Bridging Socio-Technical Capital in an Online Learning Environment

Daniel Suthers, Kar-Hai Chu, and Samuel Joseph
Department of Information and Computer Sciences, University of Hawai‘i, USA
(suthers | karhai | srjoseph}@hawaii.edu

Abstract

This work is based on the premise that online learning environments can potentially help develop communities of scholars by enabling participants to discover persons and resources from contexts other than the original course to which they were assigned. 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 course 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 suggest ways to improve our designs.

1. Introduction

Since the early expansion of online approaches to distance learning, the value of learners as resources to each other has been recognized. For example, Asynchronous Learning Networks were envisioned as "networks" not only in the technological sense, but also in the social sense, as learners networked with each other could support each others' learning [21]. A feeling of social belonging improves students' online learning experience [35], and with proper scaffolding, learners can engage each other in knowledge construction [28, 1]. Yet, much research in online learning communities has focused on discussion forums within a single course, rather than the community of scholars in which the course is embedded. This is not surprising, since many commercial courseware systems are implemented in their institutional context in a manner that isolates courses from each other. Students encounter materials and each other in individual course contexts in systems such as WebCT [5] and Moodle [10], but the inter-course space is not emphasized. This "silo" approach is somewhat intentional: institutions need to restrict access to tuition-paying students, and 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 [18, 34, 8]. Learning takes place through apprenticeships [20] in professional communities of practice [36], and the development of professional identity via transdisciplinary associations [7], not just through formal courses. Following a tradition of open conversation in interdisciplinary communities that goes back to the earliest efforts at online education [e.g., 11], our own approach to university level education is collaborative, valuing students building on each others' work and seeking to build a sense of community that transcends individual courses. We are supporting two overlapping learning communities: Ph.D. programs in the Department of Information and Computer Sciences (ICS), and the interdisciplinary Communication and Information Sciences (CIS) program. Students and faculty in these programs participate in multiple nested and overlapping groups and are members of a larger community; yet this reality is not well supported by current online learning environments. We designed our environment, disCourse (discourse.ics.hawaii.edu), to support individual courses while also allowing for serendipitous discovery of other persons, ideas and resources in the larger social network. After several years, we are now beginning to analyze whether participants discover persons and resources from contexts other than the original course to with they were assigned, and if so to identify how the various digital media available in our software support these encounters. This paper reports on our first analyses addressing these questions. We begin with a background discussion of the concepts of bridging socio-technical capital and the software environment. The methods section describes how we have adapted tools from social network analysis [33] of log files as a method for tracing out bridging socio-technical capital. We then report on the results of our analysis and its implications.
2. Background

For background, we present some concepts from studies of social networks and online communities; describe the origin of the main idea behind this paper; and describe the software environment that is the source of the data.

2.1 Bridging Socio-Technical Capital

Long before the advent of the “Web 2.0” and currently popular “social networking” sites such as MySpace and Facebook, researchers predicted that social networking based on “computerized conferencing” would have large impacts on society [14], and studied social networking as a phenomenon in diverse settings such as scientific collaboratories [6, 17] and online learning communities [25, 2, 21, 24]. The difficulty of building close relationships or strong ties [23] in computer-mediated communication (CMC) environments has been noted and attributed to lack of cues [4, 22]. At the same time, CMC enables each person to participate in a much larger number of weak ties [12] than is possible through face-to-face interaction [9]. 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 their immediate strong tie circles [12]: what Putnam [23] calls bridging social capital. Properly social technologies potentially increase this kind of social capital. Since the capital (resources for potential action) resides in part in the technology affordances as well as in the social network, Resnick [26] 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 the sharing of something of value between participants beyond the specific instrumental objectives that brought them to the environment (e.g., taking a course).

