Impact of Communication Patterns, Network Positions and Social Dynamics Factors on Learning among Students in a CSCL Environment

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Abstract: At present, it is difficult to assess the quality of learning in Computer-Supported Collaborative Learning (CSCL) environments, because standard pretest and posttest measures do not capture the differences in the learner's ability to engage in the material, pose interesting new questions, engage others in learning and work collaboratively. This research investigates the impact of communication patterns, network positions and social dynamics factors on students' self-perception of learning in a CSCL environment. The study involved a combination of methodologies combining questionnaires, and archiving of communication logs for data collection. Social network analysis tools were used to analyze relational data, map emergent student communication patterns and calculate centrality scores based on the electronic and face-to-face communication patterns among class members in the CSCL environment. Structural equation modeling was then performed on the hypotheses model to determine the impact of these centrality measures and the social factors on students' perceptions of knowledge gained and their satisfaction with their performance in the course.

Keywords: Computer-Supported Collaborative Learning (CSCL), distance learning, social network analysis, social dynamics, respect, influence, structural equation modelling, path analysis, interaction, participation, motivation to participate and learn, satisfaction with performance, gaining new and conceptual knowledge

1. Introduction

Computer-mediated communication (CMC), consisting of highly interactive communication tools, including electronic mail, electronic bulletin boards, asynchronous multimedia notebooks, remote screen-sharing, and desktop video teleconferencing, is becoming increasingly common in modern classrooms, in addition to face-to-face time between the instructor and the students. It must be noted however that the increase in the use of these CMC tools has been more to facilitate online learning for distance students. For example, many university classes use WebCT® (a Computer-Supported Collaborative Learning - CSCL tool) to post topics on the discussion boards, post grades and manage student projects. Others use Blackboard® or Elluminate®. The use of these discussion boards allows students to discuss topics related to the material they are learning in class, allows them to interact with one another and the instructor asynchronously and also post, view and if required rate group projects, thus allowing for a certain level of peer involvement and assessment. As predicted by Fishman (1995), such technologies have become more integrated into education, and, therefore, it is important to understand student learning, behaviors and attitudes towards the use of these communication technologies.

While Picciano (2002) raises questions regarding the nature and extent of the interaction and its effects on student performance, he reiterates that much of the research is based on student perceptions of the quality and quantity of their interactions and how much they have learned in an online course. In his study, Picciano (2002) examines performance in an online course in relationship to student interaction and sense of presence in the course and makes an attempt to go beyond typical institutional performance measures such as grades and withdrawal rates and to examine measures specifically related to course objectives. He found that though there was support for a strong relationship between students' perceptions and perceived learning, the relationship of actual measures of interaction and performance is mixed and inconsistent depending upon the measures and requires further study. Reffay & Chanier (2002), describe a situation of distance learning based on collaborative production occurring within groups over a significant time span. They found that social network analysis was a good candidate for application to their experiment in order to compute communication graphs.

The specific aims of this study are therefore to identify actors within the group/class that are central to the group/class and are sought by the others in the group/class for gaining knowledge or information pertaining to the course material. Social network analysis will be used to calculate the network

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centralities of all the actors in the group/class based on how often they use the various communication tools (Email, instant messenger – IM, bulletin boards – BB and face-to-face) to interact with one another during the course. Frequency of communication alone does not provide a complete picture of the nature of these interactions, however it does indicate the intent to participate and be involved and this will then enable us to identify whether there are any significant differences between the various communications channels like IM, email, discussion posts and face-to-face, which lead to the formation of social network structures among students in the class.

The centrality measure will then be used to determine if this structural position gives these and other actors in the group/class respect (perceived or real) among their group and/or classmates and influence (perceived or real) in group/class projects. Path analysis (structural equation modeling) is then done to see if the respect and influence gained from network positions motivate the students to actively interact and participate further in group discussions and whether they will in turn have an effect (perceived) on the conceptual and new knowledge gained by the students, their confidence in doing well in the course (performance) and satisfaction with their performance in the course. Before going into the analysis aspects of this study, I would like to review some of the literature that has guided, and motivated this study.

2. Review of relevant literature

Many believe that online learning is the "magic" answer to the pressure of growing enrolments, decreasing income (in some cases), demands by students for more flexibility, along with the explosion in knowledge created in part by the communications revolution (Land, 2002; Race, 1998). Designers of online environments and CSCL systems have striven to make online learning more interactive through the use of tools for instructor-student and student-student interaction using both synchronous (instant messenger) and asynchronous (electronic discussion boards) communication. CSCL was founded based on the idea that classrooms could be structured on the model of professional communities of practice that collaboratively built knowledge, such as scientific theories (Scardamalia & Bereiter, 1996).

Furthermore, following the principles of Vygotsky (1930/1978), knowledge was seen to be generally constructed socially in interactions among people before it was internalized as individual knowing. Taking a cue from instructional theories, CSCL systems like Elluminate® additionally offer whiteboards, voice-over-IP (VoIP) and webcam features to increase the social presence among students in these environments.

Wellman (1997) states that an electronic group is virtually a social network, and the network structure provides for and facilitates the social interaction and enhances social presence, which in turn can lead to social learning and knowledge construction. The socio-cultural aspects that arise as a result of social interactions among members of a group of students in a CSCL environment form the basis of the social dynamics factors discussed later on in the paper. An understanding of these factors will provide insight into the design of courses and systems to support collaborative learning and the development of respect, influence and teamwork in student teams.

