Cohesion and Roles:
Network Analysis of CSCL Communities

(to be published in the Proceedings of IEEE ICALT2003, July9-11, 2003, Athens, Greece)

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Abstract

We provide empirical support for the assertions that high level of knowledge construction is associated with structured design and that knowledge construction is associated with cohesion and equivalence network structures. We built and analyzed two CSCL communities - one structured the other non-structured. The levels of learning processes were measured by content analysis. The social capital structure of the communities was analyzed by Social Network Analysis. The analysis revealed that the structured community developed social capital, encoded by a mesh of interlinked cliques, and that participants undertook bridging and triggering roles, and exhibited high levels of constructing knowledge. The tutor (guide) remained on the side. The non-structured community did not construct knowledge, cohesion was dull, and participants did not undertake any essential roles.

1. Introduction

Gladwell [14, 10] suggested that three factors affect "social epidemics" in a community" the "Law of the Few" - few people that make a difference; the "Stickiness Factor" - making messages contagious; and the "Power of Context" - influence of the immediate environment. These factors determine the social capital relations [9], which in turn determine constructed knowledge. The structure of social capital relations can be analyzed using Social Network Analysis [24]; constructed knowledge is evaluated by Content Analysis of the transcripts of the communication [15].

Social Network Analysis (SNA) provides an insight into the existence of Gladwell's factors in communities [12]. Certain "Laws of the Few", for example, *prominence*, has been observed in distance learner communities [8, 16]. Aviv assigned bridging and triggering roles to participants in online communities of learners [1]. The evolution of the "Stickiness Factor", or *cohesion*, has been studied [23]. Details of the "Power of Context" or the *design* of the activities of the community are provided through the Social Interdependence Theory of Cooperative Learning [18].

We relate to CSCL communities according to the constructivist paradigm [19]. Rafaeli argued that constructive communication is determined by its responsiveness [22]. Accordingly, we analyzed the network structures of the responsiveness relation between communities of learners in asynchronous communication.

We hypothesized that the social capital structures – in particular, cohesion – as well as bridging and triggering roles, are factors in determining the quality of the knowledge construction of the community. To test this hypothesis, we analyzed two different CSCL communities. We tested the following assertion: *A marked difference in the design of communities is associated with a marked distinction in the cohesion and role structures of the communities, which is associated with a marked distinction in the levels of constructing shared knowledge*.

2. The two communities

We analyzed transcripts of two CSCL communities – two groups of students who took the Open University of Israel course, *Business Ethics*. The communities were established for 17 weeks during the fall 2000 semester (18 participants) and the spring 2002 semester (17 participants). Each community had a guide – the course tutor. The designs of the activities of the two communities were different. The fall 2000 community was more structured than the spring 2002 one. Hence we label the communities the *structured community* and the *non-structured* community, respectively. The data is available at the *TELEM* website at **http://telem.openu.ac.il/** and accessible by username and password.

The structured community engaged in a formal debate. Participants committed to active participation, and an associated reward mechanism was employed. Students were asked to simulate the role of an advisory committee to a high-tech company on how to handle the Business/Ethical problem of cellular phone emissions. The debate was designed as a 5-step process of moral decision making with predefined goals [13]: the first step: identify facets of the problem, debate solutions and propose a synthesis; the next three steps: test the synthesized solution against prescribed sets of principles; the last step: provide a summary of the proposal (see Geva [13]).

The non-structured community was open to all students in the course with no need to commit themselves in advance. Participants could raise issues related to the course. Table 1 summarizes the differences between the environments of the two communities. Parameters are defined in [18].

	Structured community	Non-structured community
Registration	Yes	No
Cooperation commitment	Yes	No
Goal-directed scheduling	Yes	No
Predefined procedures	Yes	No
Resource interdependence	Yes	No
Work interdependence	Yes	No
Reward mechanism	Yes	No
Reward interdependence	No	No
Pre-assigned roles	Yes	No
Reflection procedures	No	No
Individual accountability	Yes	No

Table 1. Design of Communities

The SNA was performed using *Cyram NetMiner* - a software tool for exploratory network data analysis and visualization [21]. We first constructed the *Response Matrix* for each of the communities: The (i, j) entry is the number of messages sent by member i responding to messages sent by j. The response matrices served as the input for subsequent clique and role analysis by *NetMiner*.

3. Content Analysis of transcripts

In the structured community, 248 responses were exchanged; in the non-structured community, 70. In performing the content analysis, each message was classified as belonging to one or more of the 5 levels of the Interaction Analysis Model [15]. Table 2 summarizes the results.

Level	Meaning	Structured community	Non-structured community
1	Discuss information	38	70
2	Handle disagreement	34	
3	Synthesis	28	
4	Test vs. principles	143	
5	Apply knowledge	5	

Table 2. Classification of the messages

We see that the structured community worked in steps (as designed), directing the participants toward increasing levels of knowledge construction, up to and including level 4 of the Interaction Analysis Model. Participants' evaluation of this community supports this finding: the participants rated the collaborative knowledge construction of their community at 4.6 (out of 5) – the highest scores on students' assessment of learning in comparison with all 68 courses that were evaluated that semester. (Participants' evaluation will be presented elsewhere). In contrast, none of the issues raised in the non-structured community developed into knowledge construction beyond the lowest level, 1.

