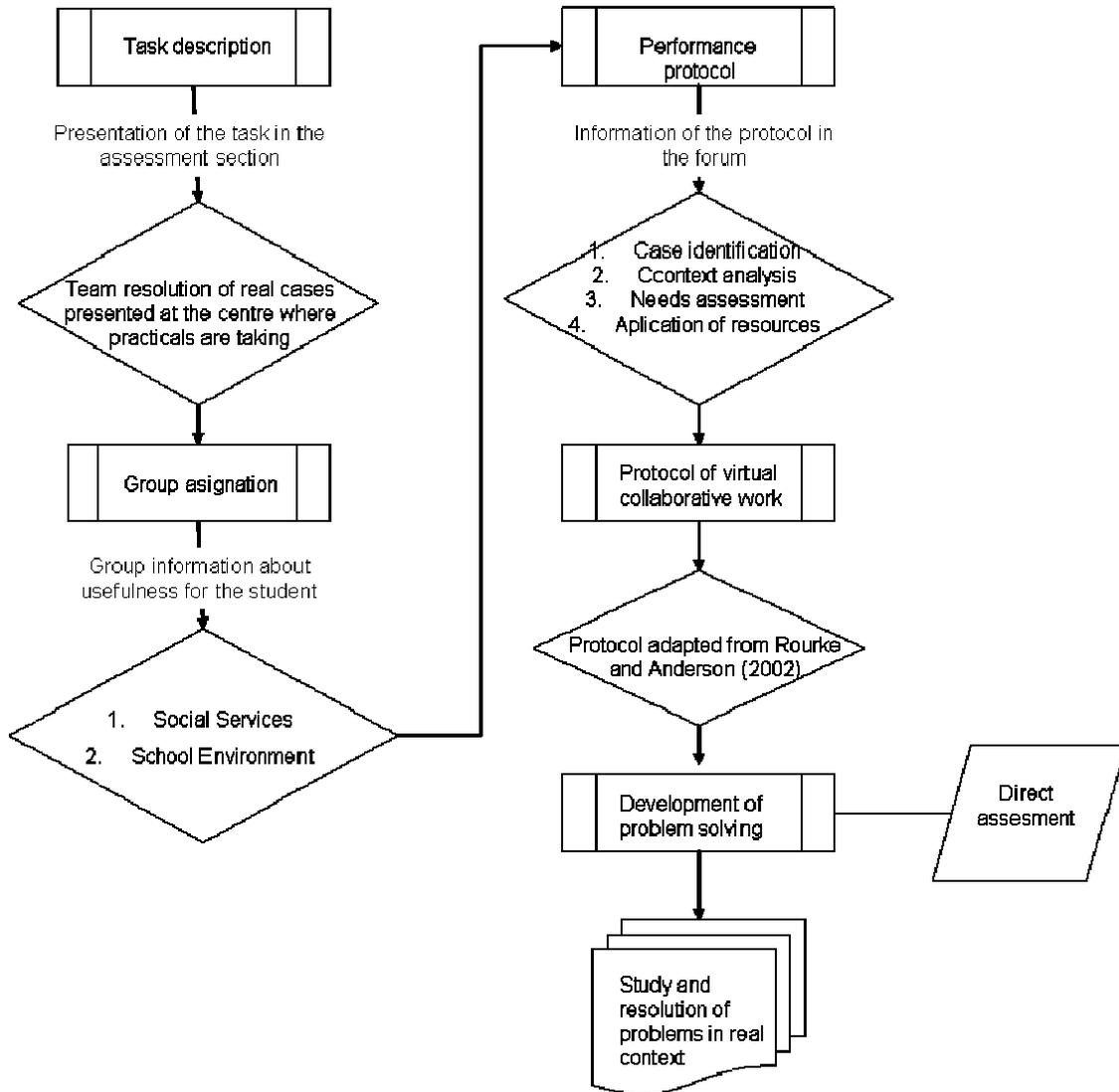


Figure 1

The task, which falls within the framework of techniques compiled by Barkley et al. (2007) for collaborative learning in the university context and which is applicable to the virtual environment, is a structured technique for problem solving. The students follow a structured protocol for solving problems that is used in the method procedure of cases

in social work. That is: identify the problem situation (investigation), understand the situation, find out how this situation has arisen, why it persists (diagnosis), and propose an assistance plan (treatment) supported in available or viable institutional resources to solve the problem.



