

A Social Network Analysis of a Teaching Science as Inquiry Online Learning Community

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Abstract: A professional development series was analyzed for teachers’ use of an online learning community (OLC) embedded within four *teaching science as inquiry* modules. The interactions of teachers in the OLC were designed to foster extended discussion and sharing of inquiry science. We used social network analysis (SNA) to explore the structural patterns of online connections between actors on levels of importance. Raters coded the OLC comments ($N = 492$) and determined that 64% related to OLC *activities*, 35% were *teacher to teacher*, and 1% were *technical*. Teachers interacted with each other about 35% of the time when given free reign to do so. SNA revealed strong central figures within different OLC cohorts. In addition, the level of comfort that a teacher had on the internet was not strongly correlated to the frequency of posting messages. However, the time of exposure to the OLC did significantly increase teachers’ likelihood to continue to use the site to interact with other teachers.

Introduction

There is increasing recognition that teachers, like most of society, seek information from the Internet (Herman & Nicholas, 2010) to supplement their teaching as well as increase relevancy for their students (Shih, 2004; Aikenhead, 2011). A US Department of Education (USDOE, 2010) report states, “Today, low-cost Internet access devices, easy-to-use digital authoring tools, and the Web facilitate access to information and multimedia learning content, communication, and collaboration. They provide the ability to participate in online learning communities that cross disciplines, organizations, international boundaries, and cultures.” Seventy-eight percent of teachers in public schools indicated that independent learning prepared them best for effective use of educational technology (Gray, Thomas, & Lewis, 2010), which causes many institutions of higher learning to question professional development effectiveness.

Purposes and Objectives

In this paper, we complete our analysis of a full professional development series and analyze teachers’ use of an online learning community embedded within four modules geared for teaching science as inquiry. Research has shown that the teachers’ role and engagement are critical in a successful online learning community (Loucks-Horsley, 2003; Maor, 2003; Palloff, 2007; Wilson, Ludwig-Harman, & Thornam, 2004). Furthermore Arne Duncan makes the statement in the Aug 2013 issue of *Scientific American* that “teachers can connect with one another virtually, not just to share lesson plans but also to mentor and share strategies for effective teaching through online collaboration.” Our research question explores if there is a relationship between teachers’ self-perceived use of an online learning community and the amount of use categorized as user prompted (not required by course facilitators and moderators).

Perspectives/Theoretical Framework

Communities of practice, whether they are formally recognized or not, have existed in every organization and industry throughout the history of their existence (Wenger, McDermott, & Snyder, 2002). According to Wenger

et al. (2002), a community of practice is a “group of people who interact, learn together, build relationships, and in the process develop a sense of belonging and mutual commitment” (p. 34). Another phrase used in conjunction with communities of practice is professional learning communities, “a strategy to increase student achievement by creating a collaborative school culture focused on learning” (Feger & Arruda, 2008, p.1). In trying to leverage modern digital technologies with the notion of communities of practice and professional learning communities, social networking sites may have established means for teachers to interact more readily and in a more timely manner outside of their isolated classrooms (Lieberman, 2000).

Online learning communities have naturally provided a source for professional development (PD) for teachers (Duncan-Howell, 2010). It would also provide a “meaningful form of PD” (p. 338) in a way that it is relevant to their practice. If the activities were relevant and core to the learner’s job, then online participation and engagement for professional development could be easily attained without any problems (Macdonald, 2011). Macdonald (2011) has shown that tutors have valued a combination of the activity-based approach and online discussions in which they are able to participate in the activity and reflect with other tutors. In addition, Tsai, Laffey and Hunuscin (2010) have found that teachers gained valuable insights and emotional support from other teachers, thus improving their teaching confidence. A source of this support can be social network sites.

Social network sites (SNS) have become immensely popular in the past decade with hundreds of SNSs existing and accessed with today’s emerging technologies, supporting a broad scope of interests, activities and practices (boyd & Ellison, 2007). boyd defines SNSs as “web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system” (p. 211). Although, there is lack of experimental and longitudinal studies on SNSs, there may be opportunities to research its uses on learning communities or communities of practice.

