

Socio-Technical Capital in Online Learning: A Preliminary Investigation

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Abstract: Online learning is often supported by technologies that provide task-oriented groups such as classes or professional development teams with their own workspaces for interaction. This paper begins an exploration into the proposition that participants may benefit if they are not isolated from each other, but rather are enabled to discover persons and resources from contexts other than the original context to which they were assigned. The potential value that resides in technology-supported social networks has been called *socio-technical capital*. Our software, Prometheus, is being used to support online university level education and teacher professional development under an open community model inspired by this idea. The analysis reported in this paper tests whether people who come to the online environment for instrumental objectives such as taking a course encounter persons or products of others from outside their immediate workspace, and also seeks to identify how the various digital media available in Prometheus support these encounters. Results show distinct roles for each of discussions, resources, user profiles, and wiki pages, and point the way to further work.

Keywords: virtual communities, post-secondary education, representational affordances, socio-technical capital, social network analysis, weak ties

1. Introduction

Long before the advent of currently popular “social networking” sites such as MySpace and Facebook, researchers have studied social networking as a phenomenon in diverse types of computer-mediated communication (CMC) environments such as online learning communities (Barab, Kling, & Gray, 2004; Mayadas, 1997; Renninger & Shumar, 2002). The difficulty of building close relationships or *strong ties* (Putnam, 2000) in CMC environments has been noted and attributed to lack of cues (H. H. Clark & Brennan, 1991; Olson & Olson, 2000). At the same time, CMC enables each person to participate in a much larger number of *weak ties* (Granovetter, 1973) than is possible through face-to-face interaction (Donath & Boyd, 2004). Weak ties are important because they provide those involved with a large network of persons on which they can draw for resources beyond those available in one's immediate circles of strong ties (Granovetter, 1973): what Putnam (2000) calls *bridging social capital*. A properly designed online learning environment potentially increases this kind of social capital. Since the capital resides in part in the technology affordances as well as in the social network, Resnick (2002) refers to it as *socio-technical capital*. Combining these ideas, we have designed for *bridging socio-technical capital* in two learning related applications: one for teacher professional development and another for university level education. In these online environments, a number of people who may have something in common are participating in a shared virtual space. Our objective is to design this space to offer affordances for forming connections and

sharing resources between participants. People often use CMC applications for other reasons, in particular to achieve specific instrumental objectives that are relevant to smaller task-oriented groups. Therefore we designed our learning environments to support groups' instrumental objectives while also allowing for serendipitous discovery of other persons, ideas and resources in the larger social network. After several years of running these online environments we are now beginning analyses to answer the following research questions:

1. Do people who come to the online environment form connections and share resources with others outside the workspace in which they pursue their instrumental objectives?
2. If they do, by what technological pathways do they form these connections that we might strengthen and exploit further? What potential pathways are underutilized?

This paper reports on our first analyses addressed at these questions. After introducing the two applications, we discuss how social network analysis (Wasserman & Faust, 1994) of log files can partially address the research questions. We then report on the results of our first analysis.

2. Seeking Community in Online Social Networks

The primary concept behind this paper first developed in the context of a technology-supported systemic reform effort called Hawai'i Networked Learning Communities (HNLC.org). Our objective was to improve science math and technology education in rural schools of Hawai'i with a program of professional development, supported by a "virtual community center", hnlc.org, that was intended to enable teachers to reach both human and digital resources across geographic and institutional barriers (Suthers et al., 2004; Suthers, Yukawa, & Harada, 2007). Simultaneously, HNLC.org supported several other special interest groups related to education in Hawai'i. During the evolution of the HNLC project, a tension developed between the objectives of supporting small-team work and supporting a statewide community of educators. Our synthetic solution was to support the emergence of socio-technical capital in the larger social network that forms out of smaller groups with well-defined purposes (Joseph, Lid, & Suthers, 2007; Suthers et al., 2004). Our research questions are oriented towards this practical objective.