Figure 2

Those who took part in the experience were third-year students of the Social Education diploma course placed at centres where they were to do their curricular practicals (tackling absenteeism, disabilities, minors at risk, senior citizens, addictions...). As concerns this article, we divided these students into two groups. The selection criteria used were development discrepancy and communicative structure, and we set up representative cases for the experience. The number of members per group was seven and nine, respectively.

4. Method of analysis

From the descriptive point of view, we made an analysis of the interaction among members of the different learning groups throughout the experience; each group was self-managed. The dimensions considered for the analysis were the following:

- 1) From a time perspective: phases of cooperative work, its development in time in the process of solving real practical problems with regard to the categories previously defined: psychosocial relations, positive interdependence and construction of meaning.
- 2) From a structural perspective: density, centrality and centralization of the social network.

As an instrument for discourse analysis, we used the records of interventions in the forums created by each group on the platform.

We chose this direct observation technique in order to define more objectively the frequency of intervention of each member and the types of interactions that were taking place. This type of analysis is increasingly common in studies of virtual learning communities (Fahy, 2003; Rourke & Anderson, 2002; Wasson & Morch, 2000; Heift & Caws, 2000; Fahy, Crawford & Ally, 2001). However, it excludes a longitudinal analysis of the interactions that occurred.

The system of categories for the register and analysis of the activities of each group's members was focused deductively and inductively, taking Hunter's models (1997) as reference for the analysis of the case study processes for the team work, Rourke & Anderson's proposal (2002) & Casanova's synthesis (2008).

Table I. System of categories for the register and analysis of activities

Category	Subcategories	Definition	Examples
Psychosocial Relations	Encouragement	Interventions whose aims are to encourage the group and / or affective contact to maintain cohesion among group members.	<i>...Come on everyone! There isn't long to go! (let's not get stressed out, eh!)...</i> (Message, 1310, Belinda Pinzón, Tuesday, June 10, 2008 19:04)
	Greetings, Apologies...	Affective contributions necessary for creating a predisposition towards communication.	<i>...Sorry for the delay but I am only just getting used to this...</i> (Message, 498, Juan J. Escobar, Wednesday, May 14, 2008 17:03)
Positive inter-dependence	Clarifications	Interventions that consist of clarification of some aspect of case resolution.	<i>... If you click on "students" you will see the names of all the students in the group... (We are 10). Each of us presents a case and two are selected...</i> (Message, 254, M ^a Paz, Thursday, April 24, 2008 11:39)
	Questions	Contributions in the form of questions that seek clarification on certain aspects of the case.	<i>...the child according to Ramón, where did we have to place him? In the School Absenteeism Plan?</i> (Message, 1136, Ana M ^a , Thursday, June 5, 2008 17:10)
	Proposals for investigation	Contributions of investigation proposals that enhance the legal, conceptual and technical knowledge of the case to be resolved	<i>The steps we have to take are: plan, discuss the case demands, assess and share out roles, etc</i> (Message, 309, Nazaret Peguero, April 30, 2008 12:34)
	Organizational communication	Interventions whose purpose is the organization and distribution of tasks, and maintaining contact among group members.	<i>You're welcome, Inés. If anybody still can't see it, they can contact either of us and we will copy it here as a message...</i> (Message, 900, Sonia Castro, Wednesday, May 28, 2008 15:08)
Shared construction of meanings	Enclosing information	Interventions based on	<i>With respect to institutional support, we have:</i> - Ticket purchasing programme. - PAHI assistance. - Purchase of medication...

