# ANALYZING ASYNCHRONOUS STUDENT DISCOURSE IN WEB-ASSISTED UNDERGRADUATE MATHEMATICS COURSES

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## Introduction

Adapting Garrison, Anderson, & Archer's (2000) Community of Inquiry model to teaching and learning in web-assisted courses, the authors investigated the structure of online Supporting Discourse (See Figure 1) among students in three undergraduate mathematics courses as they wrestled with mathematics concepts and procedures outside of regular class hours. In particular, the authors sought to characterize the relationship between the structure of student asynchronous communication (e.g., "Who is communicating with whom?" and "What leadership roles are assumed by different students?") and student achievement. This approach does not include a content analysis of the asynchronous communication (e.g., "What is the mathematical or social significance of a given message?").

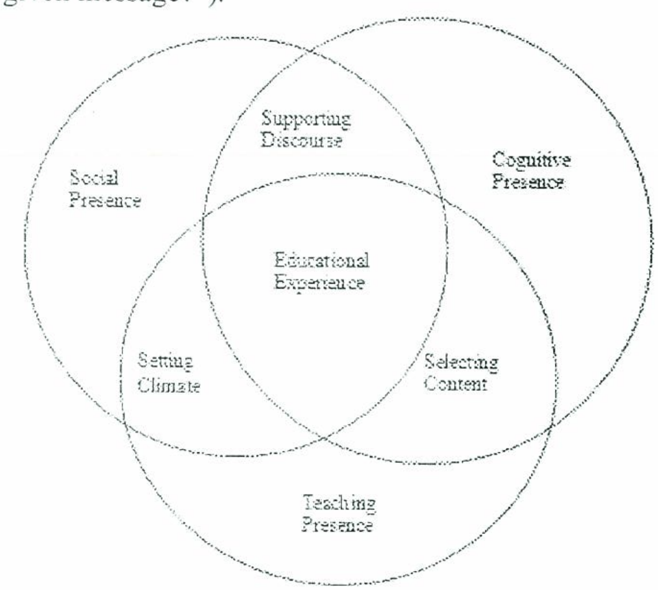


Figure 1: Community of Inquiry Model

According to Krebs (2006), "Social network analysis is the mapping and measuring of relationships and flows between people, groups, organizations, animals, computers or other information/knowledge processing entities." In the process of communicating with one another in asynchronous threaded discussions, students create implicit networks of relations with one another (Aviv, Erlich, Ravid, & Geva, 2003). By studying the connectivity structures of these networks, researchers may probe the underlying mechanisms that establish and maintain the networks, making possible the development of theories that explain their emergence (Contractor, Wasserman, & Faust, 1999; Monge & Contractor, 2003).

Network relations are represented using a response relation matrix (Aviv et al., 2003), illustrated using the fictional data seen in Table 1. In this table, cell *(i,j)* indicates how many times the *i*-th (row) learner responded to postings by the *j*-th (column) learner during asynchronous communications. Notice that this matrix is not symmetrical. That is, not all learners engage one another in the same ways.

| | John | Thomas | Anna | James | Peter | Mary |
|---|---|---|---|---|---|---|
| John | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Thomas | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Anna | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| James | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Peter | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Table 1: Discussion Forum Relation Matrix (Fictional Data)

In Social Network Analysis, the network characteristics of individuals are often quantified using measures based on message-counting techniques. By considering triads (i.e., triples) of learners, one may note structural differences and similarities in the roles that individuals play in facilitating communication within or between groups of students. For instance, there are five *node types*: Isolate; transmitter; receiver; carrier; and ordinary.

**Methodology**

Spring term of 2005, the first author of this paper taught three web-assisted undergraduate mathematics courses at the University of Idaho: Math 235 Mathematics for Elementary Teachers I; Math 236 Mathematics for Elementary Teachers II; and Math 391 Modern Geometry. In each course, students met face-to-face with one another and the instructor three or four times per week. In addition, students engaged in a sustained, purposeful (e.g., required and rewarded) asynchronous online dialogue focused on homework assignments. In the process, students accustomed to working entirely on their own gradually developed mathematical communication, composition, editing and collaboration skills in collaborative groups. During the semester, each group of students created, edited, and submitted several lengthy (graded) homework reports. As each homework report came due, students also prepared for and completed individual hour-long paper-and-pencil examinations covering the most significant concepts and skills addressed in the course. Their achievement as individuals was assessed via these examinations and term papers. Overall grading schemes were consistent in all three courses. The evidence of their engagement in online discussions was stored automatically on the *Idaho Virtual Campus* server. This dialogue, in the form of threaded discussions, was stored as long strings of textual data on the *IVC* server. A parser was written (Dickenson, 2006) for converting this data into a useable file format for analysis.

## Results

The following analyses were performed using *NetMiner*™'s (Cryam, 2005) built in data visualization and statistical analysis functions. Student data from all three courses were combined into a single data set representing 49 students.