2.2 Transcendent Communities

The primary concept behind this paper was first developed in the context of a technology-supported systemic reform effort called Hawai‘i Networked Learning Communities (HNLC). 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 [32, 30]. As the project matured, we developed a “community of reflective practitioners” approach to professional development [37]. Simultaneously, HNLC.org has supported several other groups related to education in Hawai‘i. These groups arose out of special interests and areas of expertise.

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. While some project members felt that we should focus solely on the former, others argued that school reform efforts cannot exist in isolation, and need community support. There are overlaps in membership between the various workgroups and there is much they have to share with each other. All of these groups collectively form a more vaguely defined collection of users, the members of the statewide community of educators who participate in HNLC.org. It is in this context that we first realized the need to support “transcendent communities” or the emergence of shared value in the larger social network that forms out of smaller groups with well-defined purposes [30, 15]. Subsequent revisions to the software base for HNLC.org were oriented towards this practical objective, and soon we realized that the community-oriented nature of HNLC.org also suited our approach to university education. Therefore, we developed an integrated code base, Prometheus, that underlies both HNLC.org (teacher community) and disCourse (university community) instances.

2.3 Prometheus: The Software Base

Prometheus was written by Sam Joseph in Ruby on Rails. A Prometheus instance may contain the following resources for collaboration and community. (These features are commonplace now in social networking software but are less common in courseware environments and offer potential pathways for community building.) Any user, without logging in, can access “stories” that are posted on the home page. This facilitates awareness of major community events even by those who are either peripheral to the learning community or have not yet obtained an account. When a story is posted, all members receive an email notification for awareness purposes. The general public can also access a “resource database,” searchable metadata on web-based resources. When new resources are registered by a community member and made public, they also appear on the home page on a recent resources list. This also helps the public as well as
members become aware of the topics of interest to the community and relevant documents.

Logging in, a registered user has additional access to member profiles, discussions, and workspaces. Many kinds of contributions, including stories and resources as well as messages, are tagged by a link to the profile of the person who posted them, enabling members to check out persons who may have similar interests. 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 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 [29].

In summary, 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.

3. Method

Our work addresses the following research questions:
• Do people who come to the online environment find potential value that derives from the presence or products of others outside the workspace in which they pursue their instrumental objectives?
• If they do, by what technological pathways do they find this value that we might strengthen and exploit further? What potential pathways are underutilized?

Our method is based primarily on automated log file analysis using social network analysis methods. In this section we discuss the line of reasoning that takes us from the concept of finding value in a social space to specific measurables.

3.1 Operationalizing “Value”

To answer the first research question, “Do people who come to the online environment find potential value that derives from the presence or products of others outside the workspace in which they pursue their instrumental objectives?” we need to define “value” and how this relates to the presence of others in a technology mediated environment. Our analysis is based on the simplifying assumption that a digital artifact offered someone value if that person has accessed it. We include read access and write access where it is applicable. 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 read and post discussion messages, view and post resources, view user profiles, and read and edit wiki pages. If a person does one of these things, then we credit the associated artifact with having potentially provided value. 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: one gets socially-derived value from a discussion if others have posted to the same discussion; from a resource that someone else has provided; from viewing someone else’s profile; and from a wiki if others are editing it.

3.2 Social Network Analysis

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 [33, 27]. 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 [19] and treat technological artifacts as actors—Latour’s “actants”—that can participate in ties just as persons can. Following Latour, we call these ties “associations” to emphasize the fact that they do 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, the traditional approach might say that 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 visualize the association between persons as mediated by the resource or other artifact. Therefore we include artifacts in the graph and represent associations with arcs from person to artifact to person. We call these actor-artifact graphs “associograms” to distinguish them from sociograms.