Social networking analysis (SNA) provides a “visual graph and quantitative representations of patterns and density of interaction” and assists in understanding how students interact with each other in class, therefore proving to be a very useful method to investigate interaction in online learning environments (Shen, Nuankhieo, Huang, Amelung, & Laffey, 2008, p. 32). Shen et al. (2008) discovered through SNA and traditional statistical analysis that students in an online course realized a greater sense of community through higher interaction frequency. Limitations in the study revealed that the data collected/gathered did not account for the communication outside of the course management system including other communication tools such as email, outside SNSs, and instant messengers. With this limitation, it may not show complete data to represent all of the students’ interactions (Shen et al., 2008).

In a study that investigated the relationship between communication styles, social networks and learning performance in a computer-supported learning community (CSCL), the learners’ communication styles and their previous involvement in social networks were a major influence on how distributed learners perform in networked learning environments. The learners’ performance is a direct result of a developing collaborative social network environment (Cho, Gay, Davidson, & Ingraffea, 2007). Educators may consider looking at each learner’s communication style and pre-existing SNS in order to design an effective CSCL that is supported by active participation among learners. For example, seamless collaboration can be achieved between all members in the CSCL environment by matching individuals with low willingness to communicate with those that have high willingness to communicate, once the educator administers a personality survey to the learners (Cho et al., 2007). In another study, the learners’ perceptions of self-efficacy were supported through appropriate communication strategies, collaboration, interaction with each other and frequent participation through the learning environment (Gabriel, 2004).

Network research has flourished during the later half of the 20th century, shifting from its main focus from the individual and its attributes to the understanding of social ties between actors in a structure or system (Borgatti & Foster, 2003; Daly, 2012). These social ties between actors form the basics of social theory (Daly, 2012). “The pattern of ties across a network creates an overall social structure that can support and constrain the access, variety, and use of resources” (p. 3). The network could be analyzed through its explanatory mechanisms of their ties through structure or how resources flow between the social ties (Borgatti & Foster, 2003).

Social network theory emphasizes the importance of the actor’s position in a social structure (Daly, 2012). Actors who occupy a central position may receive a higher number of interactions with other actors. However, the peripheral actor may receive less interaction in the social structure due to their peripheral or isolated positions in the network.

Centrality is a measure that is frequently studied in SNA (Borgatti, 2005). The popularity of its concept had resulted in measures that include degree centrality, *closeness* and *betweenness*. Nevertheless, the importance of the actors or nodes could not be identified without referencing traffic flows in the network. In addition, all ties and

relations should be considered when analyzing networks whose actors are involved in multiple ways of communication that include online forums (Enriquez, 2010).

Background

In our work, we undertook development of an online learning community (OLC) in which science teachers who trained in various science curricula of the Curriculum Research & Development Group (CRDG) are able to interact and support each other without CRDG faculty and staff continuously present. In this current project called Teaching Science as Inquiry-Aquatic Science (TSI-A), an online learning community was designed outside of a course management system tied to the structure of the university. The course management system is its own entity and is not blocked by the extensive firewalls at K-12 schools. The development of the OLC was part of a larger project whose purpose was to promote teaching science as inquiry (TSI). The OLC was designed to enhance communication and collaboration amongst the participating teachers, as well as to provide a mechanism by which resources could be shared.

The CRDG is an organized research unit in the College of Education at the University of Hawai'i. Since 1966, CRDG has served the educational community locally, nationally, and internationally by conducting research and creating, evaluating, disseminating, and supporting educational programs that serve students, teachers, parents, and other educators in grades preK–12; and contributing to the body of professional knowledge and practice in teaching and learning, curriculum development, program dissemination and implementation, evaluation and assessment, and school improvement. Recently, CRDG has delved into developing online learning communities within professional development research and have encountered various issues technology in K-12 teaching and learning including teacher experience, comfort in online environments, integration of technology into teaching, and expectations of technology. CRDG's online work is guided by research that has shown that effectiveness of online learning communities are increased by factors such as community building among participants, use of an online facilitator, and blending work and training (Palloff & Pratt, 2011).

Research Methods

This study used social network analysis (Knoke & Yang, 2008; Carolan, 2013), a growing field in social psychology that explores the structural relations and patterns of connections that actors make to one another on levels of importance. The actors in this study are the teachers and the structural relations are activity comments online. The study was designed to identify comments that are activity comments (directed) and teacher-to-teacher comments (nondirected) where mutuality, such as conversing occurs. In this study, we sought the communication relations amongst the teachers.