A similar problem exists in postsecondary education. Students experience courses as "silos," isolated from each other. Materials are encountered in individual course contexts in systems such as WebCT (J. Clark, 2002) and Moodle (Dougiamas & Taylor, 2003), rather than shared between them. The silo approach is somewhat intentional: instructors are often cautious about allowing access to materials from previous incarnations of a course because of particular pedagogical approaches that rely on controlling the order in which information is revealed to the student, or in which building on others' work is seen as a form of "cheating". Unfortunately the silo approach can inhibit pedagogical approaches that can be conducive to learning (Webb & Palincsar, 1996) and the development of professional identity in graduate education (Derry & Fischer, 2005). Our own approach to university level education is project oriented, valuing students building on each others' work and seeking to build a sense of community that transcends individual courses. Students and faculty should participate in multiple nested and overlapping groups and be members of a larger community; yet this fact is not well supported by current online learning environments. These considerations motivated our decision to adopt the hnlc.org software, originally developed for online teacher professional development, to university education, in an environment known as "disCourse" (discourse.ics.hawaii.edu).

3. Prometheus: The Software Base

Both hnlc.org and disCourse were originally written in PHP/MySQL, but have been migrated by Sam Joseph to Ruby on Rails in an integrated code base known as Prometheus. A Prometheus instance may contain the following resources for collaboration and community. Any user, without logging in, can access “stories” that are posted on the home page. (When a story is posted, all members receive an email notification.) The general public can also access a “resource database,” searchable metadata on web-based resources. Logging in, a registered user has additional access to member profiles, discussions, and workspaces. Member profiles contain optionally provided contact and interests, as well as a record of recent activities in the environment and links to the member's workspaces and discussion postings. Discussions are web-based threaded discussions, displayed “in context:” one can open up multiple sub-threads at the same time on one page, and when one replies to a message the reply composition box is embedded in the context where it will ultimately appear, with all the currently open messages also visible. Discussion postings include a link to the member profile of the author as well as a record of who has read the message.

Workspaces are the most complex artifacts, which include many of the other available resources of the environment and add a few features (Figure 1). The intention is to collect in one place everything a workgroup (e.g., class, or teacher team) is using to support its work. Each workspace has a main area in which the current object being viewed or edited is displayed, plus

Figure 1. A disCourse Workspace

various tools and resources listed on the left and right hand sides. The items accessible on the sides and displayable in the main area include wiki pages, discussions, participant profiles, resources (from the resource database) files (one can upload files for sharing in the workspaces), a synchronous chat tool, and links to sub-workspaces. Wiki pages and discussions are paired: each wiki page can have a discussion attached to it where participants can discuss the contents of the wiki page as they edit it, and each discussion can have a wiki page at the top for stating the purpose of the discussion, posing questions, summarizing conclusions, etc. In either case, the motivation is “artifact centered discussion:” learning and work often require the coordinated talking about artifacts while also modifying them (Suthers, 2001).

Digital “pathways” by which users of a workspace may find value in the larger social network include links to persons who have posted a story or message or created an artifact, and tabs under which one may search and browse other available discussions and workspaces. Also, the home page has listings of recently contributed resources and recently active workspaces and discussions.

4. Analysis: Measuring Socio-Technical Capital with Spontaneous Ties

To answer the first question concerning whether “*people who come to the online environment form connections and share resources with others outside the workspace in which they pursue their instrumental objectives,*” we need to determine what events we count as forming connections and sharing resources, and how this relates to the presence of others in a technology mediated environment. To answer the second question concerning the “*technological pathways [by which] they form these connections,*” we need a way to identify which features of the environment are involved in these events. Our measures are based on events in which a person has chosen to interact with a digital artifact in the manner for which it was designed. Specifically, we consider four kinds of digital artifacts that may be created by one person and accessed by another: discussions, resources (uploaded files and meta-data on external web pages), user profiles, and wiki pages. The normal use of each of these artifacts is to post in discussions, view resources, view user profiles, and edit wiki pages. If a person does one of these things, then we credit the associated artifact with having provided the basis for connection-forming or resource-sharing. Since we are concerned with *socio-technical* capital, we need to restrict consideration to artifacts that derive from the presence of others in the social environment. The analysis reported here achieves this requirement as follows: we count discussions that others have posted to; resources that someone else has provided; other users’ member profiles; and wikis that others are also editing.

A simple yet powerful way to capture, structurally as well as quantitatively, the relationships that derive from participation in a social space is through social network analysis (Wasserman & Faust, 1994). Social network analysis normally creates *sociograms*: graphs in which vertices are persons and edges are “ties” between persons. Social network analysis is traditionally concerned with interpersonal ties between persons. Since we are concerned with *socio-technical* capital, we follow Actor-Network Theory (Latour, 2005) and treat technological artifacts as actors (“actants”) that can participate in ties (“associations”) just as persons can. Consequently, a “tie” in our work does not imply that there is any kind of interpersonal relationship between the persons involved: people can share socio-technical capital via their mutual involvement in an artifact without necessarily knowing each other. For example, when one user accesses a resource provided by another person, we may say there is a tie between the two persons, and create a sociogram that has an edge between vertices representing those persons. However, since we are concerned with socio-technical capital rather than interpersonal relationships, we believe it is more accurate to view the association between persons as mediated by the artifact, and represent this in the sociogram with arcs from person to artifact to person.

