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Teachers' Interactions in an Online Graduate Course on Moodle: A Social Network Analysis Perspective

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Abstract

A combination of social network analysis and content analysis was used to investigate the interactions that took place in an online Moodle course among 22 participants that were enrolled in a teacher education graduate program. The purpose of this study was to examine both the patterns and quality of the online interactions, which were assessed using a content analysis schema. The social network measures of the online learning network demonstrated that Moodle may have the capability to help establish a cohesive online learning community where members are able to participate in meaningful social interactions. Results from the coding of discussion posts demonstrated that, despite active online interactions, participants still lacked higher level knowledge co-construction. Factors that might impede online knowledge construction processes are examined and discussed so that higher levels of knowledge construction can be encouraged and eventually realized.

Keywords: online interaction patterns, online learning community, knowledge construction, social constructivism learning theory, social network analysis, content analysis

Teachers' Interactions in an Online Graduate Course on Moodle: A Social Network Analysis Perspective

The development of information and communication technology (ICT) has contributed to a transformation in traditional educational practices, and new approaches to 21st century learning have been evolving at a rapid pace. Online computer-mediated teaching and learning (e.g., online course management systems) is one new instructional approach that has emerged because of the advances in educational technology. One important reason for the rapid development of online courses is that they enable learners to learn "anytime, anywhere" (Tan, 2005, p. 1). Past research has recognized online learning for its capability of allowing learners who are separated by location, time, and space to learn together in a collaborative community (Hendriks & Maor, 2004; Richardson & Swan, 2003, as cited in Shen, Nuankhieo, Huang, Amelung, & Laffey, 2008).

Researchers have asserted that one of the most critical concepts in online learning is social interaction (Hendriks & Maor, 2004; Kumari, 2001; Picciano, 2002; Swan, 2003). Various studies provided validity evidence for the significant role that social interaction plays in traditional face-to-face learning environments (e.g., Brown & Duguid, 2000; Yalama & Aydin, 2004). These studies demonstrated that one of the most important factors that contributes to academic success in traditional learning environments is social interaction. Therefore, it is reasonable to assume that social interaction is equally, if not more, important in web-based learning environments. Indeed, researchers have agreed that social interaction is one of the most important features in online learning environments, as well as a key factor that contributes to the quality of students' learning experiences (Kumari, 2001; Laman, Reever, & Scardmalia, 2001; Palloff & Pratt, 1999; Picciano, 2002; Shen et al., 2008; Sing & Khine, 2006). Wenger (1998) even claimed that the social and cognitive processes involved in online interactions are critical for an online community of learners who are constructing knowledge collaboratively.

In light of the critical role social interaction assumes in online learning, research in this area is needed to foster a better understanding of this phenomenon and to ultimately improve the practice of online education. A review of the literature revealed that most research on social interaction and online learning can be placed in two broad categories: (a) research using techniques such as interviews and surveys to examine students' perceptions and attitudes toward online learning (e.g., Braun, 2008; Jiang & Ting, 2000), and (b) research using different schemas to code students' online discussion posts (e.g., Hendriks & Maor, 2004; Kanuka & Anderson, 1998; Sing & Khine, 2006). While these

data provide useful information for examining online learning, it is important that other dimensions of online social interactions also be examined to provide a more in-depth understanding of the unique features of online learning. Particularly, more research is needed to better understand both the complex social and complex cognitive processes that take place through online interaction.

These issues, however, are not completely understood because of various reasons. First, only a limited number of academic publications have addressed patterns of online interactions (e.g., Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003; Shen et al., 2008)—for instance, who is interacting with whom, how frequent the interaction is, and what positions students hold during social interaction. Second, although a few studies have provided different schemas to examine students' cognitive processes of online learning in terms of the extent to which they co-construct new knowledge through social interaction, these studies focused on only a single dimension of students' online interactions. The studies did not address how the patterns of students' social interactions affect their cognitive construction of knowledge. Moreover, as Lipponen et al. (2003) noted, these studies do not employ multidimensional research methods in the research design. However, some researchers (e.g., Hmelo-Silver, 2003; Wegerif & Mercer, 1997) have pointed out that a multidimensional research approach is necessary in order to provide in-depth understanding of the process and quality of online interaction.

To address the gap in the literature, this study examines how a group of graduate students, who are also K-12 teachers from various subject areas, interacted with each other in a fully online Moodle course entitled Reading in the Content Areas. This study aimed to go beyond previous studies to address both the social and cognitive processes of online interaction by using a combination of social network analysis and content analysis, which allowed for the analysis of both quantitative and qualitative data. Moodle is becoming more popular, but its effectiveness has rarely been investigated. Accordingly, this study also aimed to provide insight into the effectiveness of Moodle at supporting social discourse and thereby enhancing co-construction of new knowledge.