4. Cohesion Analysis

Part of the "stickiness factor" in a community is manifested via the creation of cliques [5]. A *clique* is a maximal connected sub-community. Cliques are identified through cohesion analysis [2]. The degree to which intra-clique connectivity is larger than inter-clique connectivity is measured by the *cohesion index* (C-Idx).

Table 3 presents the clique structures of the two communities. Note that there are two cliques in the non-structured community, vs. 16 in the structured community. Next, participants, labeled **Pi** in the structured community, form relatively larger cliques – at least 4 participants each (except K16); that is, they maintained response relations with several others. Moreover, the guide (**P1**) participated in one clique only (K16). The cliques in the non-structured community include only 3 participants (labeled Ni), including the guide (**N18)**.

Non-structured community		Structured community	
Cliques	**C-Idx**	**Cliques**	**C-Idx**
K1: **N18**, N11, N7	3.826	K1: P2, P8, P11,P10, P9	3.333
		K2: P2, P8, P11, P10, P12	2.786
		K3: P2, P8, P11, P16	2.147
		K4: P2, P8, P6, P12	2.439
		K5: P2, P8, P4, P12	3.073
		K6: P2, P8, P4, P13	3.033
		K7: P2, P8, P13 ,P9	1.974
		K8: P2, P8, P13, P16	1.810
K2: **N18**, N11, N9	2.000	K9: P2, P5, P9, P11	2.388
		K10: P2, P5, P9, P11	1.420
		K11: P2, P5, P12, P11	1.970
		K12: P2, P3, P9, P10	3.200
		K13: P2, P3, P9, P13	2.227
		K14: P2, P3, P12, P10	3.792
		K15: P2, P3, P16, P13	2.217
		K16: **P1**, P4, P8	1.607

Table 3. Clique Analysis

Difference in inter-clique connectivity (participants belonging to more than one clique) is striking: Many participants in the structured community belong to more than one clique. This bridges a wealth of information flows to all members of the community. On the other hand, there is virtually no bridging in the non-structured community.

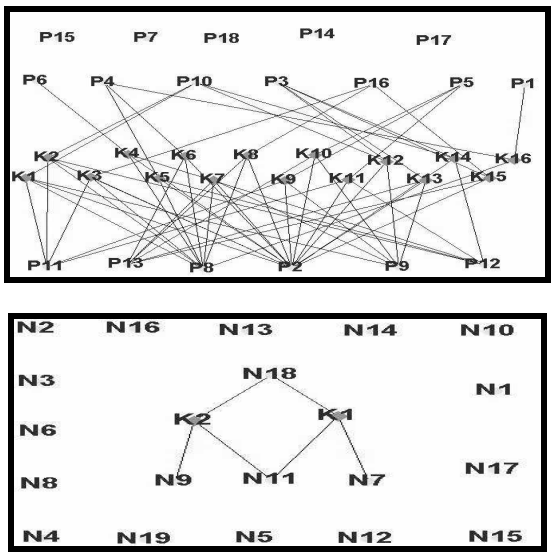

Figure 1: Clique bipartite graphs
Top: Structured community
Bottom: Non-structured community

Bridging is visualized by the clique bipartite graph (Fig. 1); nodes represent cliques (**Ki**) and participants. Links represent membership. In the structured community, we note a single person who bridges 15 cliques (**P2**), five participants bridge 4-5 cliques each, but the guide (**P1)** belongs to a single clique. In the non-structured community only one student, and the guide (**N18**), belong to the two cliques.

5. Role Analysis

Role Analysis of a community groups certain participants that implement certain *social roles* in the community into *role groups*. Individuals in one role group are equivalent in the sense that as far as the social role that these individual implement, they can replace one another. The analysis is described in [17, 5]. The role groups of the two communities are presented in the two boxes of figure 2.

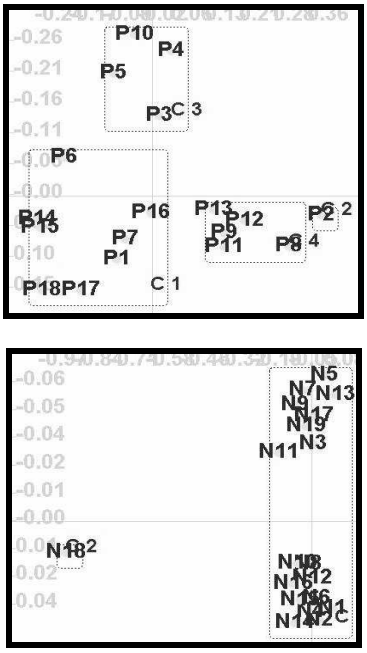

Figure 2. Role groups:
Top: Structured community
Bottom: non-structured community

In the structured community (Fig. 2, top), role group C2 consists of a single participant – P2 – the person who bridges 15 cliques (recall Fig. 1, top). Similarly, role group C4 consists of the five persons bridging 4-5 cliques each. Role group C1 contains eight persons, and role group C3 contains four persons. The roles of the latter two groups are revealed in the Network Centrality Maps presented in figure 3.

