Fluid Centrality of Social-Technical Relations in a Networked Environment

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Abstract

In this paper, centrality is explored as a measure of networked learning. Centrality measure is quite common in performing social network analysis and in analysing social cohesion, strength of ties and influence in networked learning and computer-supported collaborative learning research. It argues that measuring centrality using social network analysis is rather misleading, that in fact, it is a relational effect of many things, not just those tied by message threads in online forums. The network data described and analysed were obtained from students training to be History teachers at secondary level of schooling in a postgraduate certificate programme in an English university. Blackboard (a commercial virtual learning environment) was used in the course. Online postings in 14 separate forums in the course were considered alongside the perceived relational ties of the teacher trainees in six different communication media (ie. face-to-face, discussion board, mobile phone, email, land phone and online chat). It elucidates that centrality in networked learning is *fluid* - actors (ie. participants in the online forums) and their relational ties can not be treated as predictable and fixed and central actors can not be solely inferred from the total number of online postings and their resulting centrality measure in online forums.

Keywords

social network analysis, networked learning environment, response ties, centrality.

Introduction

Network has been used as a metaphor to understand learning with technologies, as a descriptor of the new learning configurations and as a measure of cohesion, centrality and strength of ties using social network analysis (SNA) in current networked learning (or computer-supported collaborative learning) research. As a metaphor, it has raised questions about relatedness and interconnections. As a new social formation, it allows us to recognise the effects of the mobilities of goods, peoples and ideas made possible by technological advances (Castells, 1996; 2000). And as a measure, it is driven by notions of knowledge construction, community and collaboration (e.g. de Laat, 2002; Sing & Khine, 2006). There is almost this desire to regain a sense of belonging that is curiously inscribed into the technologies we use and the patterns of relations based on *ties* stored in system or log files.

In this article, network as a measure becomes an effect in itself. In particular, centrality is enacted as a relational effect of many things, not just those tied by message threads in forums created and stored in virtual learning environments (e.g. Blackboard). Message threads that are treated as relational ties in an electronic medium are established by both social and material connections.

Furthermore, it argues that the new forms of social patterning and interactions that new communication technologies allow may not be confined within an electronic medium (ie. Blackboard). After all, technologies are not exogenous factors affecting learning. The communication flow in electronic discourse is continuous and non-transactional and the communication links established are *fluid*.

Why do researchers engage in SNA? SNA in educational research has particularly focused in identifying patterns in messages - that an exchange is a collaborative tie (e.g. Lipponen, *et al.*, 2003) and in terms of knowledge construction - a message is a knowledge object (e.g. Aviv, *et al.*, 2003) and that the online environment gathers a community of practice, where central actors who facilitate collaboration or influence knowledge construction may be identified.

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This article enacts ties by representing communication networks based on different media and by emphasising on the *ties that also bind* through the socio-technical arrangements and engagements beyond the response relations the thread structure of a virtual learning environment (VLE) is able to capture and store. It considers the perceived social ties of participants in six communication media alongside response ties in discussion forums by performing Freeman's degree centrality using UCINET (a software for SNA, Borgatti, Everett & Freeman, 2002).

Instead of the notion of community which often suggests social solidarity (Fox, 2002), this article elucidates a network reality wherein individuals are 'lifted out' from their contexts and re-inserted in largely *disembedded* social relations, and yet they remain related somehow in their mobile and multiple encounters (Wittel, 2001)..

Network Participants

The data presented in this article are based on a study which involved 21 (15 female and 6 male; between the age of 22 and 39) students who were training to be History teachers in a postgraduate certificate programme (ie. PGCE History) in an English university. The course used Blackboard and had 14 separate discussion forums. Not all of the forums were successful in terms of use, the biggest forum had 417 messages and the smallest had none. Centrality measure is performed on two forums with sufficient number of postings to partially demonstrate the fluidity of network relations. The first forum, History, Schools and Society (HSS) had a total of 56 messages and the second one, Assessment, had a total of 50 messages.

The participants who had most postings in all the forums were H1, H3, H5, H9, H10, H13, H15 and H21.One may assume that these participants are central actors in the forums. However, such inference may sometimes mislead and depict a network of learning that is rather simplistic, based solely on uni-directional and immediate ties. For example, centrality (ie. Freeman's centrality), as further described in the next section, is also measured based on reciprocal and indirect (eg. the ties of those with whom an actor is connected) ties.