Theoretical Background

Social Constructivism Learning Theory

This study used social constructivism learning theory (SCLT) as a central theoretical framework. SCLT presupposes that learning is both a social and cognitive process, which is mediated by frequent social interaction (Boudourides, 2003; Foko & Amory, 2008; Hendriks & Maor, 2004; Swan, 2003). In an SCLT environment, it is through interactive processes of discussion, negotiation, and sharing that effective learning takes place (Vygotsky, 1978). SCLT emphasizes that participants are active knowledge constructors, instead of passive individuals who just receive information from instructors or others (Wang, 2005; Zhu, 1996). Within this SCLT framework, social interaction is the core concept in any learning experience (Kumari, 2001; Picciano, 2002). A social constructivist learning environment can be well supported in the online learning environment, which has the unique feature of asynchronous online discussion forums (Swan, 2003). SCLT provides a sound theoretical framework for understanding the process of collaborative knowledge construction in a computer-mediated learning environment (Coe et al., 2004). Indeed, this theory has been applied extensively in studies investigating online learning environments (e.g., Kanuka & Anderson, 1998; Lipponen et al., 2003; Sing & Khine, 2006; Wang, 2005).

Social Network Analysis

Social network analysis (SNA) focuses on patterns of relations between individuals in social networks (Carrington, Scott, & Wasserman, 2005). SNA enables one to detect the interactions and relations among network members, describe the patterns of interactions, and trace how information flows within the network (Knoke & Kuklinski, 1982). This research method is popular in other disciplines (e.g., sociology and anthropology); however, there has been a growing interest in applying SNA to education to investigate the interactions among students. SNA provides a useful technique to study the social construction of knowledge (Vera & Schupp, 2006).

One important advantage of using SNA is that researchers can visualize and quantify the interaction patterns of learners, as well as figure out how the social interactions of participants influence the construction of new knowledge. Common SNA measures include (a) density of the network, (b) centralization, and (c) centrality measures. *Density* refers to the extent to which all the nodes (e.g., persons, students) in the network are connected with each other. The density of a binary network refers to the total number of ties (or connections) among the nodes, and is expressed as a proportion of the maximum amount of possible ties. The value of this measure ranges from 0 to 1; the higher the value, the more established the learning community (Scott, 1991). *Centralization* refers to the extent to which the social network graphic is organized around the most central points (Tuire & Erno, 2001). *Centrality* measures in this study include Freeman's degree and betweenness. The degree is the number of other nodes to which a node is connected (Scott, 1991). For this study, as the matrix is directed, we calculated both the in-degree and out-degree for each student. Lastly, betweenness refers to the extent to which a particular node lies between the various other nodes in the graphic. (See Scott [1991], among others, for information on SNA.)

Content Analysis of Knowledge Construction

Online discussion is transparent and all discussion posts can be retrieved easily from the online computer system. Thus, content analysis of participants' text-based transcripts is an effective technique for researchers to get a better understanding of participants' cognitive processes and of the quality of online learning (Gunawardena, Lowe, & Anderson, 1997; Hendriks & Maor, 2004; Sigala, 2003; Wang, 2005).

Several frameworks guide the analysis of content that is generated in an online environment. The interaction analysis model (IAM) developed by Gunawardena et al. (1997; see Table 1) is one such model. According to the IAM, knowledge construction consists of five phases: (a) sharing and comparing information, (b) discovery of dissonance, (c) negotiation of meaning and co-construction of knowledge, (d) testing and modification of proposed synthesis, and (e) agreement and application of newly constructed knowledge.

Table 1

Interaction Analysis Model (IAM; see Gunawardena et al., 1997)

Phase I	Sharing and comparing of information: • Statement of observation or opinion • Statement of agreement between participants
Phase II	Discovery and exploration of dissonance or inconsistency among participants: • Identifying areas of disagreement • Asking and answering questions to clarify disagreement
Phase III	Negotiation of meaning or knowledge co-construction • Negotiating meaning of terms and negotiation of relative weight to be used for various arguments
Phase IV	Testing and modification • Testing the proposed new knowledge against existing cognitive schema, personal experience or other sources
Phase V	Phrasing of agreement and applications of newly constructed meaning: • Summarizing agreement and meta-cognitive statements that show new knowledge construction

The IAM model has been applied in previous studies to understand the construction of knowledge in online discussion forums (e.g., Kanuka & Anderson, 1998; Sigala, 2003; Sing & Khine, 2006; Wang, 2005). The IAM model provides a solid interpretation of how information flows and how new knowledge is constructed within the network (Smith, 2009). Schellens et al.'s (2007) research tested the IAM scheme by examining the correlation with students' final grades. The results showed that this model provides an accurate predictor of knowledge construction and learning quality in an online environment.