3.3 Spontaneous Associations

In order to identify socio-technical capital gained beyond that expected by virtue of participating in an assigned workgroup, we make the following distinction. Associations arising between users participating in a workspace to which they were assigned are called assigned associations. Associations arising outside the workspace are called spontaneous associations 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 associations, we exclude associations 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 associations, as such actions could be dictated by classroom requirements. Our analysis seeks out associations 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. (Analysis based on actual class rosters would require additional institutional review board permission to obtain the rosters.) These associations indicate bridging 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 [3] to generate associograms. We applied the Fruchterman-Reingold force-directed layout algorithm that minimizes the “energy” that exists in the edges connecting the nodes, producing more readable associograms. An association is mediated by a wiki if a user has either read the wiki (directed from user to wiki) or if the user created the wiki (directed from wiki to user); the same directional rules are the same for both discussions and resources. An association is mediated by a user profile if one user viewed another’s profile (the graphs do not distinguish between the profile and the person). We recognize that a number of simplifications have been made for this analysis: more complex operational definitions of “interaction” or “value” are left for future work.

4. 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 associograms are shown for only one semester. The associograms are somewhat sparse because they are filtered to exclude associations between persons in the same class, not due to lack of activity in the environment. Associograms generated without this filtering are quite dense.

4.1 Discussions and Wikis

At first it appears that substantial spontaneous associations are being generated via wikis (Figure 2) and discussions (Figure 3), and therefore these are responsible for bridging socio-technical capital. (We discuss these together because they are both accessed primarily via workspaces, as explained below.) Yet further investigation in which we traced out the locus of the mediating artifacts revealed that the associations via wikis are mostly related to coursework or to other defined groups such as research groups.

Figure 3 shows an additional level of analysis that identifies subgroups of the main network. Each of these groups are either class-related or localized to a particular research group. Some associations were discovered to be either activity between members using disCourse for research organization or special types of class activity.

Instructors who are more accomplished with our learning environment created new 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 associations would result in sparser associograms 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.

The blue/grey sub-box in the bottom right shows an advisor/professor creating wikis for students. In this particular case, it covers notes for a comprehensive exam in the CIS program, all of which are viewed by each of the participating students. The students are very peripheral to the graph overall, with no links to any other nodes. The green box in the top right signifies a strong relationship between two users in a research group who are making heavy use of wikis in recording meeting notes. The red box in the middle left is a class workspace. However, unlike the structure seen in the grey box, several of the users here are connected to other networks. For example, user 642 also has a lot of activity within the blue box. The blue box consists of different members of a research group; similar to the red class box, the members also have activity in many different groups. The light blue box in the bottom of the screen covers activity within the CIS PhD program. The exam mentioned earlier in reference to the blue/grey box is a part of the program.

Two groups exist outside of the colored boxes. To the left of the red box is another class. Activity is noticeably less than the class inside the red box, but one point to note is that the instructor, 658, is likely the same for both. To the left of the light blue box is a small group entirely independent of the connected network. This workspace was created separately for research organizational purposes by researchers who do not use disCourse as an instructional tool.

Although some of the associations in the discussion graph are related to class work, they do not separate as cleanly into groups as in the wiki graph. It does not have that many more nodes (246 versus 206 in the wikis) but the groupings are scattered around the entire network, without much correlation to classes, research groups, etc.

This analysis shows that some “siloing” remains due to how instructors implement our flexible permissions model. Although the wiki associogram exposes a loophole in our “two week rule” formalization of assigned versus spontaneous associations, we did learn something about the role of discussions and wikis. The sub-workspaces are usually focused on student projects. These associograms show that more intensive interaction takes place between students in the context of project workspaces.
Figure 2. Associations from Fall 2007 Wikis

Figure 3. Associations from Fall 2007 Discussions
Figure 4. Associations from Fall 2007 Profiles

Figure 5. Associations from Fall 2007 Resources
4.2 Profiles and Resources

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 spontaneous associations mediated by these two kinds of artifacts (Figures 4 and 5).