	the content of the task. Information is sent in order to add it to the final synthesis or present it for critical analysis and comments.	(Message, 338, J.M. Bellido, Monday, May 5, 2008 15:43)
Information criticism	A critical evaluation of information supplied by colleagues with a constructive purpose.	<i>So far the contributions seem to be correct but apart from teachers' needs, teachers should also be trained.</i> (Message, 838, Fco Lucas, May 26, 2008 20:43)
Offering solutions	Offering case solutions	<i>What we could do is give the neighbourhood other alternatives, after-school activities that broaden their social circle.</i> (Message, 937, Cristina Cerón, Thursday, May 29, 2008 17:17)

Triangulation was used when creating and analysing the categories (Silva & Gros, 2007) in order to resolve the problem of system category reliability. In the codification process, we used various researchers who analysed the same forum applying codes with regard to definitions of categories and subcategories. We then contrasted these codifications to get a redefinition of some categories and a definitive version of the systems of categories that would give us clear, unanimous criteria when applying the codes to the discourse.

For discourse description, the subject unit was taken as the unit of analysis, as opposed to other units of analysis like the syntactic (proposition, work, phrase or paragraph) or the message. The subject unit, or meaning unit, is defined as a unit of meaning, thought or idea (Rourke et al., 2001). Although the subject unit is not objectively recognizable, like the message or the syntactic unit, it always adequately comprises the construct under investigation, even though it induces a subjective and inconsistent interpretation of the unit.

We used UCINET6 for Windows to analyse the networks. Three social network markers were analysed. Density was analysed as a network property marker, enabling us to perceive the relations among group members.

We also examined global network cohesion markers through analysis of the geodesic distance of the network applied to asymmetric networks. These markers enabled us to study the network members' connections among themselves. These markers provide profiles that help reveal the degree of decentralization of communication in the forums.

Thirdly, we analysed network centrality which, being asymmetric, involved measuring outdegree and indegree, as well as social network centralization as a manifestation of the power of forums as a medium for many-to-many communication.

The Netdraw program was used to draw graphs of the network structures. Graph distribution was non-random, taking into account the properties of the network, and its values of cohesion and centrality in terms of each subject (node) and the group (network).

5. Results

5.1. Case A

Discourse analysis

Table II: Interaction patterns. Case A

SENDER	INTERACTIONS											RECEIVED							
	Psycho-social relations		Positive interdependence				Construction of meaning					Forum	Cinta (co-ord.)	Marina	Mario	Reme (co-ord.)	Erica	Fca.	Dynamizer
	Encouragement	Greetings, apologies...	Clarifications	Questions	Investigation proposals	Communication	Enclosing information	Critical information	Providing solutions										
Cinta (co-ord.)	24	2	2	8	1	0	13	2	0	2	10	X	3	1	4	1	5	0	
Marina	12	0	2	1	3	3	4	1	0	0	3	6	X	0	2	0	1	0	
Mario	1	1	0	0	0	0	1	0	0	0	1	0	0	X	0	0	0	0	
Reme (co-ord.)	17	0	5	4	4	0	4	3	1	1	11	2	0	0	X	1	3	0	
Erica	14	2	2	1	3	1	6	2	1	1	10	1	0	0	2	X	1	0	
Fca.	21	1	1	1	6	3	8	2	0	2	11	6	1	0	3	0	X	0	
Dynamizer.	5	1	0	1	0	1	2	0	0	0	2	1	0	0	2	0	0	X	
TOTAL	94	7	12	16	17	8	38	10	2	6	48	16	4	1	13	2	10	0	
		19			79				18		46				43				

Increasing-accelerated interaction is generally characterized by a process in which a time period appears at the end of the case, when there is a notable increase in group activity; this is a phase we call *intensive*.