In order to identify socio-technical capital gained beyond that expected by virtue of participating in an assigned workgroup, we make the following distinction. Ties arising between users participating in a workspace to which they were assigned are called *assigned ties*. Ties arising outside the workspace are called *spontaneous ties* because they required that others be present for different instrumental reasons and the additional initiative of participants to find these others or their artifacts. In order to identify spontaneous ties, we exclude ties that take place within workspaces to which two persons were mutually assigned. Since we are analyzing data from disCourse, in which participation is primarily driven by university courses, we conduct our analysis on a semester basis. Students can be assigned to a class workspace at the beginning of the semester. Activity within these workspaces cannot be considered the basis for spontaneous ties, as such actions could be dictated by classroom requirements. Our analysis seeks out ties that take place either between two people who were not assigned to the same workspace in the first two weeks of the semester, or who were but the mediating artifact is situated outside of their mutual workspace. These ties indicate

socio-technical capital that would not have been obtained in a silo approach to online learning.

We analyzed data from two academic semesters to search for spontaneous artifact-mediated encounters between disCourse users. SQL queries were written to access server logs in a MySQL database, and we used Pajek (Batagelj & Mrvar, 2003) to generate sociograms. We applied the Fruchterman-Reingold force-directed layout algorithm that minimizes the “energy” that exists in the edges connecting the nodes, producing more readable sociograms. A tie is mediated by a *discussion* if both users posted to the discussion (undirected graph); by a *resource* if one user viewed a resource created by another (directed graph); by a *user profile* if one user viewed another’s profile (directed graph: the graphs do not distinguish between the profile and the person); and by a wiki page if both users have edited the page (undirected graph). We recognize that a number of simplifications have been made for this analysis: consideration of temporal ordering, read-only events, and more complex operational definitions “ties” are left for future work.

5. Results and Discussion

We discuss the results for each type of artifact in turn, beginning with discussions and wiki pages (which are generally accessed only in workspaces) and concluding with profiles and resources (which can be accessed outside of workspaces). Due to space limitations sociograms are shown for only one semester. The sociograms are sparse because they are highly filtered to exclude ties between persons in the same class, not due to lack of activity in the environment. Sociograms generated without this filtering are quite dense.

At first it appears as if spontaneous ties are being generated via *discussions* (Figure 2) and *wikis* (Figure 3), and therefore these are responsible for bridging socio-technical capital. Yet further investigation in which we traced out the locus of the mediating artifacts revealed that the ties in these graphs are mostly related to coursework. Instructors who are more accomplished with our learning environment created new