Before proceeding with centrality measure using message threads obtained in the HSS and Assessment forums, the next section describes the relational ties of the participants based on their perceived frequency of communication exchanges using six different communication media.

Perceived Relational Ties

This section 'visualises' the *perceived* patterns of interactions among the forum participants and their course tutor. The social network data was gathered based on information provided in a table matrix with 22 rows representing the students and the tutor. There were six columns representing different communication media, namely, face-to-face, email, mobile phone text messaging, land phone, discussion board (Blackboard) and online chat (e.g. MSN Messenger).

The participants were asked to indicate for each medium or mode of communication their perceived frequency of contact based on the following as discussed with the tutor based on how Blackboard was being used in the course:

3 - for almost daily contact (degree 3)
2 - for twice or thrice a week (degree 2)
1 - for every now and then, say once a week or less than that (degree 1)
0 - for no contact at all.

Network Data

A 'contact mode' matrix was prepared in an Excel sheet, which consisted of 22 columns and 22 rows. Each row and column represented each student in the cohort. Each cell was populated with values between 0 (- for no contact at all) to three (- for almost daily contact). In total, there were six data matrices, one for each 'contact mode'. Row entries represent each student's self-perceived (self-reported)

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contact, that is, 'the person I contact face-to-face' and the column entries represent the 'others perceived' contact, that is, 'the person who contacts me' of a particular student.

Five (H2, H6, H7, H15 and H17) out of the 21 students did not participate. Consequently, there were 'missing data in each of the 'contact mode' matrices. Handling missing data in SNA is quite tricky. It is not just a matter of completeness, rather a different network may be produced that may render the analysis invalid and the findings misleading (see Borgatti & Molina, 2003). For example, H15 is one of those who did not participate. She is absent in the analysis and discussion of this data, however, present in the online forums. Each of the data matrices were transformed to perform SNA. This is further elaborated later.

Communication Networks

To have a better sense of the communication network of the participants, the following sections provide the social relations or sociograms of the students based on their *own perception* of communication ties that were established based on each of the six media of communication.

The following network diagrams are translated from the matrices produced from the network survey. The level of frequency of contact between 1 - 3 are depicted with the line thickness (ie. 3 as the thickest).

From these network visualisations produced, we find the kind of relations the central participants identified so far have or do not have with one another with some network diagrams reproduced in the following discussion.

1. Face-to-face

In this network, TH is central (Figure 1). This network may have been shaped by the tutor's role and secondly as 'ordered' by the face-to-face sessions in the classroom. Without TH, eight students would be *isolates* (without any ties, namely, H2, H5, H7, H8, H12, H13, H14 and H15). This includes H5 and H15 of the eight potential 'central' participants in the forums identified in the previous section.

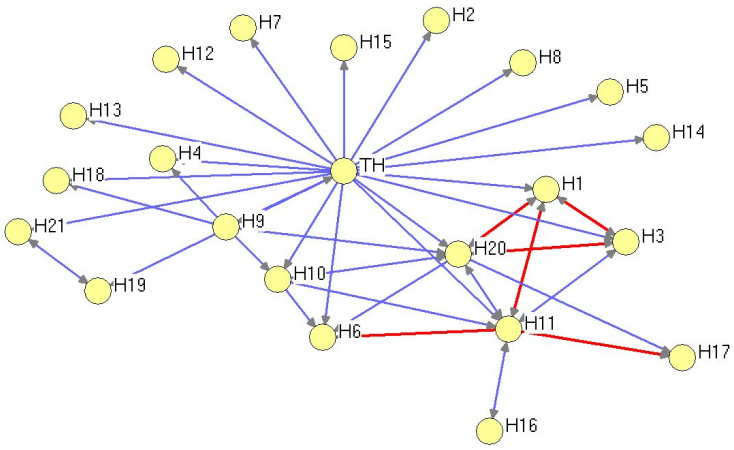

Figure 1: F2F Network (degree 2)

At degree 3 (Figure 2), H1, H3, H6, H11, H17 and H20 seemed to be 'closest' to each other. Four of these (ie., H6, H11, H17 & H20) have very few postings in the forums. Their 'close' ties did not seem to transfer on the discussion board. Therefore, they are not considered central participants as such off-line ties are not 'known' to Blackboard.

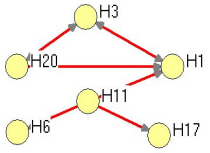

Figure 2: F2F Network (degree 3)

2. Discussion Board

In this network, no participant reported to have communicated on a daily basis.