There is a one-to-one correspondence between profiles and users. Therefore, Figure 4 (profile views) does not include profiles as vertices in the graph. The density of Figure 4 is indicative of activity in which members examine each other’s profiles outside of a pre-assigned workspace context. The level of activity is comparable to those in the wikis and discussions, even though there is no requirement to view another user’s profile to participate in coursework or research groups. Some of these views are between persons who are in the same class; however a large portion of the profile views is occurring outside of class workspaces. This activity suggests that disCourse users are utilizing profiles, and discovering users within groups that are external to their own. 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 roles of each. It exhibits the least number of associations of the four graphs, but, as with profile views, there is activity not limited to class workspaces. In many cases, the resources are not linked to any particular workspace and would not be seen in a user’s regular daily navigation, and yet users are viewing these unlinked artifacts. Three semi-distinct subgroups are visible in the main network, but the resources residing in each subgroup either belong to several different workspaces or none at all. This suggests that users are discovering resources outside of their normal workspaces.

4.3 Summary

The different kinds of artifacts play different roles. While there is more activity within wikis and discussions, it appears as though that activity does not help users expand beyond their silos. Meanwhile, resources and profiles are potentially forming the basis for more bridging events, but are limited in terms of the interaction they support, so may not be capable of realizing the potential social relationships. Discussions and, to a lesser degree, wikis inherently encourage interaction between users that profiles and resources do not. Ideally, we would like to design a form of media that combines the positive attributes of each to have high levels of unsolicited activity that supports increased interactions and discoveries.

5. Conclusions

Taken at face value, these results indicate that users are finding value (as measured by their initiative in modifying and viewing digital artifacts) outside the workspace context that meets their instrumental objectives in using the environment (taking a class). Since the value derives from others and is mediated by digital artifacts outside of the class workspace context, we have evidence for bridging socio-technical capital. The implication for online learning environments is that students will gain value from others if classes are conducted in digital environments that are embedded in a larger community space, rather than isolated from each other. These help us identify the kinds of associations that are taking place via the technological environment that might facilitate the dissemination of reified knowledge, allow for contact that lead to face-to-face relationships, and form the basis for the development of students’ professional identities.

Yet, not all media are equal and there is room for improvement. 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 wiki pages did not bridge between class contexts, as these artifacts are created and encountered within workspaces, and one typically must have membership in the workspace to write to or edit these artifacts—e.g., be members of a class, which we are filtering. Discussions are also most often encountered via workspaces, although not necessarily: one can enter discussions from the home page or from email notifications of discussion activity. The present results suggest that we find ways to make users aware of relevant discussions and especially wikis outside their primary workspaces, and increase opportunities for participation in these media.

There are different directions for future analyses concerning the associograms. We will continue...
studying other academic semesters to determine whether they differ from the 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 within the networks. Further work could also be based on alternative operational definitions of associations or ties in the traditional sense. In this study, associations were based on traces of mutual access to digital artifacts that suggested that information moved from one person to another. There would be stronger evidence that this information was of value if we could show that the recipient took it up in some manner in subsequent action. A more interactional perspective on STC might define a tie to exist only where there is a “round trip” of interaction [31], 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; and cross-media interactions are more difficult to trace.

Log file analysis provides us with an initial overview of the activity and patterns of associations in the online environment. Yet, a number of simplifications have been made for this analysis, and more sophisticated definitions of “value from others” are possible. Other research methods such as surveys and interviews may help to fill out the personal side of the experiences hinted at by the associograms. These limitations of the study provide us with directions for much future work. We also have at our disposal an entirely different data set, the teacher online community, to which we may apply these analytic techniques once they are refined further.

These analyses are undertaken both to understand how users appropriate our technology and how the technology shapes their social experience, i.e., how the technology and the social co-constitute each other [16]. We have focused on processes that take place within the medium itself, but recognize that the mutual shaping of technology and education also takes place in the realm of institutional politics [13], which is presently beyond the scope of this work.

6. Acknowledgements

We thank Nathan Dwyer, Ravi Vatrapu, Richard Medina, and Robert Brewer for comments on the analysis; and an anonymous reviewer for pointing out relevant historical work.

7. References