Here we identify three development phases:

- 1) The short prior phase. In the first week, some affective contact occurs, greetings, clarifications about the case, questions.
- 2) The positive interdependence phase. From the second week until the end of the fourth week, low intensity intervention is the norm in which communication for organizational purposes concerning the case occurs. There appear some contributions offering possible solutions but mainly they ask questions about controversial aspects of the case.
- 3) The decisive interdependence phase. A burst of group activity occurs in the fifth week, four times greater than in the previous phase. Communication is mainly about organization, although there is also a significant increase in investigation proposals, some of which are linked to work organization. There are also contributions regarding information and proposals for solutions. The subsequent decrease in activity is due to the work reaching a conclusion.

Case A. Progress of interactions

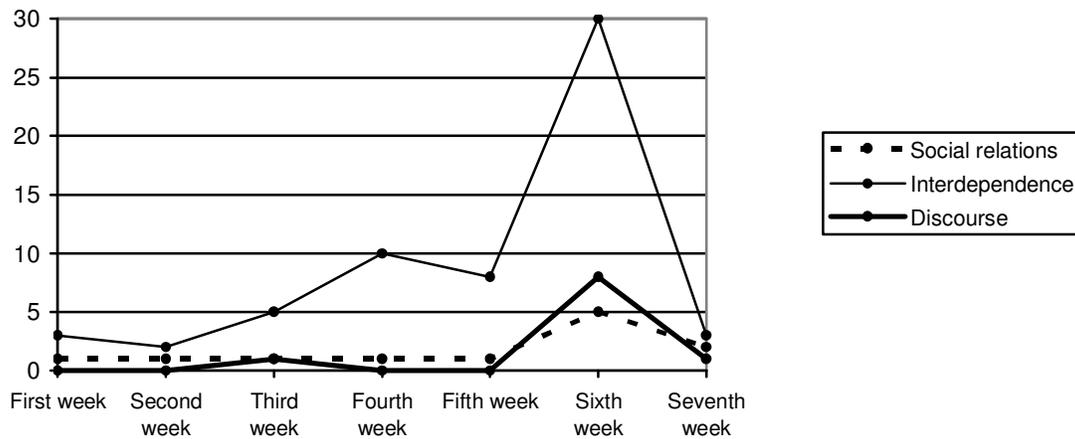


Figure 3

Network analysis

When we analyse communication density, taking this to mean the proportion between the number of connections between pairs of colleagues and the total number of possible connections within the group, we find its value to be 0.66; as a mean value, we could say that each subject has connected with 66% of the group components. However, 51.06% of participations in the group were not directed to specific working group colleagues but to the forum. As can be seen, the interactions are not all the work of specific colleagues. Almost all participants interact to a similar degree of frequency, although slightly higher levels of interaction are registered for case study coordinators. With this database, we were able to determine that this group showed that interventions were highly compact. So, we concluded that the communication among colleagues is compact but without it concentrating around one or two components, which contributes to dialogue and cooperation among all, as opposed to possible autocratic situations that arise when one member grabs all the attention and clearly takes control of the group.