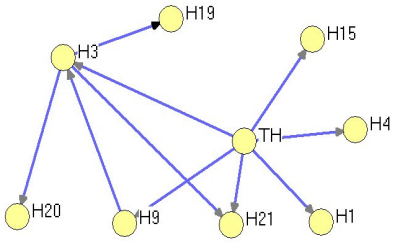

Figure 3: Discussion Board Network (degree 2)

H1, H3 and H20 remain to be in frequent contact to one another. H6, H11 and H17 did not seem to have persisted in the online environment. However, H4, H9, H15, H19 and H21 did. This includes three of the potential central participants in all forums. However, it has to be noted that their immediate ties were responses to the tutor (TH) as depicted in Figure 3.

3. Mobile Phone

In this network (Figure 4), all the students are connected. This is no surprise especially when on the first day of their course they were able to obtain each other's mobile phones collected, photocopied and distributed by TH herself.

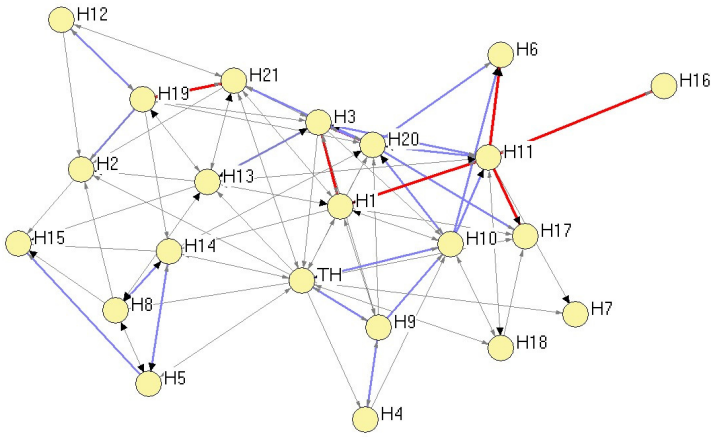

Figure 4: Mobile Phone Network

Part of this network diagram is very similar to that of the face-to-face network in Figure 2, with the inclusion of a reciprocated tie between H11 and H16 and that of H19 and H21 who were not connected with the rest with frequent (ie. degree 3) mobile phone contact.

4. Email

Just like in the face-to-face network, TH is quite central in the email network (see Figure 5). H1, H3 and H20 maintained their three-way ties in this network as well.

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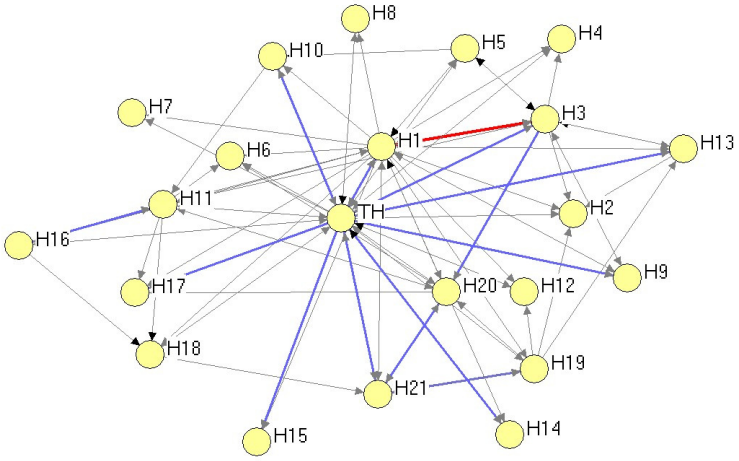

Figure 5: Email Network

5. Land Phone

The phone network has similar 'strong' ties with that of the mobile phone, in terms of H1, H3 and H20 and H19 and H21. A tie between H1 and H2 which was not so 'strong' in the previous communication networks emerged here (see Figure 6).

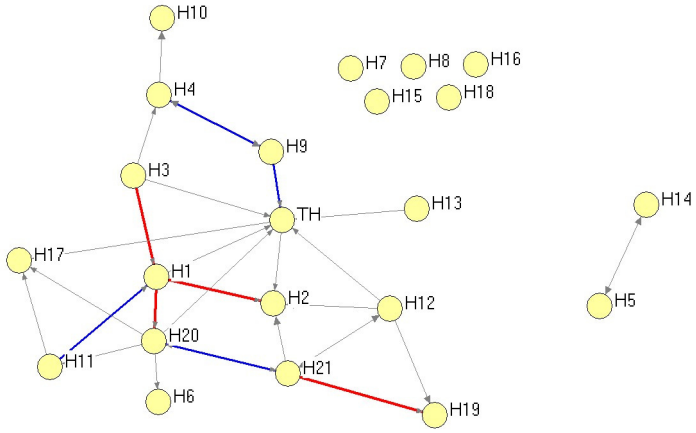

Figure 6: Phone Network

It is rather interesting that there were less people in contact using this mode of communication. The students did not distribute their landline phone numbers as they did with their mobile phones in the beginning of the course.