After surveying the literature, the authors decided that Gunawardena et al.'s (1997) IAM provided an appropriate model

for measuring teachers' knowledge construction in this study. This decision was based on two important factors. First, the theoretical assumptions of this model fit well with the SCLT approaches adopted in the online course studied herein. Second, as mentioned above, this model provides a reliable framework for identifying the interactive learning and knowledge construction processes.

The social and cognitive processes of online interactions among the K-12 teachers in the online graduate course were addressed based on this theoretical framework. Specifically, two questions were asked:

1. What is the pattern of the teachers' interactions in the online Moodle learning environment?

2. To what extent is new knowledge co-constructed through the online interaction among teachers on Moodle?

Methodology Participants

The graduate students enrolled in this required course are K-12 teachers in various content areas who are participating in a teacher education graduate program. There were 22 graduate students, of which 18 were female and 4 were male. Seventeen students were in-service teachers and five were pre-service teachers. Participants are referred to interchangeably as both teachers and (graduate) students throughout this paper.

Course Description

General information. The 13-week course, entitled Reading in the Content Areas, was delivered online through Moodle in the fall of 2009. This course was required for the participants as part of a teacher preparation program. This course was designed to promote understanding and expertise with instructional strategies that relate to reading in upper elementary, middle, and secondary school settings. The course also aimed to provide an overview of the reading process based on current theory and research, as well as instructional strategies for promoting reading in different content areas.

Course requirements.

Each week students were required to (a) post an original post to the discussion forum and (b) reply to at least two of their peers' posts. Forums were worth four points each and they accounted for approximately 50% of the final course grade. Forum discussion topics included scaffolding in reading, vocabulary teaching, technology integration in reading, assessment, and other general reading instruction reflections such as students' motivation and prior knowledge. For each forum, an instructional prompt was provided to make sure students knew what they were required to complete (see Appendix A).

Facilitator role.

Video tutorials were available on the course webpage to provide orientation for the students about the Moodle environment. Students were also given guidelines on how to complete assignments with detailed step-by-step directions provided in both Weekly Overview and Assignments. The facilitator's expectation was for students to challenge others in their replies, and this was reinforced in the grading rubric. For example, the rubric stated that a 4-point post should show evidence of "focus on the topic, listening to others, thoughtfulness in interactions and timeliness." For each forum post, students received not only a numeric score but also the facilitator's qualitative feedback. The facilitator pointed out stronger attitudes by leaving positive comments in the grade book—for example, "your replies to your peers this week were so supportive and graceful! It is always valuable to challenge others in your replies to them. Thanks for extending others' thinking!" If the student failed to interact effectively with peers, the facilitator would remind the student to "be sure to challenge others in your replies by asking questions or adding new ideas and to extend the thinking of the whole class." Another way in which the facilitator participated in the course discussion was to post to the forums. On average, the facilitator made five or six posts in each forum in order to respond to students' inquiries or comment on students' posts. The facilitator's posts included constantly raising questions about students' posts to extend their thinking. For example, the facilitator would ask for more explanation from the student by replying in this way:

> I would really like to hear your thoughts about some other salient parts of the chapter. How is reading a strategic process? Why should teachers not assign and tell? How can texts support varying levels of comprehension? Why is "questioning" so vital in the reading process?

Data Collection

The two main sources of data were computer log files and forum discussion posts for all students throughout the semester. Analysis of log files provided comprehensive quantitative indices that reflected the social process of online interaction. Analysis of students' forum posts provided qualitative results that revealed the depth and quality of interactions among students.