Network of interactions (Group A): compact without leadership

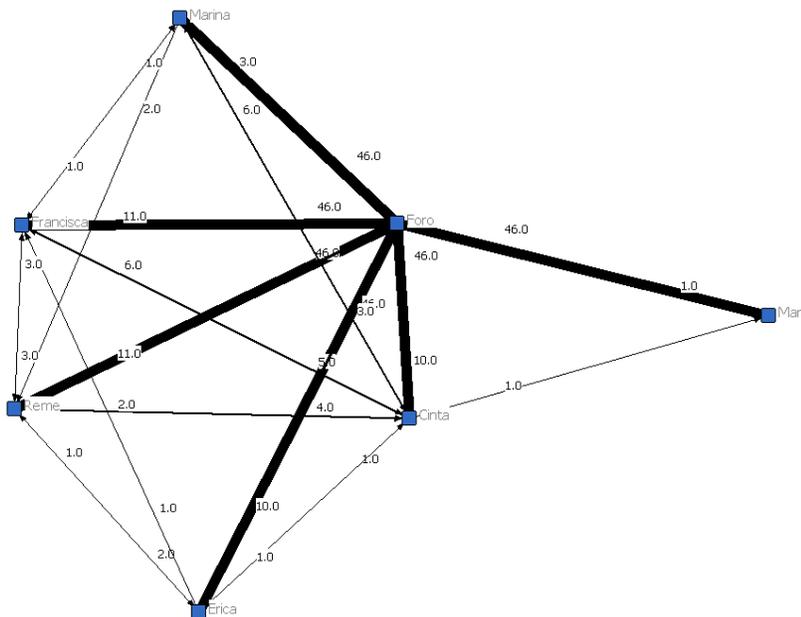


Figure 4

<i>Geodesic distance</i>	<i>Case</i>
	<i>A</i>
Average distance (among reachable pairs)	1.310
Distance-based cohesion ("Density").	
Range 0 to 1; higher values indicate greater cohesiveness	0.845
Distance-weighted fragmentation ("Breadth")	0.155

The geodesic distance markers show a low mean distance between pairs of reachable subjects (1.310), high levels of cohesion based on the distance between pairs – density – (0.845) and low levels of distance fragmentation (0.155), all of which demonstrates a high degree of group cohesion.

	<i>OutDegree</i>	<i>InDegree</i>	<i>NrmOutD</i>	<i>NrmInDe</i>
	<i>e</i>		<i>eg</i>	<i>g</i>
Forum	276	46	100	16.66
Cinta	24	61	8.69	22.10
Francisca	21	56	7.60	20.29
Reme	17	57	6.15	20.65
Erica	14	48	5.07	17.39
Marina	12	50	4.34	18.11
Mario	1	47	0.36	17.02

Network Centralization (Outdegree) = 94.626%

Network Centralization (Indegree) = 3.744%

Network Centralization Index = 25.19%

The outdegree and indegree markers reveal the central role of many-to-many communication in initiating communication. Nevertheless, the network's centralization

index is low (25.19%). The graph shows that the forum is not always at the centre of network activity, since one of the working group coordinators also acts as a hub. Likewise, the connection among group members is compact, with the exception of one participant who remains on the periphery.

5.2. Case B

Discourse analysis

Table IV: Pattern of interactions. Case B

		INTERACTIONS																											
		PSYCHO-SOCIAL RELATIONS											CONSTRUCTION OF MEANING																
		Positive interdependence											of RECEIVED																
SENDER	Participation	Encouragement	Apologies...	Clarifications	Questions	Invitations	Proposals	Communication	Encouraging	Information	Clarifying	Information	Proposals	Solutions	Forum	M ^a Paz	Gloria	Lucia	Cecilia	Noelia	Isabel	Elena	Gema	María	M ^a Jesús				
M ^a Paz	16	0	0	1	5	1	7	1	0	2	8	X	0	2	6	0	0	0	0	0	0	0	0	0	0				
Gloria	10	0	2	0	1	0	4	1	0	2	8	0	X	0	2	0	0	0	0	0	0	0	0	0	0				
Lucia	24	0	1	2	1	5	10	6	0	3	18	3	0	X	2	0	0	0	1	0	0	1	0	0	0				
Cecilia	40	0	7	3	5	7	17	9	1	7	27	4	0	5	X	1	0	1	1	1	0	1	0	1	1				
Noelia	7	0	0	0	0	0	7	0	0	4	5	0	0	0	2	X	0	0	0	0	0	0	0	0	0				
Isabel	10	0	0	0	2	0	7	0	0	2	5	0	0	2	2	0	X	0	0	0	1	0	0	1	0				
Elena	6	0	0	0	0	0	2	0	0	3	4	0	0	1	1	0	0	X	0	0	0	0	0	0	0				
Gema	8	0	0	1	3	1	2	0	0	3	4	0	0	3	1	0	0	0	0	X	0	0	0	0	0				
María	6	0	0	0	1	0	3	0	0	2	4	0	0	1	1	0	0	0	0	0	0	0	X	0	0				
M ^a Jesús	8	0	1	0	1	0	5	0	0	3	5	0	0	2	1	0	0	0	0	0	0	0	0	0	X				
TOTAL	135	0	11	7	19	14	64	17	1	31	88	7	0	16	18	1	0	1	2	1	1	1	1	1	1				
		11	121		49		88		47																				