6. Online Chat

Lastly, H1, H21 and H3 persisted in all modes of communications (see Figure 7).

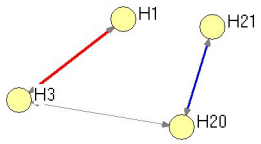

Figure 7: Online Chat Network

Commentary

The different communication networks presented in network diagrams in this section displayed different structures and network densities (ie. the number of actual ties over all possible times given a set of

actors). The potential central actors are rather loosely coupled, except for H1, H3 and H21, who maintained their 'strong' relationships across all communicative networks. Other 'strong' relations emerged in specific networks like H19 and H21 in the mobile and phone networks and H1 and H2 in the phone network. However, there are close ties that did not transfer online. For example, H6 and H17 who had close ties in the face-to-face and mobile networks at degree 3 with H1, H3 and H21, did not 'communicate' on the board at all.

Centrality Measure

According to Borgatti (2005), there are implicit assumptions about what a tie means once identified or established in a network and it is usually that something flows through the ties (as channels of information, goods, infection, etc). One of the popular measures that make particular assumptions about network flows is centrality measure.

The basic starting premise is that there is something that always flow in the network and the characteristics of the flow process indicates which actors are positioned to have control, power or influence. For example, Borgatti (2005) explored how centrality results from an interaction between position and the characteristics of the flow process and for which he described a typology of network flows - how things (e.g. package delivery, gossip, email, infection, attitudes) differ in the way they flow in a network (see Borgatti, 2005, pp 56-59) and what the appropriate centrality measure might be (see Borgatti, 2005, p63).

The notion of centrality

Centrality measure embodies a particular way of theorising and understanding a network phenomenon. It has been considered an attribute, an abstract property of an actor's position in a network, measurable without regard to how it is connected with others and who and in turn, how these others are position in the network themselves.

Borgatti identified three main attributes that we have to consider in understanding the kind of network flow we are dealing with: is the flow by replication or transfer and for replication-based flows, is it serial (one at a time) or parallel (at the same time), and lastly, does it flow in a directed or non-directed ('blind') way.

There are two mechanisms of flow: transfer (e.g. package delivery) and diffusion or duplication (e.g. email, gossip) (Borgatti, 2005). The formulas behind each type of centrality measure generate expected values of certain kinds of participation (e.g. transfer or duplication) in network flows. What this means is that its calculations do not measure *actual* participation *per se*. Instead, it indicates or predicts *expected* participation if things flow in the assumed way. Now the question to ask is what type of flow is an online message/post? Is it like a package being delivered passing from one participant to another? Is it like email that may be sent to many others simultaneously? Which measure should we use for a message flow in a network of learning? It is definitely not like a package delivery.

Freeman's (1979) centrality is the appropriate measure for a package delivery. It is used as an index of importance of a given node for the information or transactional exchanges. What kind of network data would require this kind of measure? Data that is first of all indivisible, travels in the shortest of paths, when there is more than one, it randomly chooses one. Surely, not information or message posts, which diffuse by copying rather than moving and which do not have a preference for the shortest path.

However, this centrality measure was used by de Laat (2002) in his study of what he called a community of practice of 46 Dutch police officers involved in dealing with drug-related investigations. He used Freeman's degree centrality and betweenness to find out who were the central actors in this particular network.

Freeman's degree centrality measure argues that the more ties an actor has the more powerful (e.g. influential or prestigious) it is likely to be, because it can directly affect more 'alters'. This makes sense. However, it is still rather 'ego'-centric as having the same degree or 'alter'-relations does not necessarily

make actors *equally* powerful. Their power will further be affected with whom their alters are connected to and whom this alters are connected themselves, and so on and so forth. Besides, centrality based on the 'strength' of ties does not always make an actor powerful (see Granovetter, 1973).