Data Analysis

For the social process of online interaction, students' participation in the forum discussions was analyzed using SNA techniques. Analysis of the course log files and activity reports focused on the pattern and frequency of interaction in terms of sending and receiving comments and responses. The frequencies of interactions were counted and the results were presented in a valued case-by-case matrix. For this study, the matrix was dichotomized so that the presence or absence of interactions was represented by 1 or 0, respectively, in the appropriate cells. Based on the dichotomized data, the density and centralization of the entire network, as well as individual degree and betweenness for each student was measured using SNA software (Ucinet 6.0). A directed matrix was used because it is important to specify who sent and who received comments. In order to provide a comprehensive understanding of the interaction patterns and frequencies, the results were also visualized using NetDraw 2.0. For the cognitive process aspect, all forum discussion posts throughout the semester were downloaded from the Moodle course website and coded based on the theoretical framework presented in Gunawardena et al.'s (1997) IAM. Posts from the first week were excluded because that week was a self-introduction forum. Two graduate students evaluated forum posts from Weeks 2, 3, and 4. Coding results were compared, and any differences were resolved through discussion among coders. The interrater reliability was sufficiently high (.91). One graduate student continued to code the remaining posts. Based on the nature of some forum posts, only slight modifications were made to the model to ensure that every segment could fit into a category. Some students suggested possible solutions for problems identified by others in their responses to their peers' posts. This was considered an important step toward knowledge co-construction, so this additional code was added to the IAM under the classification of Phase III, as suggested by Sing and Khine (2006). It is important to note that off-task or "empty" replies (e.g., "thanks for your comments") occurred occasionally and were excluded from analysis because they did not fit into any category in the model. The instructor's posts were coded but excluded to make sure that they would not bias the results.

Results and Discussion

In this section, students' interactions in the Moodle environment are described, and then the quality of their interactions in terms of the extent to which new knowledge was co-constructed are examined. The density, centralization, and centrality measures of the course are presented along with the coding results of forum posts.

Social Network Analysis of Students' Interaction Patterns

According to course requirements, each student had to respond to at least two other students' original posts in each forum. Thus, each student sent out a minimum of 30 responses to other students in the 15 forums throughout the semester, resulting in 945 total responses. Dividing the total by the number of students, it was found that the average number of responses sent out by each student was 42.95 throughout the semester. This indicates that students in the online community actively participated in discussions and interacted with each other.

The case–by–case matrix of who built on whose forum posts is presented in Table 2. This matrix shows the valued relations among all students, thereby providing more detailed information about the interactions among students. The numbers in the cells show how many responses in total the students whose name appears in the left column sent out to the students whose names appear on the top row. This table provides information on who was (or was not) interacting with whom, as well as the strength of these connections, thereby allowing us to glean an overall understanding of how established the community was.

For the density, centralization, and centrality measures, the matrix was dichotomized (cutoff value = 0) using the function of "transformation of data" provided by the aforementioned SNA software (i.e., Ucinet 6.0). Dichotomous relations are marked with one of two values: 1 (representing an existing relation) and 0 (representing no existing relation) (see Table 3).

Table 2

Students' Interaction Patterns: Who Built on Whose Notes?

	D	C	J	K	A	V	J	B	E	E	J	N	R	S	T	A	C	K	S	E	T	K
Diana	0	6	4	1	6	3	9	3	12	1	3	3	0	5	3	3	2	0	2	8	7	6
Carol	8	0	1	1	5	3	1	4	1	0	0	0	1	2	0	2	0	1	1	0	2	0
Jenny	4	0	0	0	2	4	2	2	3	2	5	1	0	1	3	3	0	0	2	2	3	1

Kristina	0	3	1	0	2	1	2	4	0	4	0	0	2	2	0	2	5	2	0	2	1	1
Anna	10	0	1	0	0	1	3	6	0	1	3	2	2	0	0	0	0	1	0	4	0	0
Vicky	4	1	2	0	2	0	2	0	3	1	1	0	2	2	2	0	2	2	2	5	8	1
Jimmy	8	0	3	2	5	0	0	3	8	2	6	4	4	1	7	8	3	9	5	5	10	4
Ben	0	3	0	0	4	2	2	0	2	0	0	0	1	2	0	0	0	0	4	1	3	0
Emma	8	2	1	0	0	0	3	2	0	1	0	2	0	0	2	1	1	2	0	3	8	1
Ellen	1	0	0	0	0	1	0	2	2	0	1	1	2	3	2	3	2	4	1	1	1	1
Jack	2	2	5	1	2	1	5	0	1	2	0	1	0	0	2	2	3	1	3	2	3	0
Nelson	6	1	1	0	0	1	2	3	1	0	0	0	1	0	0	0	2	1	2	1	1	0
Robin	1	4	1	5	2	2	0	1	0	1	0	3	0	1	0	4	0	0	1	3	0	1
Sherry	3	2	0	2	1	2	0	3	0	1	2	3	1	0	1	5	2	4	3	0	3	3
Tina	3	0	2	0	0	6	13	1	10	1	5	0	0	2	0	5	6	3	6	2	2	2
Amy	3	0	1	0	0	2	7	1	4	2	3	0	1	6	4	0	3	5	3	1	3	1
Charlie	1	1	1	2	1	5	3	2	2	1	2	0	0	2	5	5	0	9	2	4	2	1
Karen	0	1	1	0	1	3	0	0	1	2	1	0	1	2	1	2	7	0	2	2	2	2
Susan	0	0	2	2	0	1	2	1	1	1	0	3	2	1	3	1	1	2	0	1	0	2
Emily	1	1	2	1	5	1	2	5	3	0	1	0	1	2	1	2	3	1	0	0	3	4
Tiffany	7	2	3	1	0	6	8	1	10	0	1	0	1	5	2	3	0	0	1	2	0	1
Kristin	2	2	2	1	1	2	4	0	0	0	1	0	0	2	4	2	1	1	2	7	3	0