In the TSI-A professional development series, the OLC was established for participants and facilitators to share experiences and advice with one another. For this study, we extracted participant activity comments from the period of October 2010 to July 2012. The 34 participating teachers made a total of 492 comments during the time frame. We were seeking evidence to understand the frequency that teachers used the site, as well as the frequency of teachers' interactions with other teachers. To determine if comments were *activity*, *teacher-to-teacher*, or *technical* in nature, three project staff read the posts independently and gave each online post a designation or code. An interrater reliability analysis using the Kappa statistic was performed to determine consistency among the raters. We then compared the number of designations against the required activity comments versus teacher-to-teacher comments.

For social network analysis, we extracted participant activity comments from two teacher cohort groups ($N_O = 15$ and $N_K = 16$) from October 2010 to June 2013. We also extracted comments from our project facilitators ($N_F = 5$). We looked at three patterns of interaction ties. The first set looked at all comments posted between all members of the two cohorts and the facilitators. The second set looked at comments that were reciprocated. The third set looked at comments that were reciprocated three or more times.

Results

Comments were coded to determine if they were required responses to activities (coded “activity”), self-directed responses to other teachers (coded “teacher-teacher”), or technical questions about the OLC (coded “technical”). As seen in Table 1, three raters A, B, and C determined that of the coded comments ($N = 492$), 64% were activity comments, 35% were teacher-teacher comments, and 1% were technical. A mid-study review of the data found the same breakdown of teacher-teacher comment percentages, suggesting that a previous conclusion that teachers had not yet fully engaged was inaccurate. These results supported the conclusion that in a teacher-directed OLC, teacher-to-teacher comments will make up roughly 35% of the posts. As seen in Figure 1, the interrater reliability for rater A and B was found to be $Kappa = .839$ ($p < .000$), 95% CI (0.79, 0.89). The interrater reliability for rater A and C was found to be $Kappa = .895$ ($p < .000$), 95% CI (0.85, 0.94). The interrater reliability for rater B and C was found to be $Kappa = .846$ ($p < .000$), 95% CI (0.80, 0.89). According to Landis and Kock (1977), raters A and B, raters B and C and raters A and C were in almost perfect agreement.

Rater Designations

Type of Comment	Preliminary Group $N_P = 192$	Subsequent Group $N_S = 241$	Subsequent Group $N_F = 492$
First 2 modules			
Activity	95%	48%	64%
Teacher-teacher	5%	36%	35%
Technical		16%	1%

Rater A * Rater B Crosstabulation

		Rater B			
		Activity	Teacher-Teacher	Technical	Total
Rater A	Activity	286	9	1	296
	Teacher-Teacher	24	166	2	192
	Technical	0	2	2	4
Total		310	177	5	492

Rater A * Rater C Crosstabulation

		Rater C			
		Activity	Teacher-Teacher	Technical	Total
Rater A	Activity	305	14	1	320
	Teacher-Teacher	6	162	3	171
	Technical	0	0	1	1
Total		311	176	5	492

Rater B * Rater C Crosstabulation

		Rater C			
		Activity	Teacher-Teacher	Technical	Total

	Activity	291	29	0	320
Rater B	Teacher-Teacher	4	164	3	171
	Technical	0	0	1	1
Total		295	193	4	492

Table 1: Activity comment comparisons between preliminary and subsequent groups by raters A, B, and C

At the mid point in the module, teachers had indicated that they would continue to use the OLC beyond the scope of the professional development series. This finding was still positive at the end of the project with all teachers reporting, as seen in Table 2.

OLC Feedback Results

Statement	1=Strongly Disagree, 10=Strongly Agree		Mid Program		Post Program					
I will continue using this OLC after these TSI-Aquatic workshops...	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i> -value	<i>df</i>	<i>p</i>	<i>eta squared</i>		
To interact	6.57	2.40	7.78	1.69	-3.5	27	.001*	.037		
For course activities	8.32	2.16	8.61	1.69						
For curriculum content	8.21	2.21	8.46	1.60	-1.02	27	.316	.322		
To recommend to others	7.54	2.33	8.46	1.71						

Table 2: Feedback in response to teachers' beliefs that they would continue to use the OLC in the future

The relationship between self-report level of comfort using the internet and posting in the OLC (as measured by in degree and out degree measures in social network analysis) was investigated using Pearson product-moment correlation coefficient. There was no significant difference between level of comfort on the internet and out degree [$r = -.32$, $n = 28$, $p < .093$]. There was also no significant difference between level of comfort on the Internet and in degree [$r = .093$, $n = 28$, $p < .637$].