In increasing-progressive interaction, there is a tendency for the interaction to grow. There are two periods of intense interaction either side of a phase of low communication activity. Here we can identify three development phases:

- 1) The pre-organization phase: interaction was low in the first two weeks. The students shared out the tasks, made suggestions for investigation, aired doubts and sent attachments containing information relevant to the task, etc.
- 2) The positive interdependence phase. There was a significant progressive growth in communicative activity in the third and fourth week. There was a rise in interventions concerning organization and contributions towards case solutions. This is still an early phase in the process, so these contributions might be more diagnostic in nature than providing conclusive solutions to the case in question.
- 3) The reflexive phase or individual work. The dip in interaction when the communicative phase is in full swing in the fifth week leads us to think that the students are spending more time working alone on research and proposals. Possible proof of this is the notable increase in personal contributions a week later.
- 4) The decisive interdependence phase. Following the period of reflection and individual work characterised by a decline in interactions, there is a considerable increase in contributions of solutions and organizational activity. Since the practicals are coming to an end, it could be that these contributions consist of decisive measures applicable to the cases. Likewise, it is important to note that contributions offering solutions are the most prevalent, much more than in previous weeks, while the number of interactions related to organization remains the same as in the fourth week.

Case B. Progress of interactions

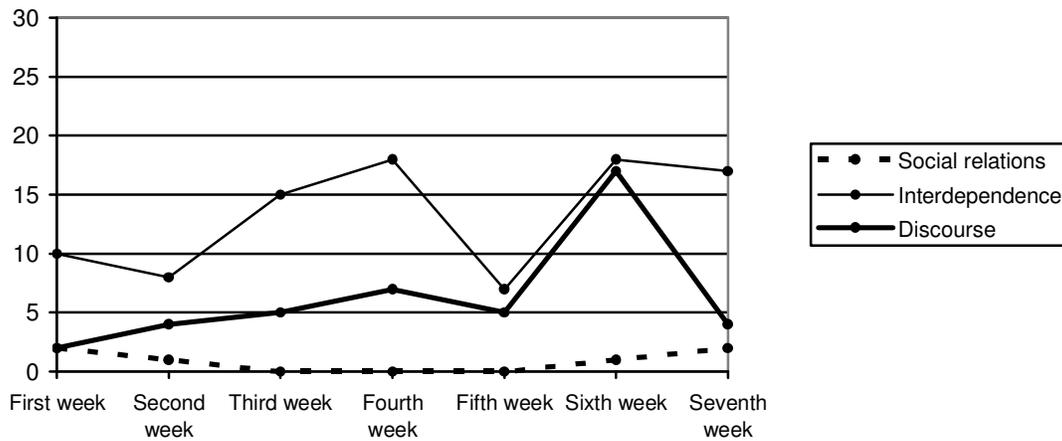


Figure 5

Analysis of networks

The density of communication, understood as the proportion between the number of connections between pairs of colleagues (9) and the total number of possible connections within the group (28), stands at 0.32. Taking this as a mean value, each subject has connected with 32% of the members of the group. This study shows that 71.57% of student participation took place in the forum, with very few messages sent directly to a specific colleague. Thus, communication among group members has not been compact.

In conclusion, this is a large group that seems to be split it two. There are those who communicate one-to-one as well as via the forum, and those who only interact with colleagues via the forum. We find compact communication occurring among three colleagues and none among the rest. As a contrast to the lack of compact group communication, a concentration of interaction is found in one of the colleagues who we

understood to be the one who provides dynamism and leadership, even though that person is not group co-ordinator in either of the cases.

