CJLT RCAT

Canadian Journal of Learning and Technology
La Revue canadienne de l'apprentissage et de la technologie

Volume 38(1) Winter/hiver 2012

Pilgrims' Progress: The journey towards a knowledge building community in a university undergraduate class

Le voyage du pèlerin: Le parcours vers la création d'une communauté d'apprentissage dans une classe de premier cycle universitaire

Donald Philip, *University of Toronto*

Abstract

The purpose of this study was to examine the progress of a class of third- and fourth-year undergraduate science students as they attempted to create a knowledge building community in a blended or hybrid science education class. The research sought to examine this process through analyses of the frequency of their note postings and responses, and through a social network analysis of their communication patterns for note reading. These data were automatically harvested by the Knowledge Forum knowledge building environment, and downloaded for later analysis.

Contribution levels indicated that the frequency of note postings increased three-fold following the mid-term of the course causing maladaptive student work patterns to reduce information overload. As well, the disparity between high-frequency note posting students and low-frequency note posting students followed a linear curve with the ratio between the highest posting and lowest posting student to be 2.7:1. A similar pattern was found with regard to responses.

A disparity was also found among the students in the number of postings read, with the highest note reading student reading six times the number of notes as the lowest note reading student.The social network analyses revealed evidence of community formation in the note reading network. Analysis showed both one-way and reciprocal interactions, indicating that the pathways needed for the transfer of complex information were present.

Considering all the data together, while some communication patterns necessary for a knowledge building community were present, contribution patterns suggested that a true knowledge building community did not form, but that there was progress towards it.

Keywords: Knowledge building, Knowledge Forum, online facilitation, online courses, social network analysis, data mining.

Résumé

Cette étude avait pour objet d'étudier la progression d'un groupe d'étudiants en sciences de troisième et de quatrième années du premier cycle universitaire dans leur tentative de créer une communauté d'apprentissage dans une classe hybride d'étude des sciences. Cette recherche visait à étudier le processus à partir de l'analyse de la fréquence d'affichage et de réponse aux notes de la part des étudiants, et de l'analyse de leurs habitudes de communication lors de la lecture de notes. Ces données étaient recueillies automatiquement par l'environnement de partage des connaissances *Knowledge Forum* et téléchargées pour des analyses ultérieures.

Les niveaux de participation indiquaient que la fréquence des affichages de notes augmentait du triple après la mi-session, entraînant une réduction de la surcharge d'information dans les habitudes de travail sources d'une mauvaise adaptation chez les étudiants. De plus, la disparité entre les étudiants qui affichaient fréquemment et les étudiants qui affichaient peu suivait une courbe linéaire selon le rapport 2,7 :1. Le profil des réponses aux notes présentait une tendance similaire.

On observait également une disparité entre les étudiants du point de vue du nombre d'affichages lus, où les étudiants dont la fréquence de lecture était plus élevée lisaient six fois plus d'affichages que les étudiants dont la fréquence de lecture était moins élevée. Les analyses du réseau social ont révélé des formations communautaires dans le réseau de lecture des notes. L'analyse a démontré des interactions tant à sens unique que réciproques, indiquant que les canaux nécessaires à la transmission d'informations complexes étaient présentes.

Compte tenu de l'ensemble de ces données, malgré la présence de certaines habitudes de communication nécessaires à la formation d'une communauté d'apprentissage, les tendances observées dans la participation suggèrent qu'une véritable communauté d'apprentissage ne s'est pas formée; néanmoins, elles dénotent une progression en ce sens.

Introduction

One of the commonplace beliefs of teaching at all levels is that if the work assigned is not marked, it is not done. This includes class assignments like readings, as well as attendance at class meetings. Yet there is evidence that when students attend and do the assigned tasks, they perform better (Hovell & Williams, 1979; Wong & Wong, 1979). In terms of online work, evidence suggests that students who participate more do better overall (Davies & Graff, 2005; Nagel, Blignaut, & Cronjé, 2009). These results indicate that participation in the online portion of a course enhances learning.

Another concern in online education (Bielaczyc & Collins, 2005; Hewitt, 1996; Palloff & Pratt, 2001; Scardamalia & Bereiter, 1994) is the formation of a supportive online community. Many students in university undergraduate science classes have never been in classes in which community was encouraged, and are also quite isolated because of their competition for the marks needed to get into graduate or professional schools.

These two factors, taken together, indicate that forming a community in an online learning environment can be difficult with undergraduate science students. This study examines the progress made towards the formation of a knowledge building community made by students in a third-year science education class who worked in a blended class. Machiavelli noted that people, "…do not readily believe in new things until they have had a long experience of them," (1532/1998, p. 24) and instructors in such courses need to know what degree of progress is realistic to expect from these students. It is hoped that studies such as this will help establish a baseline for comparison of classes at this level.

Learning Online

Allan and Seaman (2005) give four categories of courses based on the online content: traditional courses having no online content, courses having web-based content that basically supplements the traditional approach, blended (also called hybrid) courses that have both a traditional component and online discourse, and fully online courses with no traditional component at all. The course described in this paper was a blended course, in which online participation counted for 40% of the final mark. The traditional lecture component was held weekly for two hours in a regular classroom, not a computer lab.

Blended courses have become increasingly popular in recent years (Horn & Staker, 2011). In 2000, there were approximately 45,000 K-12 students using online learning and by 2009, there were in excess of 3 million K-12 students taking courses online, with most of the growth being attributed to the blended approach (Horn & Staker, 2011). Strickland (ScienceDaily, 2008) notes that the benefits of blended classes include, "…increased classroom size, accessibility of material and flexibility, but noted that motivation and technological ability are major factors in the success of a student in a blended environment" (p. 1).

Another dimension upon which online learning can be measured is the level of interactivity among the students that the online system allows. Allan (2004) notes that the early online learning systems were largely based on traditional distance education models and lacked the ability to provide interactivity among students. However, newer models of online learning have leaned more towards "the formation of social networks and communities, the emphasis on creation rather than consumption, and the decentralization of content and control" (Downes, 2007, p. 19). The emphasis on the formation of community is echoed by Palloff and Pratt (2001) who note that "Teaching in cyberspace requires attention needs to be paid to developing a sense of community in the group of participants in order for the learning process to be successful" (p. 20). However, one problem for instructors is how to tell that a community has formed and is functioning properly. Failing this, events like flame wars in which students post IN ALL CAPS TO SIMULATE SHOUTING can erupt, disrupting the learning process (Palloff & Pratt, 2001).