It was noted by Yildiz and Chang (2003) that the quality of feedback from peers and instructor in web-based courses was superior to that of face-to-face courses and onsite instructors should consider incorporating web-based asynchronous discussion to their face-to-face classes. They recommend that researchers should examine how the quantity, quality or immediacy of feedback or response from peers or the instructor in web-based courses might differ or be similar in relation to these components (participation, grades, technology and course content).

In the rest of the paper we will discuss the CSCL system, the social dynamics factors and assessment in a little more detail and also introduce the concept of social network analysis. Social network analysis is widely used in the social and behavioral sciences and focuses on relationships among social entities, like communications among group members, transactions between corporations or organizations and this focus on relationships can help reveal social network properties like centrality, prestige, cohesive subgroups, affiliation networks etc. This approach is important and relevant to classroom social behavior, because in some ways the classroom is a microcosm of the real world, where roles are sometimes assigned, while on other occasions they are adopted because of the skill sets and motivation that each individual brings to the classroom in their bid to learn, get an education and succeed in a competitive environment. During these periods of learning and interaction, students

have the opportunity to build and develop relationships with their peers and social network analysis can be used to investigate whether these relationships help the students gain knowledge, and obtain satisfaction on their performance.

3. Communication in CSCL environments

While contemplating the physical separation of the learner and the instructor, Moore (1993), believed that this separation contributes to "psychological and communication gap" and he proposed and developed "the theory of transactional distance", emphasizing the effect of distance on teaching as well as learning behaviors, forms of interaction, communication, instruction, and curriculum. He identified three components of distance education: dialogue, structure, and autonomy, where dialogue refers to the interaction via actions, words, or ideas between the instructor and learner or among learners. The nature and extent of dialogue depends on the course design, subject matter, medium of communication, personalities of instructor, learning styles of learners, and size of the class. Moore speculated that when everything else is controlled, chances are interaction between instructor and learners in a small class will be more frequent than in a large class (Moore & Kearsley, 1996). Moore (1993) further proposed that when similar media are used, graduate courses in social sciences and education tend to be more interactive with project work than those in sciences and mathematics that demand teacher direction.

Moore suggested that structure is determined by the educational philosophy of the instructor, academic level of the learners, course content, as well as communication media (Moore & Kearsley, 1996). While autonomy, on the other hand, is the extent to which learners have control over learning objectives, implementation procedures, resource, and evaluation (Moore, 1990:13), with the belief that learners are capable of making decisions for their learning. Moore hypothesized the tendency that "the greater the structure and the lower the dialogue in a program the more autonomy the learner has to exercise" (Moore, 1993:27).

The goals of the group (or students in the class) activity (performance, rewards), its constraints (materials, time), its medium (computer support, meetings), its division of labor (group selection, mix of skills) and its social practices (homework, native language) are given by the larger community beyond the group or class itself (Stahl, 2004). The individual, group and community all develop new skills and structures through the influence of one unit upon the other; none is fixed or independent of the others; learning takes place at each unit and between them (Stahl, 2004). So CSCL communication can be thought of as a mediated discourse, involving the knowledge of the language, symbols, metaphors, and shared meaning. The language, usually the medium of instruction, will take the shape of the course the instructor has developed, while the symbols, in face-to-face and mediated interactions will revolve around socially constructed and accepted norms of cooperation, 'espirit de corps', standards of behavior (online and offline) and a common goal of learning the subject matter. And collaborative discourse is situated in the shared understanding of the group members, which in turn is historically, socially and culturally situated (Stahl, 2004).

Thus a CSCL environment would have to take into account interactions among many people, mediated by various artifacts, and cater to the learning objectives of individuals and groups that will interact in this environment. The design of CSCL environments has involved the use of several learning styles like project based learning, scaffolding, situated learning in communities of practice and educational theories like the theories of constructivism, collaborative interaction and activity theory. And it was recognized early on (Scardamalia & Bereiter, 1996, Yildiz and Chang, 2003) that a CSCL environment must contain all the aspects of computer-mediated communication like electronic mail, instant messenger, teleconferencing, videoconferencing (to provide for face-to-face interactions), presentation media (electronic whiteboards), and electronic discussion boards to name a few, in order to promote easier communication and foster social interaction among the students and thereby facilitate better learning outcomes as a result of these interactions.

4. Social network analysis

Social network analysis (SNA) is a set of research procedures for identifying structures in systems, based on relations among components (Barnett, Danowski and Richards 1993; Rogers and Kincaid 1981; Wasserman and Faust 1994). To describe the underlying structure, network analysis not only examines node-level indicators such as centrality, but also the pattern of connections among nodes by examining their clustering into subgroups. In this study these emergent network maps reveal the influential actors in student groups and their use patterns of the communication technologies. They

also reveal whether these roles that students assume (intentionally or otherwise) impact learning and social dynamics in student groups, and whether the role of the instructor is only to facilitate learning as an authority figure or to be part of the information flow in these communication exchanges between students.