A paired-samples *t*-test was conducted to evaluate the impact of the TSI Aquatic OLC on teachers' use of the OLC to interact or refer to content. There was a statistically significant increase in interaction scores from the mid program ($M = 6.57$, $SD = 2.40$) to the post program [$M = 7.78$, $SD = 1.69$], $t(27) = -3.5$, $p < .001$. The *eta squared* statistic (.037) indicated a moderate effect size.

There was a no statistically significant increase in website use for content scores from the mid program ($M = 8.21$, $SD = 2.21$) to the post program [$M = 8.46$, $SD = 1.60$], $t(27) = -1.02$, $p < .322$].

Using the UCINET analytical software and applying the NetDraw feature to derive Freeman's degree centrality measures, two central figures emerged from each cohort — teacher 2 from cohort O and teacher 11 from cohort K — as seen in Figure 1. Figure 2 is a visual depiction of an ego analysis on each of the central teachers. Teacher O2 had an out degree value of 14 and an in degree value of 15. Teacher K11 had an out degree value of 6 and an in degree value of 20.

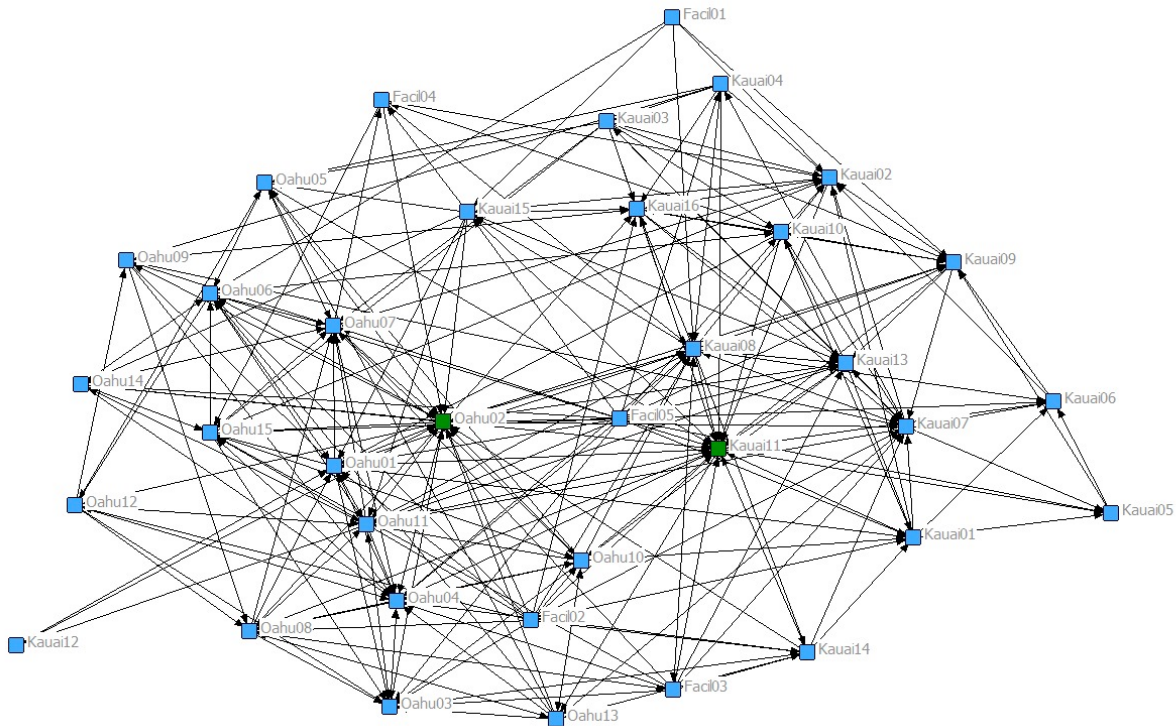


Figure 1: Social network of the TSI online learning community

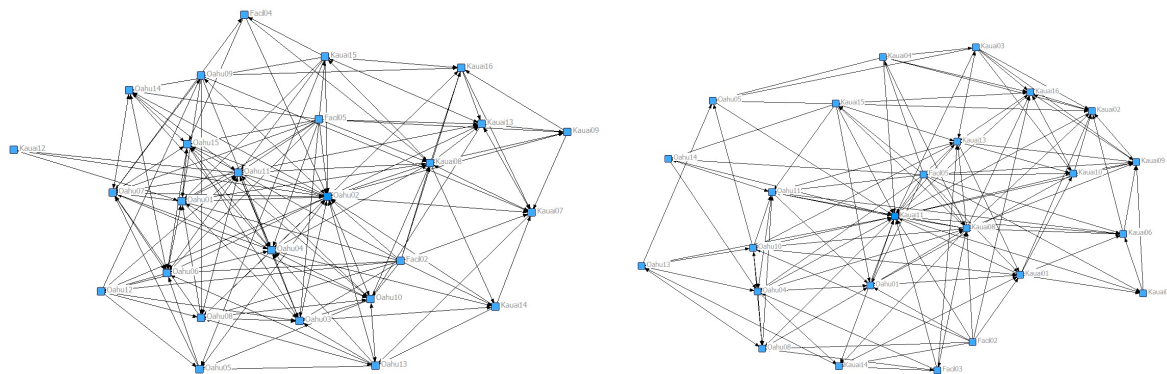


Figure 2: Ego networks for Teacher O2 and Teacher K11

Discussion

In our TSI Aquatic project, we found that our facilitators have maintained good periphery status, supported by the finding that they are on the periphery of the social network through social network analysis. Thirty-five percent of interactions continue to be teacher-teacher interactions from year to year. As we progressed in the three-year project, we found that longer exposure to the OLC significantly increased the likelihood that teachers would continue to interact with each other, supporting Wenger et al.'s (2002) notion of mutual commitment to TSI pedagogy. Even as two teachers emerged as central actors within their cohorts, we are not certain if there was a temporal factor to who received (in degree) and sent (out degree) comments, or what the nature of those comments were. Additional analysis by content experts of the TSI pedagogy is needed. Additionally as Shen et al. (2008) posited, we also did not know the additional interactions that may have been occurring outside of the OLC, such as

emails, other social networks, or even our own face-to-face workshop element of our TSI Aquatic professional development.