Assessment and Online Learning

Critics of online classes demand proof that online classes provide the same kind of quality as traditional classes (Carnevale, 2001). New forms of assessment are being developed partly in response to this concern. Often these assessments are almost identical to old forms of assessment, but are ported to the online environment. An example is online multiple choice tests. However, researchers have not restricted themselves to new versions of older forms; some have suggested that continuous assessment is possible and desirable (Chung, Shel, & Kaiser, 2006). This approach values formative assessment over summative.

One factor in online discourse is that it does not follow the rules of traditional discourse. Whereas in a traditional class, the teacher chooses who can speak and when, online comments can be made by anyone at any time; discussions become less hierarchical and more democratic. This allows for what Allan (2004); Higgins, Koktsaki and Coe (2011); and Palloff and Pratt (1999) call feedback and what Scardamalia (2002) calls embedded and transformative assessment.

This feedback should come as much from the students as from the instructor (Palloff & Pratt, 1999). Palloff and Pratt (1999) state that online discourse should include, "constructive and extensive" feedback among students (p. 123). Such critical feedback can reveal gaps in learning, or misunderstandings. Effective feedback can provide deep interactions that create points of connection among students and allow for alternate perspectives on ideas (p. 124).

Data that are logged by online environments can be used to examine student interactions. This can include measures of log-in or contribution frequencies (Allan, 2004), or it can include more sophisticated analysis such as *social network analysis*, a form of analysis in which interactions among individuals can be mapped to reveal the patterns of interaction. These patterns can reveal a great deal about the information flow within a community (Allan, 2004).

Social Network Analysis (SNA) and Other Measures

Social network analysis (SNA) is a form of quantitative analysis that focuses on the relations among individuals in a community (Marin & Wellman, forthcoming). An established discipline in the social sciences (Degenne & Forsé, 1999; Scott, 1991; Wasserman & Faust, 1994), its application to education is more recent (Allan, 2004; Hakkarainen & Palonen, 2003; Hakkarainen, Palonen, Paavola, & Lehtinen, 2004; Lipponen, Rahikainen, Lallima, & Hakkarainen, 2003; Philip, 2009; Sha & van Aalst, 2005). Krebs (2007) has created a short introduction to social network analysis that can be found here: http://www.orgnet.com/sna.html.

SNA can be useful in assessing 21st century skills, including communicating and elaborating; collaborative skills such as teamwork and leadership; and working productively with others (Crane et al., 2005; Partnership for 21st Century Skills, 2008). Palloff and Pratt (1999) refer to collaborative online interactions among students as creating, "a web of learning" (p. 6) and SNA can be used to capture critical aspects of this web.

In SNA, data are collected about the frequencies with which individuals in a group interact. These interactions can be of various types depending on the kind of study being performed. In the case of Enron, SNA has been used to examine e-mail contacts among the employees to analyze who was part of the conspiracy to commit fraud (Ehrenberg, 2011). Multiple types of interactions have also been studied to examine terrorist networks (Mathiesen, 2006; Memon & Larsen, 2006). In this study, data were collected on who read whose notes because note reading is important in spreading ideas for community discourse (Palloff & Pratt, 1999).

Once the data are collected, a number of statistical measures can be used to examine the interaction patterns. One of the most common analysis techniques is to create a sociogram, a kind of network map in which actors in the network are represented as nodes (often dots or squares) and the interactions among them as connecting lines (Degenne & Forsé, 1999; Valente, 2010). Such network graphics can be useful, and Cross, Borgatti, and Parker (2003), in analyzing social networks in business settings, note that, “Simply reviewing [sociograms of business communications] with managers usually results in myriad recommendations, as people immersed in the patterns of relationships define and resolve issues affecting group performance. In short, a picture really is worth a thousand words" (p. 275).

One of the key concepts in SNA is *centrality*. While various types of centrality have been defined (Valente, 2010), they all share one key idea: the frequency of interactions with an individual indicates their importance or influence in a network. As the centrality of the individual increases, the more they influence the flow of information through a community. Ideally, in an online community, centrality should be quite even, with individuals contributing equally to the flow of information. However, in practice, some networks show different patterns.

Boutillier (2009) gives a typology of nine different common network patterns ranging from perfect equality to perfect dictatorship. Online learning communities would ideally look more like the perfect equality network than the perfect dictatorship (although some online education models do tend to resemble the perfect dictatorship model). An example of the latter would be virtual schools that provide materials and programs tailored to individual students, but that assume the students will work in isolation from one another. The Florida Virtual Schools operate in this manner (http://www.flvsft.com). While there is collaboration among the teachers, none is mentioned among the students.

In this study, *indegree* centrality is used for the social network analysis portion. This is a measure of how many times a student’s postings have been read or responded to by others, and is considered to be related to the amount of information an individual receives (Buskens, 1998). Indegree centrality is one of the most commonly used and well understood centrality measures (Wellman, Koku, & Junsinger, 2006), and is robust to missing data (Valente, 2010). The term “missing data” refers to data from non-participants in the study, or individuals whose data is unavailable for other reasons.

Other measures of used in SNA include the frequency of note postings by individuals and the number of notes posted each day by the class as the course progresses. These data were downloaded, imported into other programs for further analysis. Social network analyses, and posting frequencies can be used to provide timely feedback to the students, allowing them to adjust their work habits accordingly. Specifically this study two social network measures were used: sociograms based on indegree centrality of the note reading network and the response network; and the number of notes posted, number of notes read, and number of responses created were visualized as column graphs. Although these data were imported into other programs (e.g., UCInet and Netminer II for social network analysis and Excel for graphing) for researcher analysis, the students had the same data as sociograms and graphs in the built-in suite of analysis tools in Knowledge Forum (see below). The students were taught how to use these and could examine the data at any time.

As noted earlier, it is important for instructors teaching online courses to foster the formation of an online community. In this case, the instructor decided to proceed in the manner of a knowledge building community. Details of this are provided in the next sections.

Knowledge Building and Knowledge Forum

Blended learning models are becoming an important part of learning (Horn & Staker, 2011; Stansbury, 2009). There is also evidence that online learning enhances students' education (Kassop, 2003). As well online learning is growing rapidly and it is likely that the science education students will be asked to teach online in the near future (Christensen, Horn, & Johnson, 2008; Paperny, 2009), so exposure to online learning would benefit the students. For these reasons, it was desirable to add an online component to the traditional lecture format of the course. Arguably, one of the more successful models for online learning for the 21st century is the knowledge building paradigm developed by Scardamalia and Bereiter (2003), and this was the model chosen for this class.