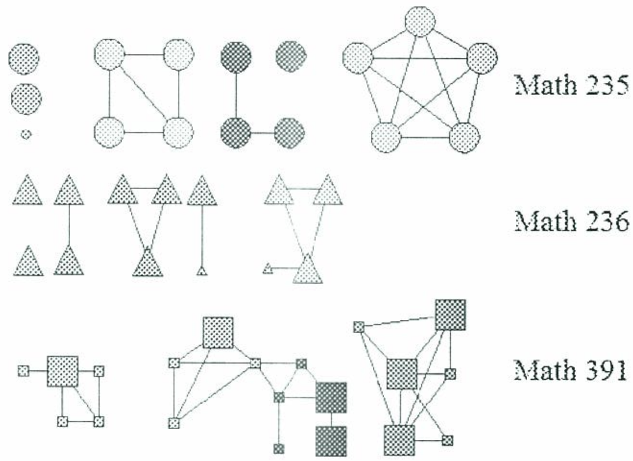


Figure 2: Spring-KK by Groups

1. *Does student asynchronous communication occur primarily within collaborative groups or between groups?* For each course, two data visualizations were performed which summarized in graphical format emergent structures in the threaded discussions. Figure 2 was constructed using the Spring-KK algorithm (Kamada & Kawai, 1989). In this graph, nodes in different courses are represented using different shapes. Within each course, different groups are represented using different colors. Differences in size represent different genders (i.e., male smaller, female larger). Each line segment represents one or more messages between two students. Clearly, student asynchronous communication, when it occurred at all, was conducted within groups rather than between groups.
2. *Is achievement independent of gender?* Examination averages for students were compared using analysis of variance. Although the females did outperform the males on examinations and homework reports, the differences are not statistically significant (p-values of 0.26 and 0.11, respectively).

| | N | Exam | Report |
|---|---|---|---|
| Males | 16 | 83.1 | 85.0 |
| Females | 33 | 85.6 | 87.6 |

Table 2: Examination Means by Gender

3. *Is student asynchronous communication evenly divided among daytime (6:00 am – 6:00 pm), evening (6:00 pm – 6:00 am), and weekend (Saturday & Sunday) hours?* Actual usage of the online discussion forum was different than anticipated. While specific percentages differed somewhat from course to course, daytime use during the week accounted for about 60% of total messaging. Evening use during the week accounted for about 25% of the total. And weekend use accounted for about 15% of the total.

4. *Is performance on exams related to node type?* ANOVA was used to test whether examination means for students with different node types were different. Table 3 presents the summary. The differences seen there are statistically significant (p-value = 0.049).

| Type | Isolate | Transmitter | Receiver | Carrier | Ordinary |
|---|---|---|---|---|---|
| N | 6 | 6 | 3 | 6 | 28 |
| Avg. | 88.8 | 81.8 | 91.8 | 80.2 | 84.6 |

Table 3: Examination Means by Node Type

5. *Is performance on reports related to node type?* ANOVA was used to test whether report means for students with different node types were different. Table 4 presents the summary. The authors are accepting the differences as statistically significant (p-value = 0.053).

| Type | Isolate | Transmitter | Receiver | Carrier | Ordinary |
|---|---|---|---|---|---|
| N | 6 | 6 | 3 | 6 | 28 |
| Avg. | 87.2 | 82.7 | 83.8 | 83.9 | 88.3 |

Table 4: Report Means by Node Type

6. *How is performance on exams and homework reports related to participation/roles in online discussions?* Multiple regression was used to investigate the relationships between achievement and parameters that characterize students' participation in online discussions. The dependent and independent variables and r-squared values associated with those regressions appear in Table 5.

| Dependent Variable | Independent Variables | r-squared |
|---|---|---|
| Examination Mean | In-Degree, Out-Degree, Node Type, etc. | 0.391 |
| Report Mean | In-Degree, Out-Degree, Node Type, etc. | 0.399 |

Table 5: Regressions

**Discussion**

Data analyzed in this study include the examination and homework reports of 49 students enrolled in three undergraduate web-assisted mathematics courses, all taught by the same instructor. During the semester, students exchanged over 1500 homework-related messages in online threaded discussions. Our analysis of those messages focused on the structure (not the substance) of those communications. (Content analyses on these and other courses will be reported as results become available.) Our goal was to determine whether the roles that students play in threaded discussions are related to their achievement. We believe that the answer to this question has important implications for the design and delivery of both web-assisted and distance learning mathematics courses.

We learned that within each course there was little communication between groups and that gender was unrelated to achievement in the course. We also learned that achievement is related to node type. That is, students playing different communication roles in the online discussions performed differently on examinations and homework reports. Collectively, variability in communication roles accounted for approximately 40% of the variability in achievement. To the extent that online discussions focused on the production and editing of homework sets and that homework sets anticipated examination items, this result is not surprising. The authors suspect, and will soon test, whether this finding holds for distance learning courses. In contexts where mathematics students and instructors never meet face-to-face, threaded asynchronous discussions may play a critical role in establishing a productive content-focused dialogue.

Scholars interested in exploring this research methodology are invited to contact the authors to begin discussions. The authors also wish to acknowledge the assistance of Dr. Libby Knott of the University of Montana and the financial support of the *Gateway to Mathematics Project*, funded by the U.S. Department of Education.

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