Are we not merely 'seduced' by the measures of SNA? Are we not just inscribing 'community' and 'collaboration' to the notion of network centrality? As pointed out by Borgatti (2005), a common criticism of social network research is the insufficient attention paid to the dynamic processes that unfold in the structuring of the network itself and the manner in which links are established in the first place

To assess the 'structural properties' of participation and collaboration in a networked environment of learning, we must not only consider the ties logged into system files (i.e., a thread established by a click on the 'Reply' button). We must take into account the content of the exchange, whether material or informational (Cook & Whitmeyer, 1992). Furthermore we must not confine the context of the exchange within the online environment nor think of ties as direct contact between human actors (e.g. Homans, 1961).

And so, even though this article used Freeman's centrality in the following section, its aim is to elucidate that structural analysis that treats actors and connections as predictable and fixed hides the *fluid* reality of network relations.

Centrality in HSS and Assessment forums

In this section, the relational ties produced through the thread structuring of postings in HSS and Assessment forums are discussed. The forum threads when translated produce asymmetric, ordinal matrices. The data had to be dichotomised (ie. non-zero values were assigned the value of 1 and zero values retained this value) to generate the data output in the following discussions.

A case of Freeman's centrality

TH may be said to be a central actor by default. The main forum threads were initiated by her and so most of the postings are threaded to her (or incident to her node in the network). Since the data in this study are asymmetric, in-degree ('ties sent') and out-degree ('ties received) centrality can be calculated. Manually, the 'ties sent' could be calculated by counting the total number of non-zero row values in the data matrix and the 'ties received' could be calculated by counting the total number of non-zero column values in the data matrices.

		1 OutDegree	2 InDegree
1	H1	6.000	3.000
3	H3	4.000	5.000
15	H15	3.000	2.000
22	TH	3.000	11.000
8	H8	3.000	1.000
16	H16	2.000	1.000
18	H18	2.000	1.000
13	H13	2.000	1.000
20	H20	2.000	1.000
10	H10	2.000	0.000
14	H14	2.000	1.000
6	H6	1.000	0.000
2	H2	1.000	1.000
17	H17	1.000	0.000
4	H4	1.000	0.000
5	H5	1.000	3.000
19	H19	1.000	1.000
9	H9	1.000	4.000
21	H21	1.000	2.000
7	H7	0.000	0.000
12	H12	0.000	0.000
11	H11	0.000	1.000

Figure 8: HSS Out/In-degree Centrality

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	1 OutDegree	2 InDegree
22 TH	5.000	14.000
13 H13	4.000	0.000
10 H10	4.000	3.000
4 H4	3.000	1.000
3 H3	3.000	2.000
15 H15	3.000	1.000
18 H18	3.000	1.000
1 H1	2.000	3.000
20 H20	2.000	1.000
5 H5	2.000	3.000
8 H8	1.000	1.000
12 H12	1.000	1.000
6 H6	1.000	3.000
14 H14	1.000	0.000
17 H17	1.000	2.000
16 H16	1.000	0.000
19 H19	1.000	1.000
9 H9	1.000	3.000
21 H21	1.000	1.000
11 H11	1.000	0.000
2 H2	0.000	0.000
7 H7	0.000	0.000

Figure 9: Assessment Out/In-degree Centrality

Out-degree ('ties sent') is usually taken as a measure of how influential the actor may be. So, H1 followed by H3 were the most influential ones in the HSS forum (see Figure 8). In the Assessment forum, TH followed by H10 and H13 had the most influence (see Figure 9).

On the other hand, in-degree ('ties received') measures how prestigious an actor may be. In the HSS forum which was set up in the first week of the programme at the Blackboard induction, H3 was most prestigious, followed by H9, H5, H1, H15 and H21. All of these students with the exception of H15 were identified to have had the most posts in all forums and the ones who have close ties (see Figure 2). However, the Assessment forum depicts a different picture. H1, H5, H6, H9 and H10 appear to be 'equally' prestigious (see in Figure 9).

Lastly, the in-degree and out-degree measures based on the perceived relations on the discussion board are different from the online forums above (see Figure 10).