Network of interactions (Group B): semi-open with leadership

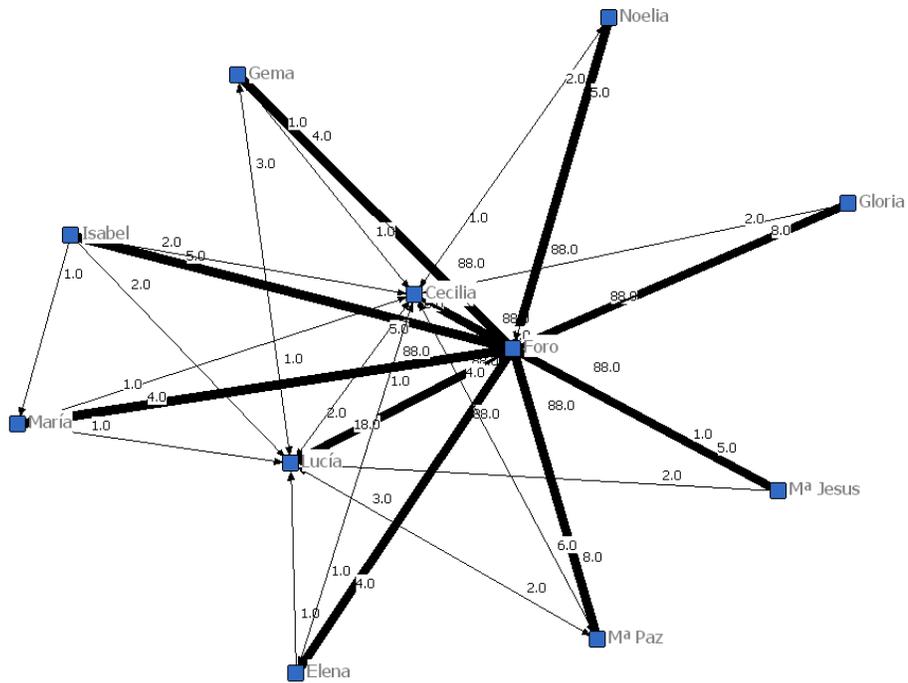


Figure 6

Case

B

Geodesic distance

Average distance (among reachable pairs)	1.625
Distance-based cohesion ("Density").	
Range 0 to 1; higher values indicate greater cohesiveness	0.700
Distance-weighted fragmentation ("Breadth")	0.300

The mean of the geodesic distance markers is close to 2 for the distance between pairs of reachable subjects (1.625), with high levels of cohesion based on the distance between pairs – density – (0.700) and moderately low levels of distance fragmentation (0.300), all of which reveals a moderate level of group cohesion.

	<i>OutDegree</i>	<i>InDegree</i>	<i>NrmOutDe</i>	<i>NrmInDeg</i>
Forum	880	89	100	10.00
Cecilia	40	106	4.54	12.04
Lucía	24	104	2.72	11.81
Mª Paz	16	95	1.81	10.79
Gloria	10	88	1.13	10.00
Isabel	10	88	1.13	10.00
Mª Jesus	8	89	0.90	10.11

Gema	8	90	0.90	10.22
Noelia	7	89	0.79	10.11
Elena	6	89	0.68	10.11
María	6	89	0.68	10.11

Network Centralization (Outdegree) = 98.466%

Network Centralization (Indegree) = 1.716%

Network Centralization Index = 46.85%

The outdegree and indegree centrality markers highlight the central role of many-to-many communication at the start of communication. Likewise, the network's centralization index is quite high (46.85%). The graph shows that the forum is at the centre of all network communication.

6. Conclusions

6.1. Discourse analysis

Following the analysis of discourse for cases of virtual collaborative learning based on problem solving in university curricular practicals, we identified two different case types by the following characteristics:

- The cases differ in the level of member participation.
- Each case has a different number of phases.
- The intensity of the interpsychological processes varies in each case and phase.
- Both cases exhibit different types of interpsychological processes in the various stages, however, the processes of knowledge generation increase in importance in the final stages of the process.