Scardamalia and Bereiter (2003) define knowledge building as:

> … the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts. Knowledge building, thus, goes on throughout a knowledge society and is not limited to education. (p. 1371)

According to Scardamalia and Bereiter (2003), traditional teaching and learning seeks to disseminate the cultural capital of a society to students; knowledge building attempts to increase the stock of cultural capital. Knowledge building does this by the continual improvement of ideas, circulated through the community in a pubic space (often online.) The ideas are placed in the public space so that they are available for others to work on, elaborate, and provide alternates. According to Fleck, (1939/1981) these ideas circulate within the community, and, "After making several rounds within the community, a finding often returns considerably changed to its originator, who reconsiders it himself in quite a different light" (p. 45).

In academia, the communities charged with producing new knowledge are research communities and these are often used as a model of a knowledge building community. Students often work to produce new understandings of knowledge, one form of new knowledge (Scardamalia & Bereiter, 2000). Much of the work of a research organization also involves trying to create an understanding within the group of the work of other researchers, which is an essential step to new knowledge creation. The online knowledge building environment, *Knowledge Forum*™, has been created by Scardamalia and Bereiter to facilitate the knowledge building process and is described in the next section (Scardamalia, 2004).

Knowledge Forum

Knowledge Forum is the second generation of the *CSILE* (Computer Supported Intentional Learning Environment) project, and is an online environment designed to support the knowledge building process (Scardamalia, 2003). In most settings, the deep underlying cognitive processes of learning and knowledge building are invisible and often not recognized by those engaging in the processes. Knowledge Forum makes those processes transparent to the students by providing supports for the advanced cognitive processes that lead to knowledge building. Space does not permit a more thorough discussion of Knowledge Forum (KF) here. An introduction and demonstration of KF is available at http://www.knowledgeforum.com/Kforum/products.htm; it will provide more complete information to the interested reader.

Relevant to this study is that Knowledge Forum has an evolving suite of online tools that students and instructors can use to provide formative assessment (feedback) at any time during the course. These include a contributions tool and a social network tool. The students were introduced to the social network tools (note reading and responses networks) and contribution tools (number of note posted, number of notes read, and number of responses created) and instructed to use them to monitor their progress as often as they wished.

Methodology

Community formation was analyzed using social network analysis (SNA) by gathering data from Knowledge Forum. As noted by Cross, Borgatti, and Parker (2003), work in online environments has an invisible quality. Social network analysis allows us to make this invisible work visible and susceptible to analysis. The overarching purpose of this study was to examine the progress the students made towards creating a knowledge building community.

The SNA data were triangulated with other quantitative data also obtained from Knowledge Forum, among these being contribution frequencies, and the rate of growth of the online database through measuring the daily postings. Triangulation of data obtained from online classes is necessary because they can otherwise be misinterpreted. For example, the note reading network can be influenced by the number of postings in a given time period. If a large number of notes are posted in a short space of time, but reading continues at a normal pace, the ratio of notes read to new postings will go down. This can give a false impression that the students are not working when in fact they are

Social network data were analyzed using the *UCINET* program (Borgatti, Everett, & Freeman, 2002). The numbers of note postings and the daily note contributions were obtained and analyzed using Microsoft's *Excel* spreadsheet.

The Class

The course selected for this study was a third year, undergraduate class for science students interested in exploring careers in science teaching. The course was originally designed using the lecture method. In this study, the Knowledge Forum was an added component to the course. Work in KF constituted 40% of the final mark, ensuring there was a considerable grade incentive to participate in the KF. Further demographic and other information about the class can be found in Exhibit 1 (http://www.cjlt.ca/index.php/cjlt/article/downloadSuppFile/571/4).

The challenge for the instructor was to get the students to put aside competitive behaviour and engage in the kinds of supportive behaviours consistent with the formation of a knowledge building community, and to do so in an unfamiliar online knowledge building environment.

Participants

The participating students were third- and fourth-year undergraduate science students. They ranged in age from twenty to twenty-three years, and 80% were women. The majority were Biology students, and the remainder were scattered among Psychology, Chemistry, Geography, and Anthropology majors.

Ethics

The instructor was the principal researcher on this study. A formal ethical review was conducted by the Ethics department of the university, and the study was approved. The students were informed of the study, the right to withdraw and informed consent was obtained by Danielle Truswell, a student assistant working in the class. She held all data about who were and who were not participants. The instructor did not see this information at any time. The data used here were not collected until after the class had ended and the final marks submitted so that nothing in the study could influence a student's marks.

There was little in the way of instructor bias to accommodate for in this study as the instructor had no idea what would be found, and therefore had little in the way of preconceptions. The data used were quantitative and collected automatically by the online system.

Results

The Progress of the Class

Figures 1, 2, and 3 show the growth of the KF database in terms of total notes contributed (new notes, responses, and others) for the science class.