In studying the work group behaviors in a class environment, (Johnson, Johnson, & Holubec, 1998) have suggested that students in work groups or a class environment tend to assign themselves according to four types of skills: forming skills, functioning skills, formulating skills, and fermenting skills. The student with forming skills will be the one to monitor turn-taking in the group. The roles for the group member with functioning skills will be to record the discussion, encourage all to participate, clarify/paraphrase the group discussion, and work to seek a group consensus. Formulating skills require a student to generate discussion and to summarize the group's work. Finally, the student with the fermenting role works to ask for justification of the group's outcome and also helps to give a rationale for the group's activities. In network terms, these roles can be assigned to each actor (student) or they earn these roles based on their past record and performance in other group or class activities.

Based on the roles and positions students in class groups assign themselves, network communication patterns in CSCL systems will reveal student self perceptions of their influence in their groups and the respect they feel they get from their group members and this in turn will help in their assessment and learning processes. The role of the instructor also becomes a point of interest, to see how the instructor is able to facilitate both the assessment and the learning processes. Thus we are looking at the network structure having an effect on the social dynamics in the group/clique and whether that leads to the success or failure of the group effort (Fernandez, 1991).

When performing social network analysis one often looks at the centrality measures for the network under study. Centrality of a node in an ego network determines the relative importance of the node (ego or node under consideration) within that network and how well the node is connected with respect to other nodes (alter egos or alters) in the network. While there are several types of centralities, degree centrality (based on the number of incoming and outgoing connections), closeness centrality (based on the shortest path between a node and all other nodes reachable by it), betweenness centrality (based on nodes that occur on many shortest paths between other nodes) and eigenvector centrality (based on the importance of a node in a network – Google's PageRank® is a variant of this type of centrality measure) are four of the more popular measures of centrality. Of these, betweenness centrality allows an actor to be either a control or conduit for information flow, between two or more other equally or more important actors and hence I have chosen this measure for this study. Brass & Burkhardt, (1993) also revealed that centrality and influence strategies each mediated the other in relation to power. Fernandez, (1991) on the other hand showed that respect in relationships follow formal structures in hierarchical organizations.

Cho, Stefanone & Gay (2002) have shown that social influences, in the form of network prestige effects, strongly affected the likelihood and the extent to which information posted in the CSCL environment was shared by peers in this learning community. Thus participation in the group/class effort was validated by their peers and increased the network prestige efforts of the participants, motivating them to continue participating and collaborating. Martinez, et al (2003) have proposed the integration of SNA in a mixed evaluation approach for the study of participatory aspects of collaboration and have adapted the SNA-related procedures to the demands of evaluators (instructors, system designers and the students themselves). In a study involving Asynchronous Learning Networks (ALNs) Aviv, Erlich, & Ravid (2003) found that the students took on bridging and triggering roles, while the instructor had relatively little power and they concluded that a well-designed ALN develops significant, distinct cohesion, and role and power structures lead the knowledge construction process to high phases of critical thinking.

In summary, the use of SNA to study the nature of the interactions among individuals in a CMC/CSCL environment has demonstrated that higher structured communication is more likely to create constructed knowledge than less structured communication and makes the case for the use of this approach in studying students' interaction and participation in CSCL environments and how they help the students in their learning processes.

5. Research hypotheses

Respect and influence play a role in the formation of "well-oiled" group dynamics with communication and network factors leading to cohesion within the group and aiding in the formation of the above social factors leading to "learning". While the literature recommends the study of all the technologies used in the CSCL environment, in my study I have limited it to the students' use of IM (instant messenger), Email and Bulletin Boards (BB), which were provided to them in the Elluminate® & WebCT® environments, in addition to Whiteboard, web camera and Voice-Over IP (VoIP) features.

To summarize the hypotheses, Betweenness Centrality (BET) from use of email (EML), IM (instant messenger), BB (bulletin boards) and FTF (face-to-face) communication respectively has positive influence on Respect and Influence (IMEMLBET will have a positive impact on RESPMOTV – motivation due to perceived respect and INFLMOTV – motivation due to perceived influence). These in turn will have a positive impact on new knowledge gained NEWKNOW, conceptual knowledge gained CONKNOW, satisfaction with one's performance in the course SATPEF and perception of getting a grade of A for the course SELFGRDA. Due to space constraints, the hypotheses are mentioned and discussed along with the results. Figure 1 depicts the hypotheses in a schematic.