Based on the analysis, the density of the network in terms of students responding to other students' forum posts was .75. Lipponen et al. (2003) conducted research to investigate the pattern of interactions among a group of students mediated by a Virtual Web School. They found a density of .39 and considered this high. Therefore, it is reasonable to conclude that a density of .75 is very high. The results indicate that all students were well connected with each other, which in turn indicates that the online learning community established through online interactions was quite cohesive.

Table 3

Dichotomized Interaction Pattern: Who Built on Whose Notes?

	D	**C**	**J**	**K**	**A**	**V**	**J**	**B**	**E**	**E**	**J**	**N**	**R**	**S**	**T**	**A**	**C**	**K**	**S**	**E**	**T**	**K**
Diana	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1
Carol	1	0	1	1	1	1	1	1	1	0	0	0	1	1	0	1	0	1	1	0	1	0
Jenny	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1	1
Kristina	0	1	1	0	1	1	1	1	0	1	0	0	1	1	0	1	1	1	0	1	1	1
Anna	1	0	1	0	0	1	1	1	0	1	1	1	1	0	0	0	0	1	0	1	0	0
Vicky	1	1	1	0	1	0	1	0	1	1	1	0	1	1	1	0	1	1	1	1	1	1
Jimmy	1	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ben	0	1	0	0	1	1	1	0	1	0	0	0	1	1	0	0	0	0	1	1	1	0
Emma	1	1	1	0	0	0	1	1	0	1	0	1	0	0	1	1	1	1	0	1	1	1
Ellen	1	0	0	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Jack	1	1	1	1	1	1	1	0	1	1	0	1	0	0	1	1	1	1	1	1	1	0
Nelson	1	1	1	0	0	1	1	1	1	0	0	0	1	0	0	0	1	1	1	1	1	0
Robin	1	1	1	1	1	1	0	1	0	1	0	1	0	1	0	1	0	0	1	1	0	1
Sherry	1	1	0	1	1	1	0	1	0	1	1	1	1	0	1	1	1	1	1	0	1	1
Tina	1	0	1	0	0	1	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1
Amy	1	0	1	0	0	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1
Charlie	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	1	1	1	1
Karen	0	1	1	0	1	1	0	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1
Susan	0	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1

Emily	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	0	0	1	1
Tiffany	1	1	1	1	0	1	1	1	1	0	1	0	1	1	1	1	0	0	1	1	0	1
Kristin	1	1	1	1	1	1	1	0	0	0	1	0	0	1	1	1	1	1	1	1	1	0

Centralization measurement enables one to see if the network is centralized around a certain focal participant in the network. The SNA output demonstrated that both the out-degree centralization and the in-degree centralization were 16.3%. This value is low, indicating that the interaction among students was not centralized, but was instead distributed among many participants.

The results for the Freeman's degree and betweenness centrality measures for each individual student are presented in Tables 4 and 5. These measures allow for the identification of the most central participants in the course. Since dichotomous and directed matrix was used, the degree for each student is the row or column sum for that student. The SNA results show that both the out-degrees (total number of other students to whom a particular student sent comments) and the in-degree (number of other students from whom a particular student received comments) of students varied between 10 and 19. The mean of both out-degree and in-degree was 15.73, while the standard deviations were 2.30 and 2.24, respectively. Three students (Dianna, Jimmy, and Charlie) had the highest out-degree at 19 each and one student (Ben) had a relatively low out-degree of 10. High out-degree indicates that a student actively created connections to other students in the online community (Lipponen et al., 2003). As for the in-degree measure, two students (Emily and Vicky) had the highest in-degree of 19. Nelson had the lowest in-degree of 10. High in-degree indicates that other students often interact with this particular student. Students having the highest total degree—sum of out-degree and in-degree—have the most interactions with others. Emily, with a total degree of 37, had the most interactions with other students in the class. Finally, betweenness results showed that Jimmy and Emily had the highest betweenness values, which indicates that they were in a central position in the interaction network.