	1 OutDegree	2 InDegree
1 H1	21.000	12.000
4 H4	21.000	10.000
19 H19	21.000	8.000
22 TH	21.000	11.000
21 H21	21.000	10.000
9 H9	21.000	10.000
20 H20	18.000	8.000
3 H3	16.000	12.000
18 H18	11.000	11.000
12 H12	9.000	7.000
5 H5	8.000	9.000
14 H14	6.000	9.000
16 H16	4.000	10.000
11 H11	1.000	10.000
8 H8	1.000	6.000
10 H10	1.000	9.000
13 H13	0.000	7.000
7 H7	0.000	7.000
2 H2	0.000	10.000
15 H15	0.000	9.000
6 H6	0.000	7.000
17 H17	0.000	9.000

Figure 10: Discussion Board Perceived In/Out-Degree Centrality

The *actual* ties in the HSS forum are different from those in the Assessment forum. Inevitably, this produced different in-degree and out-degree values. This is no surprise. This demonstrates that forum threads could not be enacted as social networks, wherein the actors and their ties are 'pre-defined' and wherein messages flow between them. Instead, it is forum threads themselves that create ties. Furthermore, ties established online are not independent from social ties outside the board. In fact, the social ties outside the board of participants influence the threads that are *tied* in the forums. This means in a 'blended' learning situation, ties are not solely made on the basis of what was said, but who said it.

They are not necessarily *content-related* ties. For example, the close ties between H1, H3 and H21 have persisted across different communication media and are found to be central participants in the course.

The ties established in the two forums are also different from the perceived ties depicted in Figure 10. The perceived ties would include all the forums and exchanges that were not about specific tasks in the course. These are the *relational effects* of the their social ties, pertinent experiences, particular requirements and Blackboard use.

Fluid Centrality

The degree centrality in the actual online forums and in the perceived forum relations has been different. The communication networks have been different, too. It is rather the case that the centrality of actors has been *fluid* within and alongside other kinds of relations.

The ties depicted in network diagrams elucidate two things: first, that there are ties outside the virtual environment that have relational effects on the threads that are *tied* online, and that there are ties that are produced in the board that would have not been established otherwise.

At the core, there are *recursive* and *implicit* ties that persist in the shifting context of interaction (e.g. H1, H3 & H21) beyond Blackboard. Network links are established in the PGCE History course through social relations maintained and sustained across different communication networks and through a common goal (in this case, to be teachers). This common goal is binding in ways that is not present in the network structures or forum threads.

Conclusion

Network analysis undoubtedly has the potential for educational researchers to move research in a valuable direction from considering attributes (e.g. technical features and functions) as determinants of the effects of technology to an examination of different kinds of relations (not only human-human) in data. It provides an analytical frame to examine and evoke how patterns of relationships – the 'interaction of interactions' emerge and constitute the practices of networked learning. However, SNA, particularly its formal methods, enacts particular network realities with particular assumptions (ie. something flows in a 'pre-established' network).

Theoretically or metaphorically, we should not only focus on relations that are present online. We should also elaborate on how communicative processes and social patterns are transformed without organising our explorations around the notion of centres and peripheries. After all, a community is not the only kind of networked learning or the only way to demonstrate strong relations in learning. The notion of community has privileged the idea of strong ties and cohesion. Learning is not about tightly-coupled (strong) ties and close cohesion (Jones & Esnault, 2004).

This paper has provided evidence that network analysis has serious implications in what we 'see' to be *present* in a given network, that potentially we may be misled by the output of a software like UCINET which *acts* in 'ways' hidden, but have significant effects to what is made visible as central (i.e. influential, prestigious and strong) in the network of learning.

Secondly, as elucidated in another article (i.e. Enriquez, forthcoming), *actors* may be non-human and relations have content, direction and strength, which may not be confined to a particular kind of relation or to a particular space (Haythornthwaite, 2005). Messages do not simply *flow* within the forum space and form network of response ties. They cross boundaries and establish social and material links between and within sites and situations of learning (e.g. classroom, school, Blackboard, etc.). These are the kinds of ties that may constitute the collaborative practices and processes of learning in a networked environment. Response ties are relational effects - emergent and heterogeneous products extending beyond a thread and beyond the virtual space of the VLE (Enriquez, forthcoming).

Lastly, social relations as perceived by students and tutor in terms of their multiple engagements in different situations of networked learning must not be ignored. Humans are self-conscious and self-aware

when they act. They can monitor their activities and their physical and social contexts exactly at the same time they are engaged in activities (Giddens, 1984) between situations and across contexts (Amit, 1999; Wittel, 2000). Participants in the forum selectively link elements of past, present and future in what they have experienced, read, heard, said, seen, used, ignored, forgotten and remembered. Thus, relations are effects of the social and material constitutions of networked learning as further reified and enacted by participants' experiences in other media and places. In other words, the *disembedded* relational structures enact *fluid* centrality in the socio-technical relations in a learning situation

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