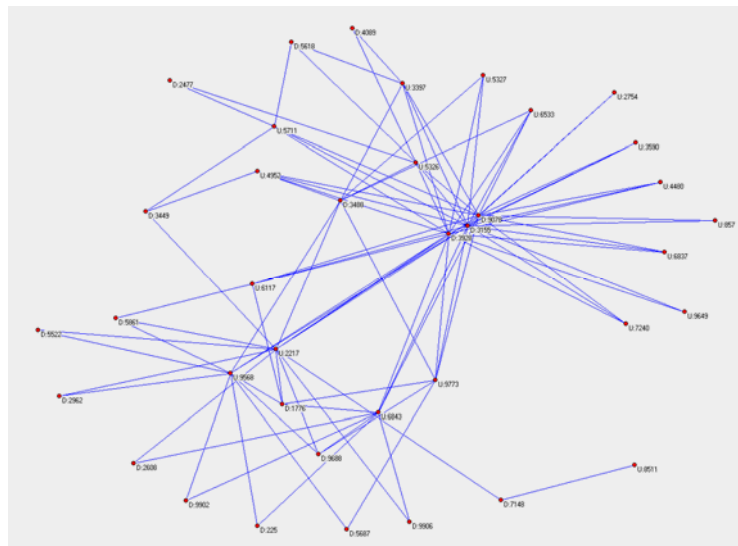


Figure 2. Ties from Spring 2007 Discussions

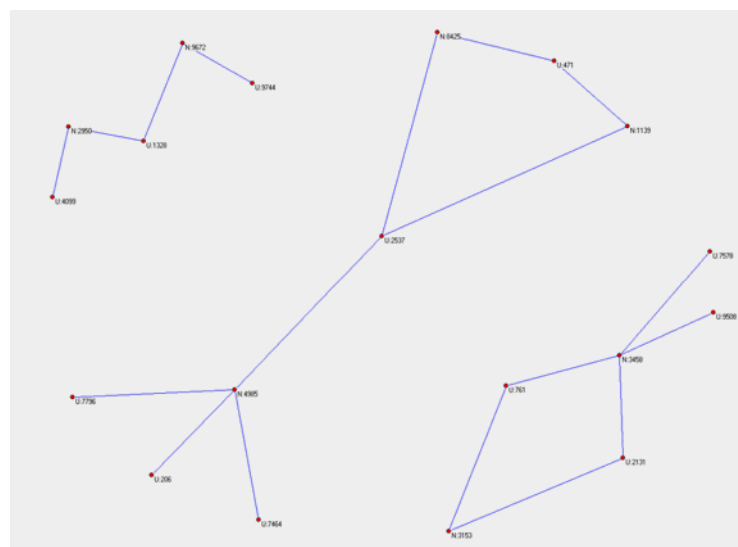


Figure 3. Ties from Spring 2007 Wikis

workspaces well after the two-week filtering window had passed, and students participated in discussions and wikis in these sub-workspaces. A more accurate filtering of assigned ties would result in empty or nearly empty sociograms for discussions and wikis in these semesters. This reflects the fact that all wiki pages and almost all discussion pages exist in the context of a workspace, and most workspaces require that one be given membership to be allowed to post or edit in these artifacts. That is, some “siloeing” remains due to how instructors implement our flexible permissions model. We need to explore ways to encourage opening up discussions and wikis.

Although these graphs expose a loophole in our formalization of assigned versus spontaneous ties, we did learn something about the role of discussions and wikis. The sub-workspaces are usually focused on student projects. These sociograms show that more intensive interaction takes place between students in the context of project workspaces.

Unlike discussions and wikis, *user profiles and resources* are more accessible outside of workspaces. When new resources are posted and made public, they are listed on a “new resources” list on the home page. There is also a resources page by which one may search for resources. Also, most artifacts have a user name associated that is linked to the user’s profile, and one can also use the membership page to search for and view others’ profiles. Therefore, we found more spontaneous ties mediated by these two kinds of artifacts (Figures 4 and 5).

Figure 4 (profile views) does not include profiles as vertices in the graph, because there is a one-to-one correspondence between profiles and users. The density of Figure 4 is indicative of activity in which members examine each others’ profiles outside of a pre-assigned workspace context. Some of these views are between persons who are in the same class. There is a sub-cluster that corresponds to the same set of users as the main cluster of Figure 2: users in a class discussion may be investigating who else is in the class. Yet, the overall results of Figure 4 indicate that profiles are an important medium for bridging socio-technical capital.

Figure 5 (resource views) includes the resources as vertices, so we can trace out the