Although a student with the highest out-degree did not necessarily have the highest in-degree, one student (Emily) did have the highest total degree (sum of in- and out-degree) and betweenness value. Thus, it is appropriate to conclude that Emily was the most visible student in the online learning community. It appears that no student was in an isolated position in the network since none had both the lowest total degree and the lowest betweenness value.

Based on the findings, one might conclude that Moodle has the capability to support a highly interactive online environment that facilitates broad participation for all students. Further, Moodle may be able to provide an online learning environment that allows students to participate fully in the course, which in turn is an important prerequisite for high quality online learning. According to Esther (2001), such frequent social interactions also scaffold students' knowledge construction.

Table 4

Individual Degree Centrality

Student	OutDegree	InDegree	NrmOutDeg	NrmInDeg
Dianna	19	17	90.48	80.95
Jimmy	19	17	90.48	80.95
Charlie	19	15	90.48	71.43
Emily	18	19	85.71	90.48
Sherry	17	17	80.95	80.95

Amy	17	17	80.95	80.95
Vicky	17	19	80.95	90.48
Jack	17	14	80.95	66.67
Susan	16	17	76.19	80.95
Elen	16	15	76.19	71.43
Tina	16	15	76.19	71.43
Kristin	16	16	76.19	76.19
Karen	16	16	76.19	76.19
Jenny	16	18	76.19	85.71
Tiffany	16	18	76.19	85.71
Kristina	15	11	71.43	52.38
Carol	14	14	66.67	66.67
Robin	14	14	66.67	66.67
Emma	14	16	66.67	76.19
Nelson	13	10	61.91	47.62
Ann	11	14	52.38	66.67
Ben	10	17	47.62	80.95

Table 5

Individual Betweenness Centrality

Student	Betweenness	nBetweenness
Jimmy	8.90	2.12
Emily	8.37	1.99
Dianna	7.52	1.79
Vicky	7.39	1.76

Sherry	7.36	1.75
Susan	6.60	1.57
Jenny	6.19	1.48
Tiffany	5.77	1.37
Robin	5.52	1.31
Karen	5.31	1.27
Emma	4.85	1.16
Jack	4.85	1.15
Charlie	4.84	1.15
Ellen	4.66	1.11
Amy	4.60	1.10
Kristin	4.40	1.05
Carol	3.90	0.93
Ann	3.83	0.91
Ben	3.47	0.83
Nelson	2.78	0.66
Kristina	2.45	0.58
Tina	2.44	0.58

In order to give a clearer picture of the entire network, the interaction pattern was also visualized using SNA software, Netdraw2.0, which is presented in Figure 1. The dark black lines indicate reciprocal interactions, meaning the pair of students commented on posts made by each other. The light gray lines indicate unidirectional interactions, with the arrows indicating the direction of interaction.