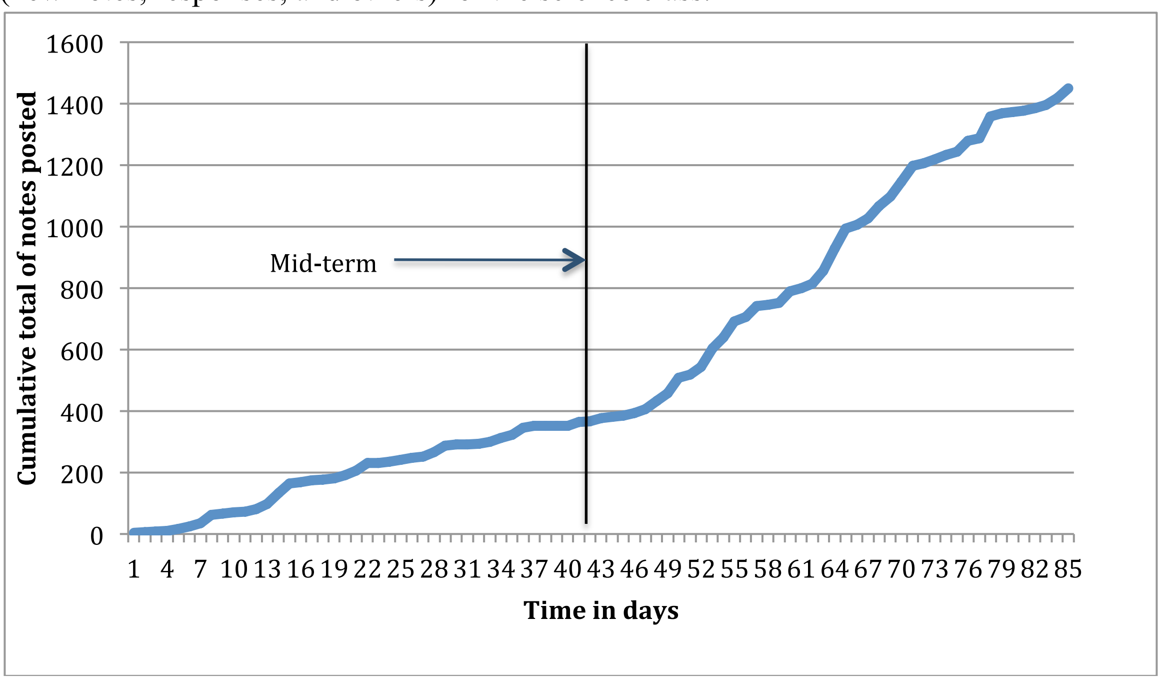

Figure 1. *Cumulative Number of Notes Posted in KF During the Term.*

As can be seen in Figure 1, there was a difference in contribution rates in the second half of the term compared to the first half. Figures 2 and 3 give more detail.

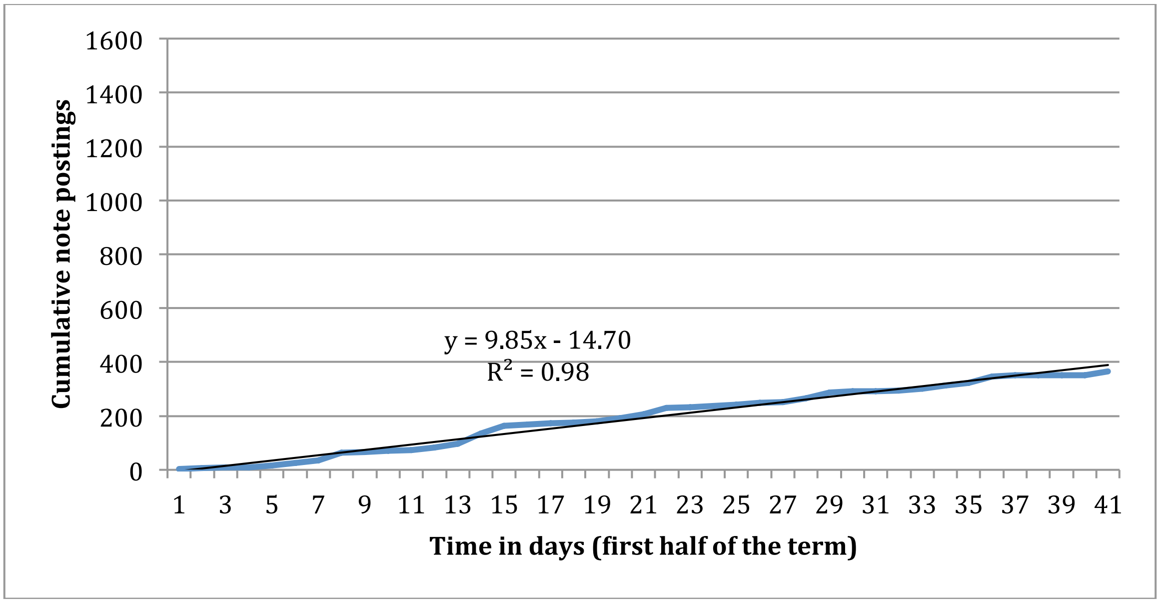

Figure 2. *Cumulative Note Contributions for the First Half of the Term.*

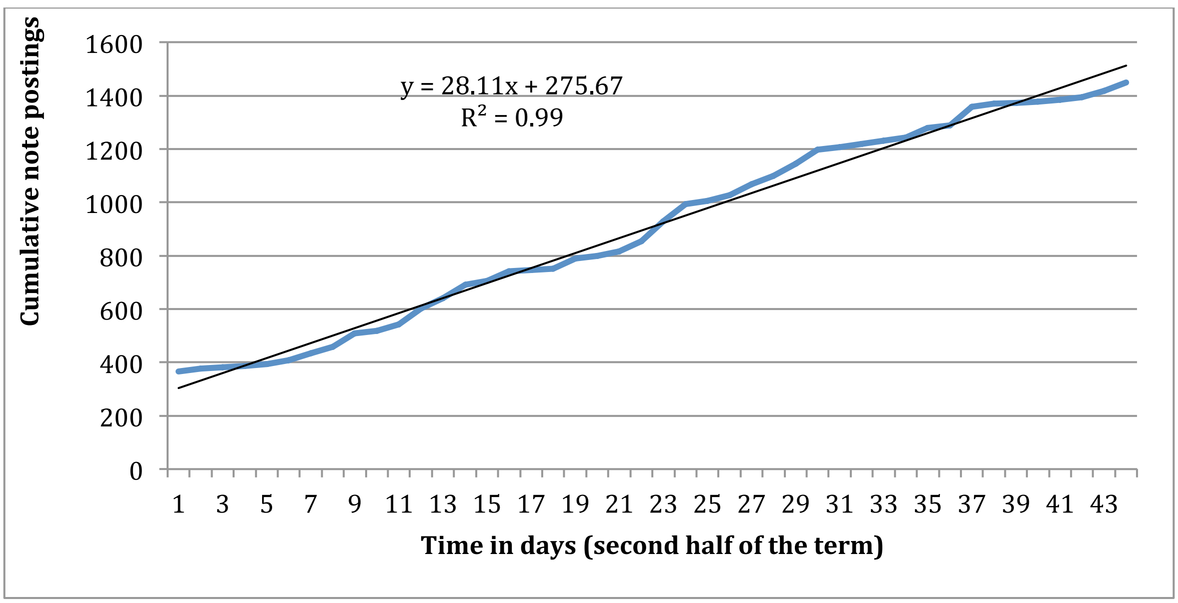

Figure 3*. Cumulative Note Contributions for the Second Half of the Term.*

The contribution rates in Figures 2 and 3 are close to linear. Trend lines were added to the figures and analyzed. In the trend line equations in Figures 2 and 3, the number preceding "x" gives the slope of the line, which in this case is a measure of the average daily contribution rate. In Figure 2, the slope is 9.8 notes per day; in Figure 3, the slope is 28.11 notes per day. For the second half of the term, the contribution rate was nearly three times that of the first half.