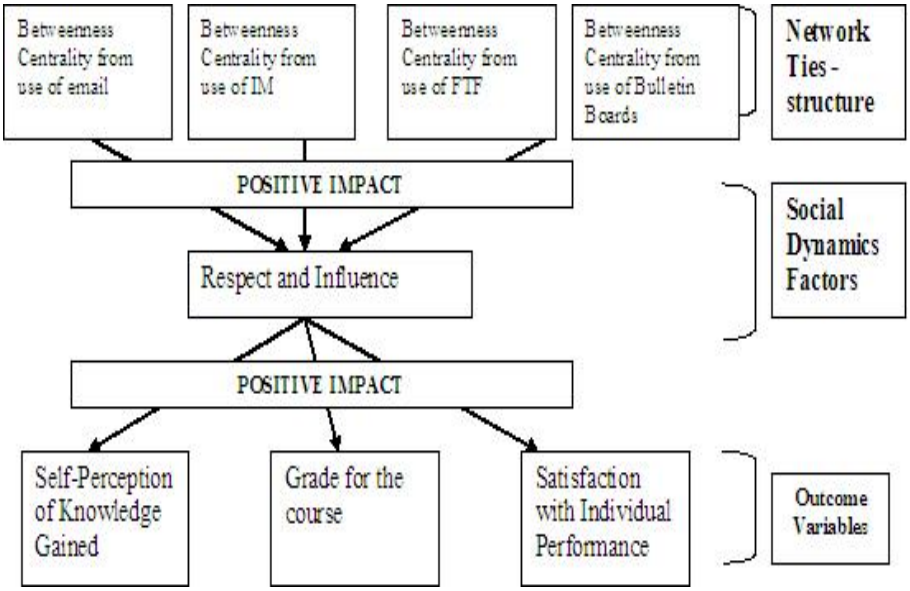

Figure 1: Hypotheses diagram for individual level measures

6. Data collection and sample

The Elluminate® CSCL tool had been successfully used in several classrooms in a medium-sized private university in the northeastern part of the US and for a variety of courses ranging from engineering and science classes to technical communication and HCI (Human Computer Interaction) classes. In all, survey data was collected from eight courses over the period of three semesters, summer 2005, fall 2005 and spring 2006. These courses were GMPM – Global Marketing and Product Management - Mgmt – 18/104 – summer '05, CDW – Communication Design for WWW – Communication – 7/46 – fall '05, FHCI – Foundations of HCI Usability – Communication –7/78 – fall '05, PP –Proposing and Persuading – 2/20 – fall '05, ETC – IT and Decision Systems Capstone – 3/26 – spring '06, SD – Studio Design in HCI – 4/35 – spring '06, IB – International Business – 5/54 – spring '06, and TCTR – Theory and Research in Technical Communication – 3/21 – spring '05. The students participating in the survey were asked to sign an informed consent form, which explained the study. Participation in the study was voluntary and the questionnaires used in the survey had the approval of the Institute Review Board (IRB). The same survey instrument was used for the entire study and proved to be reliable across the different semesters and different courses.

For this study, of the 35 items in the survey, 19 were communication items – use of email, IM, bulletin board and face-to-face, the social dynamics items, collaboration and friendship items, motivation items and the learning outcome items, while 16 items related to the use of Elluminate® tools (VoIP, the whiteboard, the video streaming quality and audio quality etc.). All items were measured using a 7-point Likert scale with 7 being most helpful or completely agree to 1 being least helpful or

completely disagree and 4 being neutral. Item 1 specifically asked the respondents about the usefulness of Instant Messenger (IM), Email, discussion boards (bulletin boards BB) and face-to-face (FTF) interactions in keeping them up-to-date in their class projects.

The 19 communication items consisted of questions that asked the respondents whether they completely agreed or completely disagreed (7-point scale) to "I feel that I gained conceptual knowledge about the course material while working with my distance classmates in this course", and a similar items addressing "new knowledge", "working collaboratively", "satisfied with my performance in the course", "confident of getting an A grade in the course", "feel that I gained the respect of my classmates during the course", "gained influence over decisions on class projects during the course", "gaining respect motivated me to participate on IM and BB discussions", "having influence on project decisions motivated me to participate on IM and BB discussions", and even "I feel that I made good friends while interacting with distant students". A set of items then asked the respondents to list between 3-5 people in their groups or in the rest of the class, whom they interacted the most with during the course of the semester, and of these who they perceived they learnt the most from. The respondents were then asked how often they used the various communication media (IM, Email, BB, FTF) with the people in their list. This is network data and was used to plot the network maps (sociograms) and calculate actor centralities.

The respondents were on-campus students as well as distance students (mostly working professionals). Of the respondents, while there was no significant difference in the gender of the students (28 male and 21 female), 37 were working professionals and 12 on-campus students. Of the 12 on-campus students, 3 were graduate students and the rest undergraduates. 30 of the respondents were 27 years old or more, and 22 were between 18-26 years old. 40 out of the 49 had taken a distance course before, and the same number had taken a distance course at this university. 45 out of the 49 had used the WebCT® bulletin board service, while only 29 out of the 49 had taken a distance education course using the Elluminate® CSCL system. This thus posed an interesting challenge while interpreting the results. Distance working professionals had more need to use the various communication tools provided in the CSCL system as they were geographically dispersed, while on-campus students, being co-located probably had more face-to-face interaction opportunities both among themselves and with the course instructor. In most cases, while motivation levels of older working professionals is already probably higher than younger on-campus students, hence higher survey responses from this demographic, the qualitative responses (not discussed in this article) from the rest of those surveyed indicated the importance of respect and influence in group work and need and efficacy of intuitive CSCL systems.

Despite repeated attempts to remind students to participate, very few actually did and only 60 (~ 17%) out of a possible 358 (over all the courses – breakups per course given above) completed responses were received. Out of the 60, 11 were rejected (8 from students who had participated in an earlier semester and 3 due to incompleteness). The final N was 49 (~14%). This is a small sample size especially when a path analysis using structural equation modeling (SEM) was also going to be performed. Hoyle (1994), states that experimental comparisons do not require as many subjects as exploratory model-building, and studies using SEM with small samples are not unusual and that experimental social science literature contains quite a few publications using SEM in small samples ($N < 50$) and gives examples of the publications that have conducted these studies.