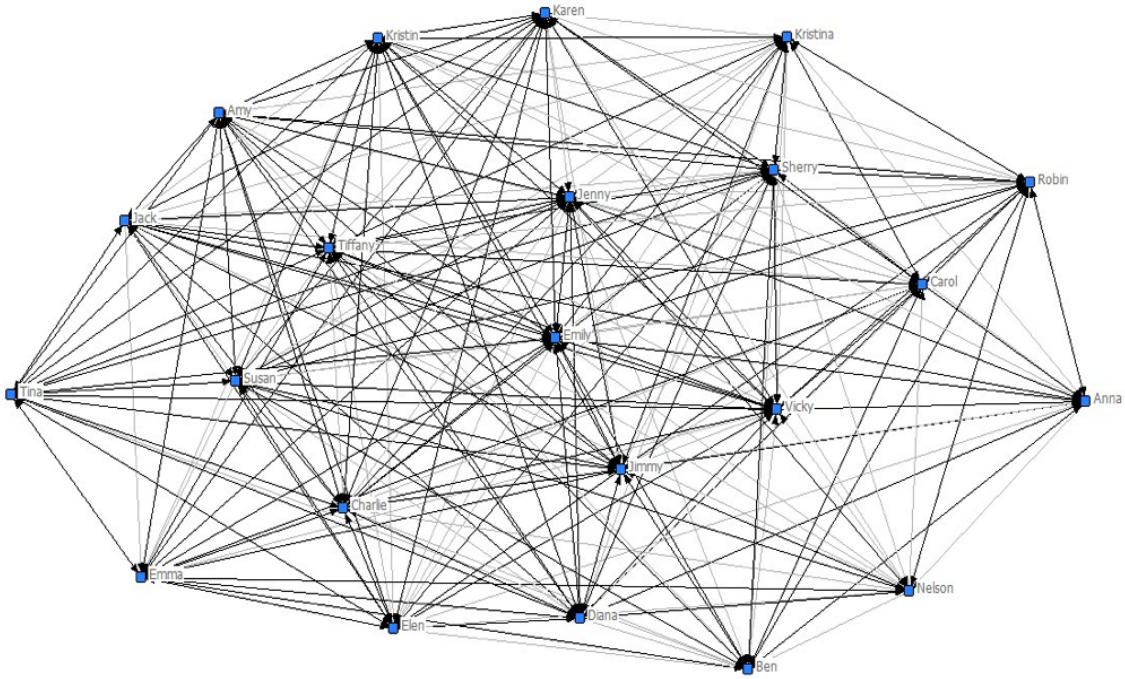

Figure 1. Visualization of teachers' online interaction patterns.

Content Analysis of Students' Online Interaction Quality

Based on examination of the 15 discussion forums, there were a total of 1170 codes. There might be evidence of more than one phase of knowledge building within one forum post. Appearance of different phases within one post was recorded but the same phase that repeatedly appeared was counted only once. The results of the coding based on these conditions—including the percentage of each phase—are presented in Table 6.

It is evident that, although these graduate students participated actively, most of the forum posts remained in the lower phase levels in the interaction analysis model, with a majority (almost 90%) of the posts in Phase I. Most responses were compliments for others or offerings of agreement for other students' statements. Typical responses were statements such as, "I totally agree with what you said" or "I like what you said about scaffolding." A review of the literature shows that this is a common phenomenon. For example, Gunawardena et al. (1997) obtained similar results. Gunawardena and colleagues found that the distribution of participants' posts, who were also graduate students, were 191, 5, 4, 2, and 4 for Phases I, II, III, IV, and V, respectively. Other studies of students' online knowledge construction in higher education (e.g., Kanuka & Anderson, 1998; Sigala, 2003; Sing & Khine, 2006; Smith, 2009; Wang, 2005) reported similar results, with most discussion being of a sharing and comparing nature. Maor (2003) pointed out that many students do not take full advantage of learning technologies and thus information exchange is the primary practice of online learners.

Table 6

Total Number of Posts at Each IAM Phase (N= 1,170)

Phase	Description	Number of posts	Percentage
I	Sharing and comparing of information	1044	89.2
II	Discovery and explanation of dissonance	41	3.5
III	Negotiation of meaning/Co-construction of new ideas (e.g., proposal of possible solutions to identified problems)	80	6.8

IV	Testing/modification of newly constructed knowledge against personal experience	4	0.3
V	Agreement statement(s)/application of newly constructed knowledge	1	0.1

There were instances, however, when online discussion moved to higher levels, which could have resulted in the construction of new knowledge. For example, a few posts belonged to Phase III. It is worth noting that most of the posts in Phase III were proposals of possible solutions for identified problems. This indicates that one advantage of an online learning community is to provide opportunities for students to collaborate, which can potentially lead to co-construction of new ideas. Students' posts also revealed that they were able to negotiate meaning and integrate new knowledge into their existing knowledge schemas. For example, in the discussion about scaffolding strategies in reading instruction in Week 3, one student said, "After I read your post, I realized that.… Now I am clear what scaffolding is…" The student stated that, because of exposure to other students' different points of view, he had gained new understanding of the issues.

Students' discussions also moved to Phases IV and V in Weeks 7, 8, and 12 (see Figure 2). Forum discussion posts during these weeks showed a range of higher phase levels in knowledge construction. In Week 8, for example, students' posts developed into discussions about free writing. The following is an example of a post during this week that shows how students tested new knowledge against personal experience: "I will admit that despite the fact that I'm sure that free writing can be a very successful tool for some students, I know first-hand that it does not work for everyone. Now, just a little background on me…"

In the discussion about web-quest projects in Week 7, one student (Student A) applied new understanding and knowledge to practice. Student A could not decide which website to use for her web-quest project. Students B and C both suggested in their posts that Weebly.com had several unique advantages and was therefore best for the project. Student A expressed different thoughts by replying that, "I am thinking of using this website, but…since I also have some other ideas…" Finally, Student A tried the solution proposed by Students B and C, and stated that, "So, I used Weebly.com and now I completely agree with you all that it is really cool. I love it. I would like to play with it more." When students were able to summarize and make statements about agreement, knowledge construction was attained.