In the top box of figure 3, the relative intensity of *receiving and sending* responses are presented: the more active actors are closer to the center. The eigenvector algorithm [3, 11] was used to calculate the combined sending and receiving intensities. The most active member is (again) P2. The eight members on the fringe who are

relatively inactive, are the members of the *lurkers* role group, C1. The middle box of Fig. 3 presents the relative intensity of the *receiving responses* in the structured community. The central, prominent *response triggers* are seen to be the members of role group C3, and P2.

Consider now the role groups of the non-structured community (Fig. 2, bottom). Role group **C3** consists of the guide (**N18**). The special role of the guide is seen in the bottom box of figure 3 which presents the centrality map of the *sending responses* in this community. We see that in this community, the guide was a *responder*; all others only sent questions. It was a centralized Q & A community.

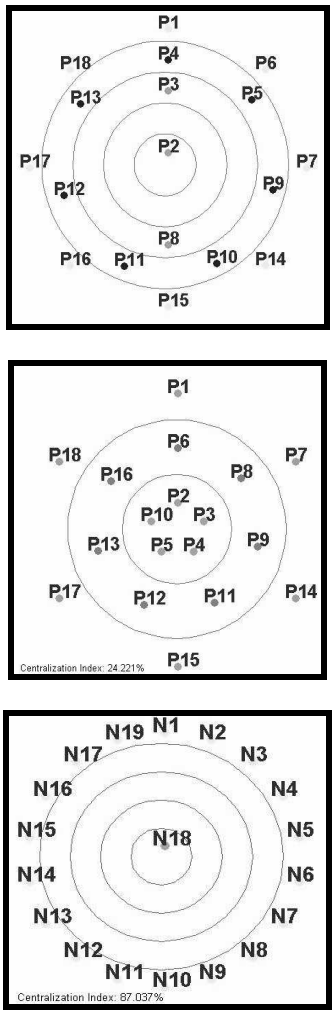

Figure 3: Centrality Maps
Top: Structured community, send & receive intensities
Middle: Structured community, receiving intensities
Bottom: non-structured community, sending intensities

6. Discussion

The structured community was designed to achieve high-level knowledge construction. Critical thinking goals were structured into the design. Participants committed themselves to the collaborative project, were instructed about the rules, and were appropriately rewarded. The knowledge construction was closely monitored by the guide, and the participants had a feeing of togetherness as indicated by the participants' evaluation: they rated "sense of community" as 3.6 out of 5. The Social Interdependence of Cooperative Learning Theory [18] attributes a high level of the knowledge construction process to this structured design.

Social Network Analysis presumes that what people feel, believe and do depends on the patterns of relations between them. In particular, cohesion patterns are a primary network structure that contributes to the creation of shared beliefs and behaviors. In Burt's words [5], "Similar actors are tied together by socializing bonds of interaction through which they come to share beliefs and behavioral tendencies". A second structure is role similarities. "Pattern similarity defines social boundaries around reference groups and feelings of relative deprivation, creating homogenous beliefs and behavioral tendencies among equivalent actors" [5]. Network similarity structures are usually referred to as network equivalence.

SNA is useful for describing relations that are based on traditional *synchronous* communications (face-to-face, telephones). Extending them to online asynchronous communication is a significant step. This is what we have done here, following [12] and [25]. We combine the results of the Social Interdependence of Collaborative Learning Theory, asserting that a high level of knowledge construction is associated with structured design, with the results of the Social Network Analysis (extended to virtual communities), asserting that knowledge construction is associated with cohesion and equivalence network structures. We provided empirical support for these associations.

One should note that the non-structured community was *not* a failure. It was designed as a simple Q&A and did not include knowledge construction (which was included in other learning activities). It seems that the lack of cliques and bridging roles reflects this design.

Maintaining roles like bridges and triggers requires effort on the part of the participants, and yet, they felt that the effort was worthwhile. Why did they do it? There is no guarantee that this will happen in every (structured) community. This calls for further research on the attributes and motives of the participants. Other lines of research might be:

Network Dynamics: inquiring into the time development of network structures. Do cliques develop

early? Are they stable? Preliminary analysis provides a positive answer to both questions.

Information Overload: The dynamics of large groups lead to boundary effects [20]. How are these manifested in CSCL communities?

Efficiency: Increasing the density of communication links may lead to redundant connectivity; an efficient network has "holes" around participants [6, 7]. We found that a well-structured cooperative community is effective in knowledge construction; but is it also an *efficient* community? This is a question which might be worth examining.

7. References

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