The first case consists of a final period in which all participation is concentrated and where the process contains mainly social relations and manifestations of interdependence. In this case, exchanges for knowledge creation (discussing problems and their solutions) have little value.

The second case is determined by a high level of participation that grows in the first weeks, in which processes of social relations and interdependence predominate and where there is a rise in the processes of meaning construction. This is followed by a decline in communication which we believe is due to a period of individual study. Finally, there is a notable increase in communication when the processes of knowledge and meaning construction are as equally important as the processes of positive interdependence.

6.2. Analysis of networks

The analysis of the networks reveals two different types of network identified by density, cohesion, centrality and centralization of many-to-many communication:

- The first is a group with moderate communication density (66%) among its members as well as an acceptable level of commitment among members. However, some fail to integrate within the group for lack of participation and correspondence – not responding to messages received or because the messages they sent were not answered.
- The second type is a large working group with low compact communicative activity with interventions that are mainly directed to the group as a whole, with some intense interaction between colleagues. Nevertheless, there are several cases of students who remain outside the specific exchanges that take place between colleagues.

Cohesion within the Case A group is higher than in the Case B group, although group size needs to be taken into account.

However, the Case B group is more centralized than the Case A group, thus demonstrating the importance of many-to-many communication over one-to-one communication in the Case B group.

In the Case A group, dyadic communication is more frequent, and there is greater cohesion and density.

The data from discourse and social network analysis allows us to hypothesize that many-to-many communication is essential at certain stages in the process of knowledge construction, particularly when cooperation is required for creating meaning. Further research is needed that is more fragmented and associated to the different stages of the process of collaborative learning, enabling a link to be established between those phases in which importance is given to social relations and positive interdependence or to the creation of meaning and the properties of the social network, through markers like those used in this study: density, cohesion and centrality of communications.

7. Critical reflection

The uniqueness of collaborative learning in a context of university curricular practicals mediated by the use of asynchronous communication forums for the development of professional problem-solving competences requires the development of specific models that respond to these particular circumstances.

Analytical models and category systems like those of Henri (1992), Guanawardena, Lowe & Anderson (1997), Garrison & Anderson (2005), or Casanova (2008) are appropriate as a general analysis framework of virtual collaborative learning situations. However, they require specifications and adaptations to provide more precise indicators for each didactic circumstance in natural contexts. The system used in this analysis needs more exact and rigorous development if it wishes to identify valid categories that enable us to accurately describe psychosocial relations, the collaborative construction of

meanings and positive interdependence as defining factors of the processes of collaborative learning in virtual contexts.

Mercer (2001) states that the search for virtual collaborative learning indicators in curricular practical cases based on problem solving that allows us to progress in the knowledge of the appropriate management of these didactic processes demands studies that relate case analysis to the results of learning. Therefore, the aims and methodologies behind these analyses must take into account the presence of categories relative to performance that have a solid base and prior validation.

One important limitation of this experience, if one wishes to extrapolate the results to similar didactic situations, is the low competence shown by the students in the use of the learning platforms and forums, as well as in the cooperative construction of solutions. Familiarization with these tools and a prior simulation of the experience are essential before the real experience begins.

These considerations are also subjected to a rigorous control of the modulating factors of the efficacy of the virtual collaborative learning process, that is, of group composition (Barberá & Badia, 2004), the task characteristics (Rodríguez, 2001; Colombina & Onrubia, 2001), teacher performance and the selection of appropriate didactic techniques (Barkley et al., 2007; Monereo & Durán, 2002), and context (Harasim et al., 2000; García et. al., 2007).

Any collaborative learning process needs to go through a stage in which the working group is constituted socially and given cohesion before work starts on the task and its content. As a result social network analysis, as demonstrated by its traditional use in sociology, is a valid tool for measuring relationship variables within a social context.

Epistemological progress in this field will depend on the validity and reliability of observational tools. Asynchronous writing environments such as forums make this possible via analysis of the records of participation and of the social networks.

8. References

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