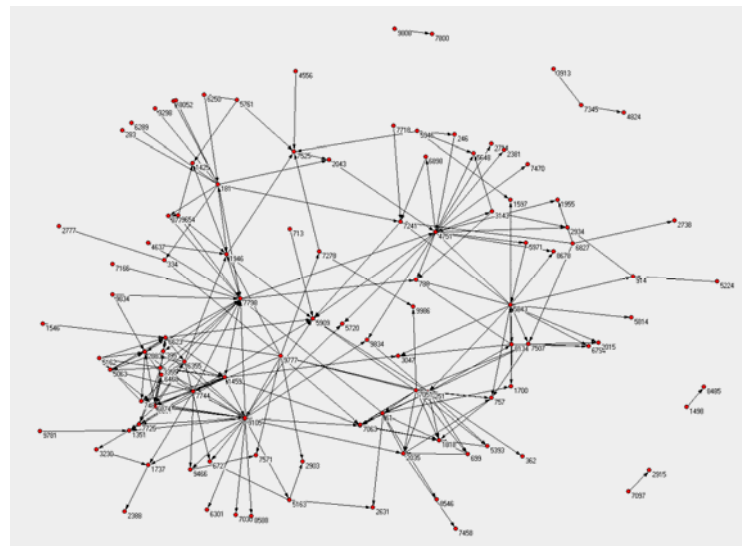


Figure 4. Ties from Spring 2007 Profiles

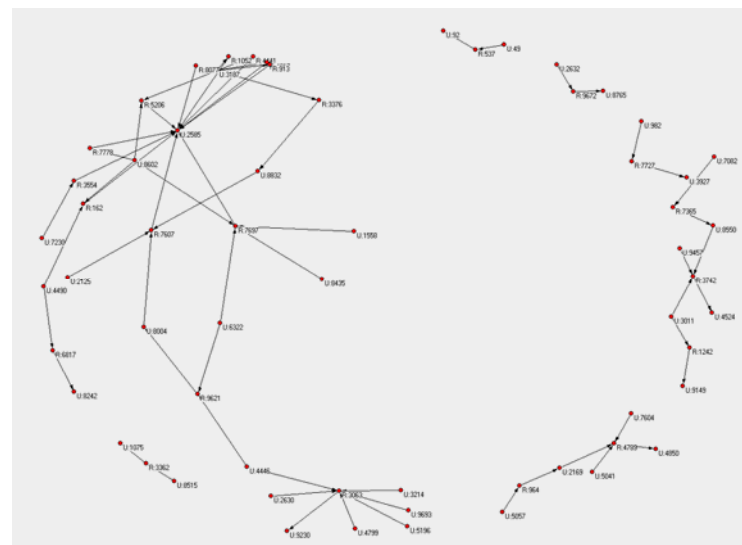


Figure 5. Ties from Spring 2007 Resources

roles of each. One user (an instructor) contributed several resources viewed by others (left-hand cluster), and another resource (a syllabus for a seminar) was viewed by students outside of the seminar workspaces (lower star cluster). The latter may indicate more about how students use our system than about the formation of bridging ties. However, there are many other small subgraphs indicating that students are sharing resources with each other.

6. Conclusions

These results show in what ways users are making connections to others and sharing resources (as measured by their access to digital artifacts) outside the workspace context that meets their instrumental objectives in using the environment (taking a class). That is, we have identified potential *bridging socio-technical capital*. The implication for online learning environments is that students will benefit if classes are conducted in digital environments that are embedded in a larger community space, rather than isolated from each other, assuming that weak ties to others and the resources they provide are of value.

Turning to our second research question, we found that in our current design the potential for bridging socio-technical capital is realized the most via user profiles and resource sharing. To take advantage of these vectors for social capital, we should make profiles and resources visible wherever they are relevant. We should also examine what users are *doing* with the users and resources they encounter, respectively, and consider adding more options for activity (e.g., personal messaging) that further realize the potential for socio-technical capital.

It is not surprising that discussions and wiki pages did not bridge between class contexts, as these two types of artifacts are generally created and encountered within workspaces, and one typically must have membership in the workspace to write to or edit these artifacts—i.e., be members of a class, which we are filtering. A caveat is that for simplicity of analysis we allowed ties only between users who both modified a discussion or wiki page. Writes followed by reads may also form the basis for bridging ties; a matter for future analysis. The present negative results concerning discussions and wikis suggest that we find ways to make users aware of relevant discussions and wikis outside their primary workspaces, and increase opportunities for participation in these media.

There are different directions for future analyses concerning the sociograms. We will continue studying other academic semesters to determine whether they differ from present results. Different classes might utilize each artifact type in a different way, which can influence user interaction more than spontaneous activity. Identifying user types (e.g. boundary spanners) might also reveal whether we can support them in ways that create more value for others within the networks. Further work could also be based on alternative operational definitions of “ties.” In this study, ties were based on mutual access to digital artifacts in ways that were specific to those artifacts. If we more consistently took an information sharing perspective on socio-technical capital, we would define ties to include write/read sequences as well as mutual writes. Alternatively, an interactional perspective on socio-technical capital might define a tie to exist only where there is a “round trip” of interaction (Suthers, Medina, Vatrappu, & Dwyer, 2007), in which a user’s contribution is transformed in some way by a second user, and this transformation is accessed by the first. However, round-trips don’t apply to profile views and resource sharing. A number of simplifications have been made for this analysis. More sophisticated interactional definitions of social ties are possible within the realm of log-file analysis, and ethnographic techniques such as interviews might be applied to determine which connections and resources are valued by the participants. These limitations of the study provide us with directions for future work.

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