Discussion of note contribution results.

Two events contributed to the upswing in note contributions in the second half of the term. The first was that oral presentations began immediately following the mid-term break. During each class, there were four to five 20-minute oral presentations. A topic workspace created by the presenters and the other students could contribute with each presentation. In the first half of the term, the students only had one workspace per week to work in; now they had a number.

The second event was that the instructor, having noticed that some students were not contributing very much, sent out an e-mail message to the class following the mid-term break reminding them that work in KF constituted 40% of their final mark. Included in the note was a graph showing relative contribution rates (names removed) so that the students could see the differences in contribution levels. They were reminded in the note that they had assessment tools available to allow them to examine their participation at any time. As well, the same information was presented in Knowledge Forum, and discussed in class. This was an attempt to present the students with timely formative feedback, but as can be seen, it had unexpected consequences that attenuated the hoped-for benefits of the feedback.

The combination of these factors (plus experience with the system) appears to have catalyzed the upswing in contribution rate. However, as will be seen, this was not entirely successful in that it increased the students' workloads, but did not have the desired result for some students.
There was no evidence that the majority of students made use of the online assessment tools available. Many of the students seemed to be nonplussed when the mid-term results were shown to them, something that would not have happened if they had been using the assessment tools themselves. It is also probable that their workload would not have increased so much had the non-contributing students not suddenly started contributing.

Participation patterns.

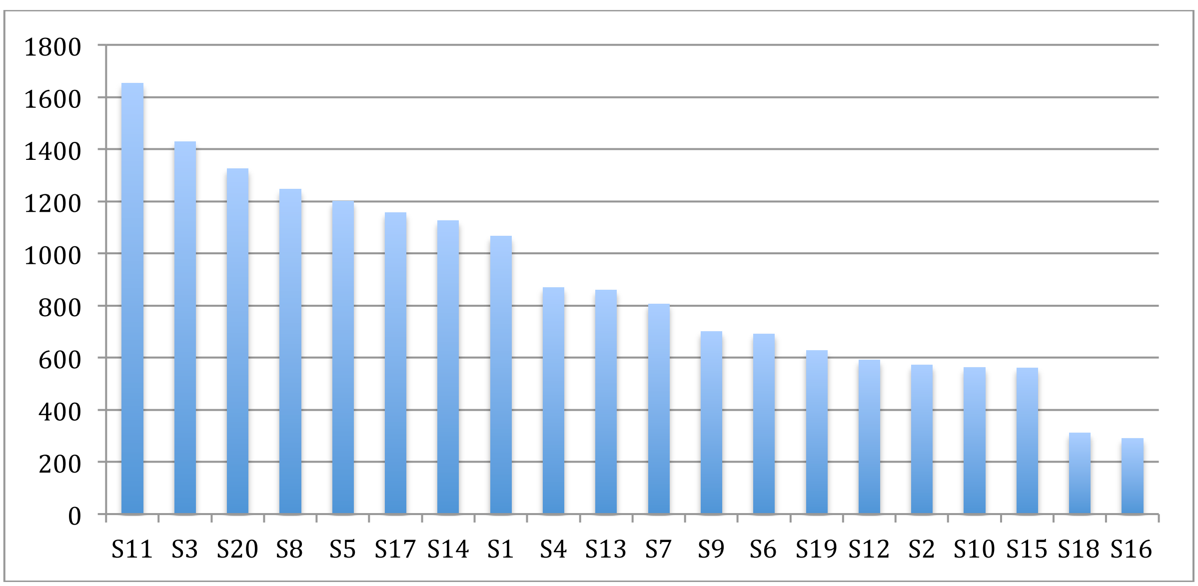

Figure 4. *The Number of Note Postings Read by Each Student (sorted data.)*

Figure 4 shows the note reading pattern for the class. The highest-reading student read almost six times the number of notes as the lowest-reading student, a ratio of 6:1.

The pattern for responding was similar, almost linear. However, the student who created the most responses created only two and a half times the number of responses as the lowest scoring student, a ratio of 2.5:1. This is less disproportionate than is the case for note reading.

The student who read the fewest notes (student 16) was in the middle of the group for response contributions (at 63). Likewise the second lowest reading student (student 18) was also in the middle of the group for responding (59 responses.) Reading few notes, but responding more frequently is an indicator of a maladaptive learning strategy discussed in the next section.

Note contributions also followed an almost linear pattern. The disproportion between highest- and lowest-contributing students was similar to that for responses at 2.7:1. Again students 16 and 18, the lowest-reading students, are found in the middle of the group for notes contributions. This is another indicator of a maladaptive learning strategy.

Discussion of contribution patterns.

Contribution patterns indicate that some students were following a strategy of reading relatively few notes (thereby reducing their reading load), but contributing on a par with the middle of the group. This was true for both responses and new note postings. This pattern is problematic because these students may not be exposed to the full spectrum of ideas presented by the other students. It also raises the possibility that some students were posting notes without having read postings by other students.

An examination of the reply ratio (a ratio of the total number of responses to new note postings) (Nagel, et al., 2009), and a comparison of this to social network data and contributions data indicated that some students were reading few notes, but posting almost as many replies as notes read (Philip & Truswell, submitted for publication). Thus the tripling of the number of notes read by the students indicated the use of maladaptive learning strategies used to lighten information overload.

Figure 5 shows the note reading network that developed over the course of the term. In this sociogram, students are represented by squares, and the connections among them by lines with arrows. Larger node sizes indicate more frequent reading interactions (these students' noted have been read frequently.) Arrows indicate who is reading and who is being read. Following social network conventions, an arrow pointing to a student means that the student from whose node an arrow is emanating has read a note or notes by a student to whose node the arrow points. Here, indegree centrality can be viewed as *influence*.