With N=45 (there were missing values in four of the completed surveys), and all of the 35 items, the Cronbach Alpha was 0.9082. With N=49 and only the 19 non-Elluminate® specific items, the Cronbach Alpha was 0.9106. Also, with N=49, the communication items registered a Cronbach Alpha = 0.6045 and proved to be not reliable at all. This Alpha may be low because of lack of homogeneity of variances among items, for instance, and it is also lower when there are fewer items in the scale/factor. In this case, the possible reason for the low Alpha is probably because all of the students did not use the media equally (more distance students than on-campus ones). Students who were familiar with one another (from earlier classes and interactions - history) reported a higher usage of cell phones and IM, while those who were new to the course/class reported a higher usage of email and bulletin boards.

7. Analysis and results

The information collected about the communication patterns was input into an adjacency matrix and that indicated degree for each communication type – email, IM, BB and face-to-face. UCINET (Borgatti, Everett & Freeman, 2002) software was used to determine the various centrality scores for each individual in the group and plot the sociogram (figure 2). I then used Structural Equation Modeling (SEM) to test the path leading from respect and influence obtained from the betweenness centrality scores and how they affect students' motivation to participate in class discussions using the CSCL tools and how they affect the self-perception of knowledge gained (individual), satisfaction with the performance in the project (individual) and the grade for the course (individual).

8. Social network analysis

Understanding the way students in a class learn is never easy, but a pictorial representation of the flow of information among these students can shed some light how their interactions affect the way they form social structures, and possibly impact their learning. Figure 2 depicts the sociogram of actors in all the eight courses over three semesters. As you can see, since the N's are small, the networks are also small and sparse. The impact of this low N can vary depending on the type of network that emerges. If a decentralized network were to emerge (an all-channel network in which everyone connected to everyone else), then information floats inefficiently in such a network (Lazer, 2007). In the case of a centralized network information transfer would be more efficient (Lazer, 2007). Of the various centrality scores, betweenness centrality was the centrality measure of choice because this score is calculated based on who else the actor is connected to and whether they are strategically placed between others with higher degree/power.

The names of the courses are mentioned along with the actor names to differentiate the networks from one another. Though there were a few students who took more than one of the above courses at the same time there was no evidence of them talking to one another across courses, hence there are no lines linking them. Degree, closeness and betweenness centrality scores were computed for all the actors (for email and IM communications). The scores for bulletin board conversations were not computed as the N was very small from the bulletin boards. Even though they were computed together, these networks are distinct from one another and the values are specific to their network alone.

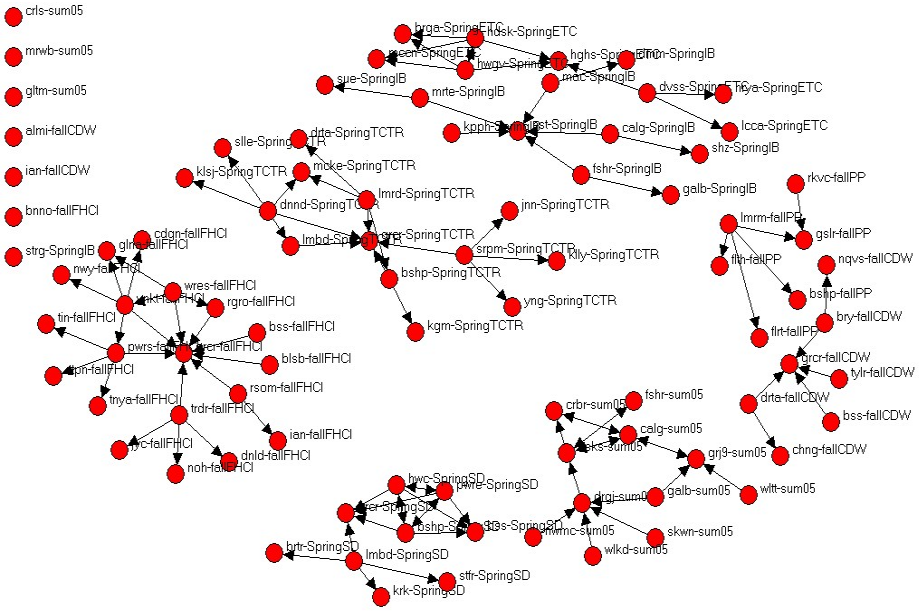

Figure 2: Sociogram of actors in eight different courses over three semesters

The reason for betweenness centrality being the centrality measure of choice is because this score is calculated based on who else the actor is connected to and whether they are strategically placed between others with higher degree/power.

Their connectedness to other actors with power (or knowledge) places them in a position to act as controls or conduits for information and hence provide them with indirect network prestige effects. For those who did not respond to the survey, there was no data to suggest whether they were connected to these actors or not and hence that data was eliminated. Thus the networks are only for the respondents and in essence this would be an incomplete network representation of those who took the courses. However, this is a limitation and as is the case with any survey based study, the self-selected sample (as they volunteered to participate) is expected to represent the population. Table 1 lists the actors with high betweenness centrality scores.