Future social network analysis data is needed to account for these outside elements. Some possible future inquiries are to consider if teachers have taken courses together in teacher preparation programs, if teachers teach at the same school as other teachers, if teachers have attended workshops with another teacher involved in this particular workshop series, and if they consider another teacher in the workshop a friend. In addition, facilitators of our professional development workshops could contribute their understanding of teacher socializations by offering their perceptions of teacher interactions in the face-to-face workshop.

Furthermore, data from our the social network degrees of centrality can contribute to additional analysis to determine if there is a relationship between number of “hits” online and the mastery of content. We posit that perhaps teachers who are weaker in content mastery may depend more on the availability of content on the site or feedback and advice from their peers. Of interest is whether, pre-post gains in content mastery can predict use of the OLC. This has implications for professional development facilitation as well continued efforts in the development of OLCs.

Educational and/or Scientific Importance

As schools of education continue to move towards providing a means by which their graduating teachers and teachers in the field can share experiences, support one another, and provide links to promising practices, we need to keep in mind that teacher choice and engagement are key factors to success of an OLC. Over moderating a site where teachers are encouraged to take control and share expertise may hinder that process. We found that in our experiment, teachers will interact with each other about 35% of the time when given free reign to do so. Professional development providers should not be alarmed if the comments between players in a social network hover around that figure of 35%. Although this study is of only one science program, its results can benefit schools of education and curriculum providers by providing them with information about community outreach efforts and online supports for teachers in schools. It also provides some insights to professional development providers of the kinds of online facilitation that is needed to promote the development of self-directed learners in a healthy social network independent of content experts.

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Acknowledgements

This paper was initially presented at the 2013 International Society for Technology in Education Conference.

The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A100091 to the University of Hawai'i (UH) at Mānoa. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education. This research was approved by the UH Human Studies Program CHS # 15657.