Social Network Analysis Results–Community Formation

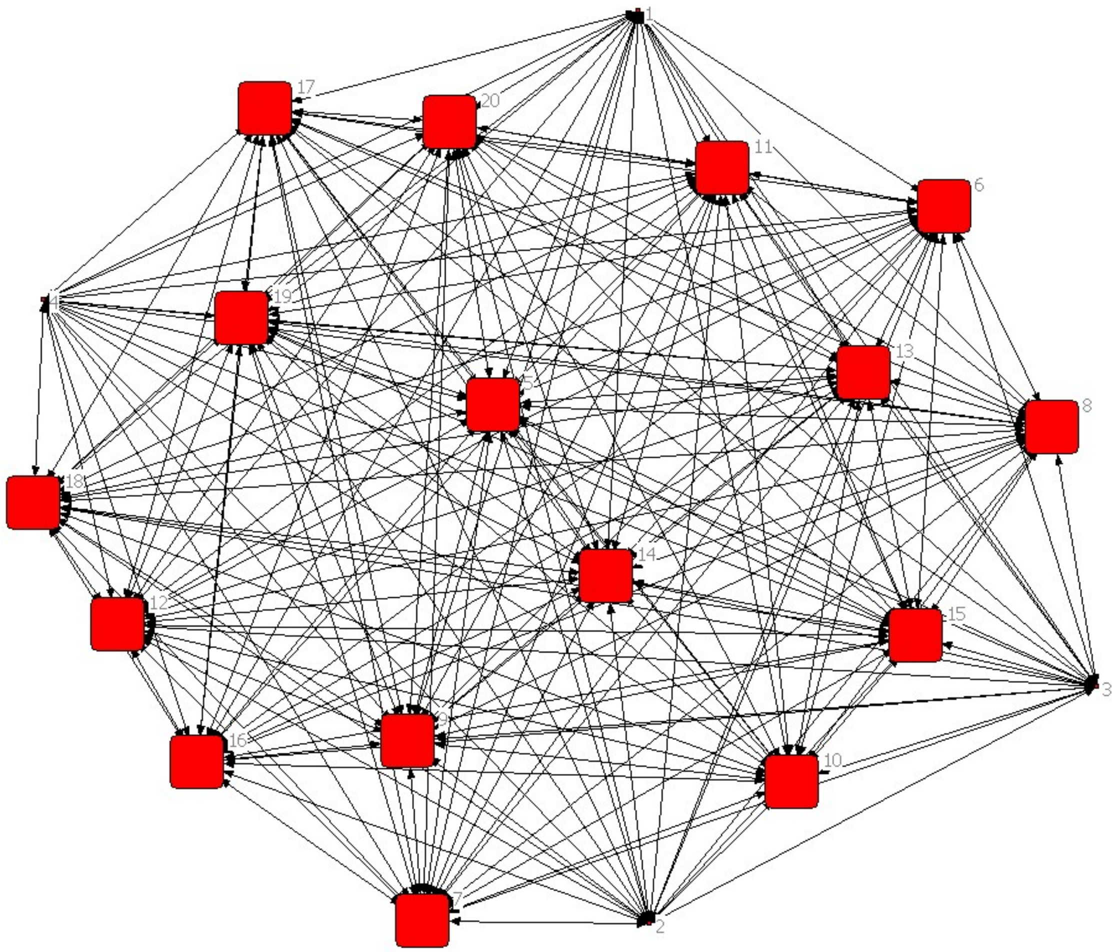

Figure 5. *The Note-Reading Network (Indegree Centrality.)*

The strength of ties within a network is important in the nature of the information transferred. Both strong and weak ties are important in the transfer of information, but differ in the type of information transferred. Strong ties are characterized by a higher level of intimacy in the exchanges, more self-disclosure, emotional as well as instrumental exchanges, reciprocity in exchanges, and more frequent interactions (Haythornthwaite, 2002). The latter two are the most commonly measured in social network analysis, and those are what were used here. Weak ties are less frequent, often one-way, share fewer types of information (often simple, statable information) and are less supportive (2002). In this analysis, ties were characterized as weak if it was one-way and exchanges were infrequent. Strong ties among actors in a network (indicated by bidirectional arrows) are important in the spread of complex information (for example, tacit information); weak ties indicate the spread of simple information (facts and other statable information) (Haythornthwaite, 2002; Kavanaugh, Reese, Carroll, & Rosson, 2005; Ruef, 2002; White & Houseman, 2003). Figure 5 shows that most students are connected to the network and have strong tie relationships with other students. However Figure 5 shows four students who are peripheral to the network, and whose notes have been read infrequently by the other students.

This is something that should draw the instructor's attention as it may indicate that the student is not engaging with the work of the community.

As a default, a single interaction among individuals is enough to establish that a social tie exists. However by raising this threshold, it is possible to examine the network actors who interact the most frequently, and determine how robust the network is. In social network analysis, this type of analysis is called a *k*-core collapse. For the purposes of this study, a network collapse was defined as the point when 50% of the network was disconnected. The *k*-core collapse analysis found that the community was robust to the 60-event level–at least 50% of the students read 60 or note postings by other students. A high level of note reading is considered one indicator of membership in a knowledge building community (Scardamalia, 2002). Details of the threshold analysis can be found in Exhibit 2 (http://www.cjlt.ca/index.php/cjlt/article/downloadSuppFile/571/6).

Discussion of the social network analysis results.

Community formation is an important element of participation in online classes. A knowledge building community "commits to producing valuable ideas for the community, and shares the collective responsibility for improving those ideas" (Cacciamani, 2010). What can social network analysis contribute to demonstrating this?

The presence of connected clusters is a social network definition of community (Barabási, 2002), and Figure 5 shows a high level of connectivity that proved robust to the sixty-event level for note reading–evidence of community formation, and characteristic of knowledge building communities (Scardamalia, 2002). The presence of reciprocal ties indicates the potential for the transfer of complex information. Therefore, in network terms, a note reading community formed with pathways for the transfer of simple and complex information.

Social network analysis is silent as to the content of the interactions, so it is not possible from this analysis to definitively state whether or not a knowledge building community formed (despite the indicator above.) However note posting is necessary for ideas to be contributed, and note reading is necessary for those ideas to spread and be improved. Frequent reciprocal interactions indicate collective responsibility for the development of the community. The reading network demonstrates that notes were read frequently among the students, and that the pathways for the transfer of both simple and complex information were present. Therefore the social network analysis tells us that communication patterns consistent with the formation of a knowledge building community were present in this class.

In terms of participation, which (noted earlier) enhances learning (Nagel et al., 2009), the SNA results show the levels and kinds of participation found among the students. All students participated, some more than others. There were no students isolated from the group.