Table 1: Betweenness centrality scores of some actors

Number	Actors	Betweenness Centrality Scores
1	calg-sum05	0.162
2	grj-sum05	0.262
4	ksks-sum05	0.437
8	drgj-sum05	0.662
25	grcr-fallFHCI	2.709
29	pwrs-fallFHCI	1.199
33	rosm-fallFHCI	0.424
35	trdr-fallFHCI	1.199
39	vnkt-fallFHCI	1.086
59	instr-SpringIB	0.799
79	grcr-SpringTCTR	1.223
81	dnnd-SpringTCTR	0.662
86	lmrd-SpringTCTR	0.412
88	srpm-SpringTCTR	0.824

9. SEM results for this study

Structural equation modeling (SEM) is an extension of the general linear model (GLM) that enables a researcher to test a set of regression equations simultaneously. SEM software can test traditional models, but it also permits examination of more complex relationships and models, such as confirmatory factor analysis and time series analyses. The researcher first specifies a model based on theory, determines how to measure constructs, collects data, and then inputs the data into the SEM software package. The package fits the data to the specified model and produces the results, which include overall model fit statistics and parameter estimates. The input to the analysis is usually a covariance matrix of measured variables such as survey item scores, though sometimes matrices of correlations or matrices of covariances and means are used. The betweenness centrality scores (some of which are depicted in table 1) were converted to integer values using a CEILING function in Excel® to round them to the nearest integer values and these formed the variable "IMEMLBET" – betweenness centrality from IM and Email communication, the primary exogenous variable in the (SEM) path analysis in the AMOS® SEM package.

IMEMLBET (betweenness centrality due to IM and Email usage) would form the primary exogenous variable to test the model depicted in Figure 1. RESPMOTV (motivation due to perceived respect among group/class members) and INFLMOTV (motivation due to perceived influence among group/class members) form the intermediate tier, while CONKNOW (conceptual knowledge gained), NEWKNOW (new knowledge gained), IMBBLERN (IM and Bulletin Boards were useful to the learning process), SATPEF (completely satisfied with the performance in the course) and finally, SELFGRDA (confident of getting an A in the course), were the final outcome variables. The Chi-square was 16.893 (df = 13, p = 0.204) and CMIN = 1.299. This Chi-square value is high but indicates a better fit as shown both by the probability level and the CMIN value. One additional metric of the significance of the path parameter is the Critical Ratio. When the Critical Ratio (CR) is > 1.96 for a regression weight, that path is significant at the .05 level (that is, its estimated path parameter is significant).

Table 2 gives the standard errors and the critical ratios for the default model, which contains the fit measures for the model in figure 1 and we note that CR values for all the variables are greater than

the required 1.96 and they are all significant at the 0.05 level, thus affirming that the model fits the data acceptably.

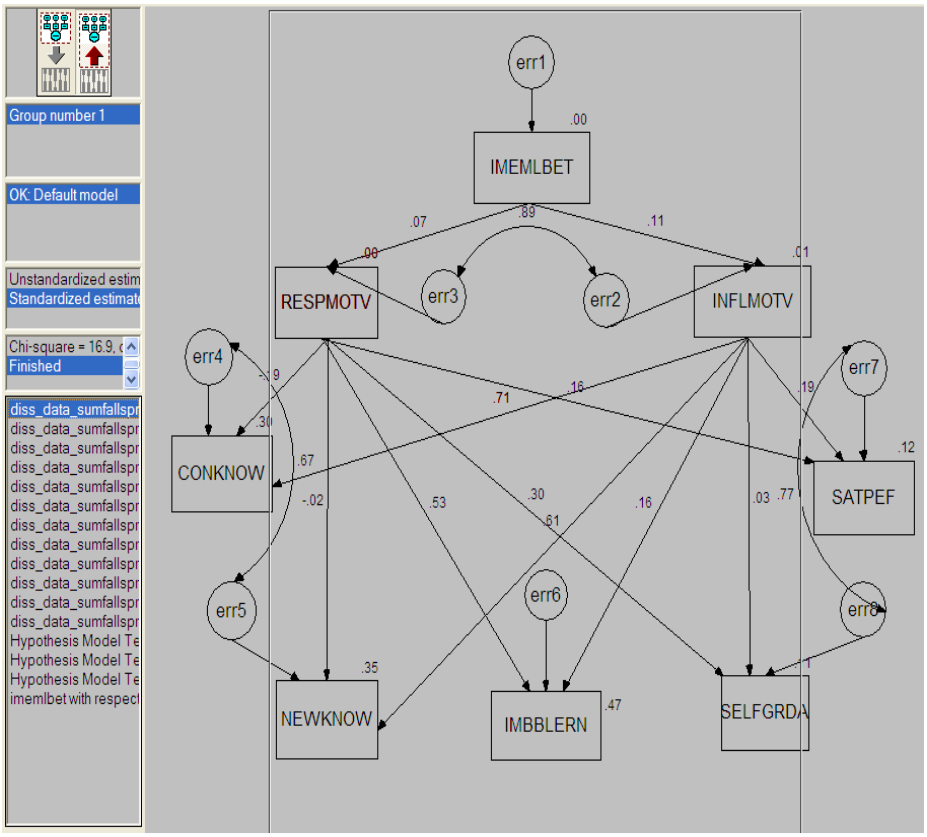

Figure 3: Final Path Model with five outcome variables comparable to hypotheses model in figure 1 – presented here with standardized weights - chi-square = 16.893, degrees of freedom = 13, probability level = .204, cmin/df = 1.299

In addition to presenting the Chi-square results and the CMIN results, the results of the RMSEA goodness of fit test (**Root mean square error of approximation)** are also presented. By convention, there is good model fit if RMSEA is less than or equal to .05. ***RMSEA for the model in figure 3 was 0.00313 and we see that this is < 0.05 and by convention indicates a good model fit.*** Also, for this model, the PCLOSE value is 0.302 confirming that the RMSEA value is < 0.05 and confirms that the model fits the data acceptably.