Conclusions

The social network analysis demonstrated that a connected cluster formed, an indicator of the possibility of community formation, and was robust to the sixty-event level, an indicator of the formation of a knowledge building community. Both strong and weak tie interactions were present, providing evidence that the pathways were in place for a knowledge building community to form. However, triangulating this with the results for contribution and note reading levels indicate that although the pathways were in place, knowledge building itself may not have proceeded as effectively as hoped. A deeper analysis would be needed to definitively demonstrate knowledge building.

Limitations and Further Research

This was a small class of twenty students and more research is needed in order to establish what is and is not normal for a third-year undergraduate science population. The use of grade-based incentives based on online participation and communication patterns (SNA) is not common, and further research is needed to establish exactly what forms of analysis are the most effective and fair. Hewitt (2004) comments that the term *community* refers to a broad range of social structures, noting, “Clearly, some kinds of community engagement offer more educational promise than others” (p. 2). One limitation therefore of these findings is that there was no class in which no grade-based incentives were used to compare with, and the level of engagement and knowledge building in such a class is open to speculation. It is likely that the networked communities would be different. As well, it is not possible to predict the levels of participation and engagement in very large classes from these results.

It is also important to avoid information overload so that students do not resort to strategies that reduce their effective participation. Further research needs to be done on how get the students to actually use the assessment tools provided to conduct their own formative assessments.

Proving that a knowledge building community has formed requires multiple analyses beyond what could be done with this class (due to ethical considerations.) Social network analysis cannot provide all of this. It can demonstrate community, as defined in network terms, and provides evidence of the patterns and frequencies of interactions among the community members. Social network data needs to be triangulated with other data to definitively demonstrate that a knowledge building community has formed.

Acknowledgements:
I would like to think the Department of Chemical and Physical Sciences, University of Toronto, Mississauga for their support of this research.

The development of Knowledge Forum has been supported generously by the Social Sciences and Humanities Research Council.

Danielle Truswell, an undergraduate assistant working with this class, provided assistance in preparing these analyses. She was unavailable to co-author the paper, but deserves considerable credit for her fine work.

References

Allan, M. (2004). A peek into the life of online learning discussion forums: Implications for web-based distance learning. *International Review of Research in Open and Distance Learning, 5*(2), 1-18.

Allen, I. E., & Seaman, J. (2005). Growing by degrees. Online Education in the United States, 2005. Needham, MA: Sloan Consortium.

Barabási, A.-L. (2002). *Linked. The new science of networks.* Cambridge, MA: Perseus Publishing.

Bielaczyc, K., & Collins, A. (2005). Fostering knowledge-creating communities. In A. O'Donnell, C. Hmelo-Silver, & G. Erkens (Eds.), *Collaborative learning, reasoning, and* technology (pp. 40-68). Mahwah, N.J.: L. Erlbaum Associates.

Borgatti, S. P., Everett, M. G., & Freeman, L. (2002). *Ucinet for Windows: Software for social network analysis*. Harvard, MA: Analytic Technologies.

Boutilier, R. (2009). *Towards network structure typology of governance systems*. Paper presented at the European Academy of Business and Society, Barcelona, Spain. Retrieved from http://www.stakeholder360.com/Boutilier_EABIS_accountability_in_network_structures_typology.pdf

Buskens, V. (1998). The social structure of trust. *Social Networks, 20*, 265-289.

Cacciamani, S. (2010). Towards a knowledge building community: From guided to self-organized inquiry. *Canadian Journal of Learning and Technology, 36(1)*.

Carnevale, D. (2001). Assessment takes center stage in online learning. *The Chronicle of Higher Education, 47*(31), A43-A45.

Christensen, C. M., Horn, M. B., & Johnson, C. W. (2008). *Disrupting class. How disruptive innovation will change the way the world learns.* New York: McGraw Hill.

Chung, G. K. W. K., Shel, T., & Kaiser, W. J. (2006). An exploratory study of a novel online formative assessment and instructional tool to promote students' circuit problem solving. *The Journal of Technology, Learning , and Assessment (JTLA), 5*(5), 1-27.

Crane, T., Wilson, J., Maurizio, A., Bealkowski, S.*, et al.* (2005). Learning for the 21st Century. A report and MILE guide for 21st Century Skills. Partnership for 21st Century Skills.

Cross, R. L., Borgatti, S. P., & Parker, A. (2003). Making invisible work visible. In R. L. Cross, A. Parker & L. Sasson (Eds.), *Networks in the knowledge economy* (pp. 261-282). New York: Oxford University Press.

Davies, J., & Graff, M. (2005). Performance in e-learning: online participation and student grades. *British Journal of Educational Technology, 36*(4), 657-663.

Degenne, A., & Forsé, M. (1999). *Introducing social networks* (A. Borges, Trans.). London: SAGE Publications.

Downes, S. (2007). Learning networks in practice. *Emerging Technologies for Learning, 2*, 19-27.

Ehrenberg, R. (2011, 3 June). Information flow can reveal dirty deeds. *ScienceNews*.

Fleck, L. (1939/1981). *Genesis and development of a scientific fact* (F. Bradley & T. J. Trenn, Trans.). Chicago: University of Chicago Press.

Hakkarainen, K., & Palonen, T. (2003). Patterns of female and male students' participation in peer interaction in computer-supported learning. *Computers & Education, 40*(4), 327-342.

Hakkarainen, K., Palonen, T., Paavola, S., & Lehtinen, E. (2004). *Communities of networked expertise. Professional and educational perspectives.* Oxford: Elsevier.

Haythornthwaite, C. (2002). Strong, weak, and latent ties and the impact of new media. *The Information Society, 18*, 385-401.

Hewitt, J. (1996). *Progress towards a knowledge building community* (Doctoral dissertation). Ontario Institute for Studies in Education of the University of Toronto, Toronto.

Hewitt, J. (2004). An exploration of community in a Knowledge Forum classroom: An activity system analysis. In S. Barab, R. Kling & J. Gray (Eds.), *Designing virtual communities in the service of learning.* (pp. 210-238). Cambridge, MA: Cambridge University Press.

Higgins, S., Koktsaki, D., & Coe, R. (2011). *Toolkit of strategies to improve learning. Summary for schools. Spending the pupil premium*. Durham, UK: Durham university.

Horn, M. B., & Staker, H. (2011). *The Rise of K-12 Blended Learning* [White Paper]. Retrieved from http://www.innosightinstitute.org/innosight/wp-content/uploads/2011/01/The-Rise-of-K-12-Blended-Learning.pdf

Hovell, M. F., & Williams, R. L. (1979). Analysis of undergraduates' attendance at class meetings with and without grade-related contigencies: A contrast effect. *Journal of Educational Research, 73*(1), 50-53.

Kassop, M. (2003). Ten ways online education matches, or surpasses, face-to-face learning. *The Technology Source Archives* Retrieved from http://technologysource.org/article/ten_ways_online_education_matches_or_surpasses_facetoface_learning

Kavanaugh, A. L., Reese, D. D., Carroll, J. M., & Rosson, M. B. (2005). Weak ties in networked communities. *The Information Society, 21*, 119-131.

Krebs, V. (2007). *Social Network Analysis: A brief introduction*. Retrieved from http://www.orgnet.com/sna.html

Lipponen, L., Rahikainen, M., Lallima, J., & Hakkarainen, K. (2003). Patterns of participation and discourse in elementary students' computer-supported collaborative learning [Research report]. *Learning and Instruction, 13*(5), 487-509.

Machiavelli, N. (1532/1998). *The Prince* (W. K. T. Marriott, Trans. Vol. 2004): Project Gutenberg. Retrieved from http://www.gutenberg.org/etext/1232

Marin, A., & Wellman, B. (forthcoming). Social network analysis: An introduction. In P. Carrington & J. Scott (Eds.), *Handbook of social network analysis* (pp. 23). London: Sage.

Mathiesen, B. (2006). The Mathematical Structure of Terrorism. *Physorg.com*. Retrieved from http://www.physorg.com/news67524254.html

Memon, N., & Larsen, H. L. (2006). Structural analysis and destabilizing terrorist networks. doi: 10.1.185.3524

Nagel, L., Blignaut, A. S., & Cronjé, J. C. (2009). Read-only participants: a case for student communication in online classes. *Interactive Learning Environments, 17*(1), 37-51. doi: 10.1080/10494820701501028

Palloff, R. M., & Pratt, K. (1999). *Building learning communities in cyberspace. Effective strategies for the online classroom*. San Francisco: Jossey-Bass.

Palloff, R. M., & Pratt, K. (2001). *Lessons from the cyberspace classroom. The realities of online teaching.* San Francisco: Jossey-Bass.

Paperny, A. M. (2009, Oct. 28). TDSB gives cautious approval to director's 'transformative' vision, *Globe and Mail*. Retrieved from http://www.theglobeandmail.com/news/national/toronto/tdsb-gives-cautious-approval-to-directors-transformative-vision/article1342959

Partnership for 21st Century Skills. (2008). *21st century skills, education & comptetiveness. A resource and policy guide.* Tucson, AZ: Partnership for 21st Century Skills.

Philip, D. N. (2009). *Networks and the spread of ideas in knowledge building environments* (Doctroal dissertation). Ontario Institute for Studies in Education of the University of Toronto, Toronto. Retrieved from http://www.scirus.com/srsapp/search?q=Donald+N.+Philip&submit=Go&rep=tspc

Philip, D. N., & Truswell, D. (submitted for publication). Online assessment considered in light of multiple data sources. *Submitted to Interactive Learning Environments*.

Ruef, M. (2002). Strong ties, weak ties and islands: structural and cultural predictors of organizational innovation. *Industrial and Corporate Change, 11*(3), 427-449.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge [Electronic Edition]. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 1-26). Chicago: Open Court.

Scardamalia, M. (2003). Knowledge Forum (advances beyond CSILE). In C. Bereiter (Ed.), *Learning technology innovation in Canada. A supplement to Journal of Distance Education Telelearning Special Issue* (Vol. 17, pp. 23-28): Canadian Association for Distance Education.

Scardamalia, M. (2004). CSILE/Knowledge Forum®. In Kovalchick & K. Dawson (Eds.), *Education and technology: An encyclopedia* (pp. 183-192). Santa Barbara: ABC-CLIO.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *Journal of the Learning Sciences, 3*(3), 265-283.

Scardamalia, M., & Bereiter, C. (2000). Schools as knowledge-building organizations. In D. P. Keating & C. Hertzman (Eds.), *Developmental health and the wealth of nations: Social, biological, and educational dynamics* (pp. 274-289). New York: Guilford.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In J. W. Guthrie (Ed.), *Encyclopedia of education, second edition* (pp. 1370-1373). New York: Macmillan Reference, USA.

ScienceDaily. (2008). Effectiveness of traditional and blended learning environments. *Science News* Retrieved from http://www.sciencedaily.com/releases/2008/09/080922155902.htm

Scott, J. (1991). *Social network analysis : a handbook*. London: Sage Publications.

Sha, L., & van Aalst, J. (2005). *Non-linear Dynamical Development of CSCL Communities*. Paper presented at the conference on Computer Support for Collaborative Learning: Learning 2005: The next 10 years! (CSCL 2005).

Stansbury, M. (2009, July 14). ED: Blended learning helps boost achievement. *eSchool News*.

Valente, T. W. (2010). *Social networks and health: Models, methods, and applications*. New York: Oxford University Press.

Wasserman, S., & Faust, K. (1994). *Social Network Analysis* (Vol. 1). New York: Cambridge University Press.

Wellman, B., Koku, E., & Junsinger, J. (2006). Networked scholarship. In J. Weis (Ed.), *Internation handbook of virtual learning environments* (Vol. 2, pp. 1429-1447). Dordrecht, NL: Springer.

White, D. R., & Houseman, M. (2003). The navagibility of strong ties: Small worlds, tie strength, and network topology. Self-organization in strong-tie small worlds. [Research report]. *Complexity, 8*(1), 72-81.

Wong, A. T., & Wong, S. C. P. (1979). The relationship between assignment completion and the attrition and achievement in correspondence courses. *Journal of Educational Research, 72*(3), 165-168.

Author

Don Philip has worked as a classical musician, and taught chemistry and biology for the Toronto Board of Education for about fifteen years. Subsequent to that he returned to academia and earned a PhD in Educational Computing. During that time, he worked with the Institute for Knowledge Innovation and Technology, and currently works in the Department of Chemical and Physical Sciences at the University of Toronto's Mississauga campus.
Email: don.philip@utoronto.ca