Table 2: Standard error and critical ratios for each of the parameters

	Estimate	S.E.	C.R.	P	Label
IMEMLBET	1.918	.237	8.108	<.001	par_22
RESPMOTV	4.624	.376	12.292	<.001	par_21
INFLMOTV	4.502	.388	11.597	<.001	par_23
IMBBLERN	1.467	.550	2.668	.008	par_16
CONKNOW	2.596	.606	4.285	<.001	par_17
NEWKNOW	1.508	.639	2.361	.018	par_18
SATPEF	4.413	.588	7.502	<.001	par_19
SELFGRDA	4.294	.637	6.736	<.001	par_20

10. Hypotheses with the results

Respect (and influence) and perceived respect (perceived influence) have been used interchangeably and the results are not affected as the questions were framed in a manner that records only the students' perceived respect and influence.

H1: Betweenness centrality from use of email and IM, among students in a computer-supported collaborative learning (CSCL) environment will positively impact respect and influence among the class members.

The CR for the relationship between IMEMLBET and RESPECT was 0.887 (p = 0.375) indicating a weak relationship and the CR for IMEMLBET and INFLUENCE was 2.014 (p = 0.044) indicating a significant relationship. **Therefore even though the model fits the data acceptably, hypothesis H1 is only partly supported, i.e. betweenness centrality from use of email and IM has a relatively higher positive impact on influence among class members than it does on the respect gained from class members.**

H2: Presence of social dynamics factors like respect and influence gained from email and IM, communication among students in a computer-supported collaborative learning (CSCL) environment will positively impact the students' motivation to participate and interact in class discussions via instant messenger chats and bulletin board message posting.

RESPECT vs. RESPMOTV had a CR = 2.757 (p = 0.006) and INFLUENCE vs. INFLMOTV had a CR = 5.295 (p < 0.001). This indicates again that respect and influence gained from and among class members has a positive impact on the motivation to participate in class discussions using the CSCL tools. Contrarily, RESPMOTV vs. IMBBLERN (participation in IM aided in the learning process) had a CR = 2.801 (p = 0.005) indicating a positive relationship and INFLMOTV vs. IMBBLERN had a CR = 0.784 (p = 0.433). This indicates that motivation from perceived respect impacted usage of IM and Bulletin Boards to learn (IMBBLERN), while motivation due to perceived influence did not impact IMBBLERN. These are mixed results. Both RESPMOTV and INFLMOTV were expected to impact IMBBLERN, but only one of them did. **So hypothesis H2 is supported. Respect and influence do have a positive impact on the motivation for students to participate in class discussions that use the CSCL tools like IM and email and that aided their learning process.**

H3: Motivation to interact and participate in online discussions, gained from perceiving respect from peers and influence in class matters gained from email and IM communication among students in a computer-supported collaborative learning (CSCL, environment will positively impact the students' self-perception of knowledge gained.

RESPMOTV vs. CONKNOW had a CR = -0.877 (p = 0.380) and RESPMOTV vs. NEWKNOW had a CR = -0.101 (p = 0.919) indicating that respect gained from classmates did not play a role in either conceptual or new knowledge gained during the course. We also note that INFLMOTV vs. CONKNOW had a CR = 2.635 (p = 0.008) and INFLMOTV vs. NEWKNOW had a CR = 2.948 (p = 0.003), indicating that influence (by the self) among class members has a positive and significant impact on both conceptual and new knowledge gained during the course. **So hypothesis H3 is partially supported in that while respect gained amongst class members motivated the students to participate (H2), it did not have a significant effect on knowledge gained. On the other hand, influence gained among class members had positive impact on their motivation to participate (H2) and a significant positive impact on knowledge gained.**

H4: Motivation to interact and participate in online discussions, gained from perceiving respect from peers and influence in class matters gained from email and IM communication among students in a computer-supported collaborative learning (CSCL) environment will positively impact students' satisfaction with their performance in the course.

RESPMOTV vs. SATPEF had a CR = 0.662 (p = 0.508) and INFLMOTV vs. SATPEF had a CR = 0.696 (p = 0.487) indicating that the motivation to interact and participate in online discussions gained from perceived respect and influence among class members did not have a significant effect on the students' perceived satisfaction with their performance in the course. Since the CR values are not significant, we cannot reject the null. **Thus hypothesis H4 is not supported in this model. Students, who are new to a class or group, earn their respect by not just being nice, but by doing their assigned parts of a group task well and to the satisfaction of the group. They earn their credibility by performing and are motivated to perform in anticipation of acceptance by the group. This is the case among non-familiars. It is the newcomers who strive for the perceived respect and influence within the group.**

H5: Motivation to interact and participate in online discussions, gained from perceiving respect from peers and influence in class matters gained from email and IM communication among students in a

computer-supported collaborative learning (CSCL) environment will positively impact students' confidence of getting an A in the course.

RESPMOTV vs. SELFGRDA had a CR = 1.239 (p = 0.215) and INFLMOTV vs. SELFGRDA had a CR = 0.121 (p = 0.903) indicating that the motivation to participate and interact in online discussions gained from perceived respect and influence among class members did not have a significant effect on the students' confidence of getting an A in the course. Again, since the CR values are not significant, I cannot reject the null. **Thus hypothesis H5 is not supported.**

11. Discussion, conclusions, and future directions

Respect (whether real or perceived and not very different from esteem) as a social factor is important to people in order to validate themselves and the skills they bring to the table in collaborative work situations. Influence in a group and among class members and motivation to actively collaborate and not be a free rider, follow from the respect that the individual gets from group/class members. This respect may be there as a result of past achievements or may be earned by the individual during the course of collaboration. In the case of distance students, respect will primarily be gained from networked communication when the students interact with one another in class. However, it is possible that they may already know one another from previous interactions from having taken similar classes before or coming from the same high school or maybe if they are working in the same/different department in the same organization. In either case, since respect and its companion, influence in a group (hypothesis H2), have emerged as important dimensions in collaboration among members in group/class project work, one can make a case for designing learning and collaborative systems which incorporate this need for validation.

Designers of CSCL systems could consider the following recommendations. They can have tools to validate the quality of the contribution to the work, for instance a tool that would prompt group/class members to send both a visual validation for work done, such as an emoticon, or textual feedback to their group members. This again follows closely from hypothesis H2. This would be helpful in preventing situations in which members, who are contributing, don't feel valued and might feel like the payback for contributing in the work doesn't meet the cost. This is exactly the type of situation that leads someone who might be productive, into becoming detached and eventually a free rider. A similar idea is to include a participation meter and making it available to the group. A group/class member could indicate the percentage of work each member has contributed and this could allow the group to address any problems that arose from lack of participation, before it got to the stage where an instructor has to intervene.

Tools to support reputation building, perhaps through building profiles showing prior examples of collaborative work, successful decision making, references and testimonials could all help people earn a reputation prior to collaborative work. These are the network prestige effects discussed by Cho, Stefanone & Gay (2002) and follow from hypothesis H1. Even simple ideas, like a star rating given by one's peers, could motivate students to actively participate in collaborative learning exercises. To avoid Groupthink, a system could support voting in decisions with the percentage of confidence in the decision, e.g. "I vote with 50% confidence that we should follow our design plan." The system should support doing this anonymously to avoid students with more authority than others dominating decisions. While negative feedback could cause people to shrink into the background, especially if they are new to a group, if they realize that the feedback is fair and based on accepted norms, they will be more accepting of this feedback.

Thus peer assessment becomes an integral part of the decision-making and the learning processes. For effective collaborative work, whether in classrooms or in industry settings, a team needs to avoid Groupthink and free riding and build a solid social network, where members feel respected and influential. Communication is a key component of this, and systems can be built to better facilitate this communication. The implementation of CSCL systems with a social network engine would aid in this endeavor and the first of such systems have already begun making their appearances in the market. Tosh and Werdmuller (2005) have created elgg® – a social network software for education (O'Hear, 2006). Described by its founders as a 'learning landscape', elgg® provides each user with their own weblog, file repository (with podcasting capabilities), an online profile and an RSS reader. Additionally, all of a user's content can be tagged with keywords - so they can connect with other users with similar interests and create their own personal learning network. However, where elgg® differs from a regular weblog or a commercial social network (such as Facebook® or MySpace®) is the

degree of control each user is given over who can access their content. Each profile item, blog post, or uploaded file can be assigned its own access restrictions - from fully public, to only readable by a particular group or individual (O 'Hear, 2006).

The reason for discussing an environment like elgg® and Elluminate® is to look at similarities and differences between these environments in the context of the constructivist and collaborative learning paradigms. While, there is much evidence in the literature and in this study that the formation of networks among students in a collaborative CMC environment does impact how they perceive one another and use these relationships to learn from one another, for all of these to work in concert, there must be more mentoring of the students as they use these environments to study and learn. The concepts of peer-assessment and collaborative learning should be inculcated from an early stage. The present generation of students is weaned on IM, AOL®, MySpace®, Facebook® and YouTube® and many form lasting relationships (online and offline). The instructors only need to leverage these behaviors in order to give the students the best experience during their learning activities. In this study some of the hypotheses were confirmed while others were not. But this is good, as it indicates that several students chose not to participate and thus exercised control over what they wanted to do. It is this control that manifests itself positively when you introduce peer assessment and students will be motivated to participate, assess and be assessed because they choose to do so.

The formation of social network structures due to communication patterns did have some significant impact on how the students perceived whether they gained respect among their classmates and whether they had influence on work related matters in online discussions. This in turn did appear to have some significant impact on the students' perception of conceptual and new knowledge gained during the course. However, this could be the result of a halo effect, but to a certain extent an individual can gauge the reactions and responses of others by the way in which they accept or reject suggestions made by the individual. So the perception is not necessarily always a halo effect.

One of the goals of this study was to look at CMC-supported collaborative learning and attempt to identify some of the underlying factors that improve learning and collaboration at the individual level. Group effects like cohesion and clique formation, Groupthink and presence of free riders have not been tested and are the subjects for a future article. It is encouraging to note that the elgg® software is an open source social networking platform that allows people to customize the tools to their needs and it will be useful to compare performance of students in the elgg® environment to the performance of students in the CSCL environment like Elluminate®.

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