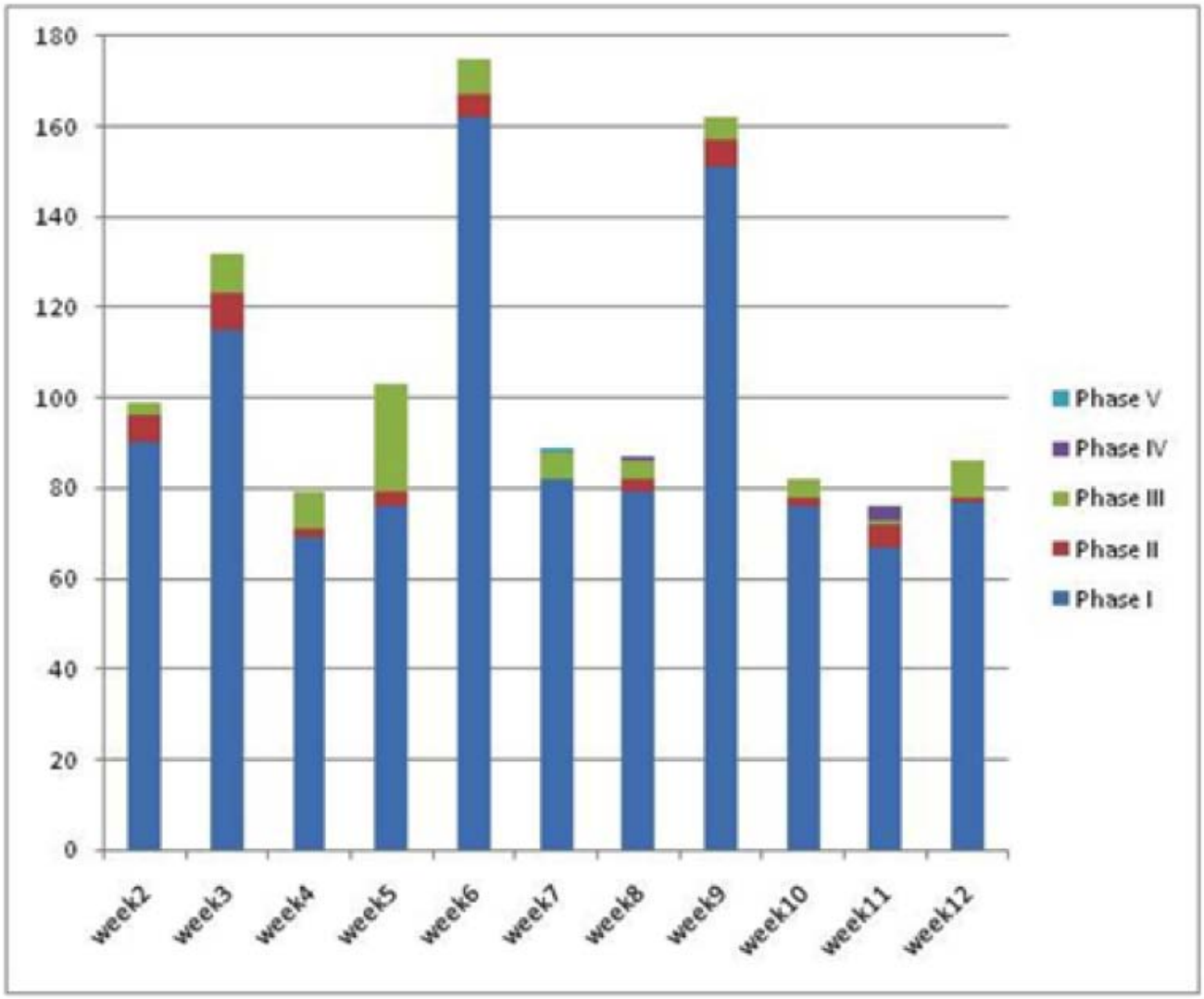

Figure 2. Bar chart of percentage of students' posts at each IAM phase by week.

The discussion during these several weeks indicated that, even though there was a lack of diversity in the phase levels of knowledge construction activities, higher levels of knowledge construction activities occurred in the online environment. It seems that Moodle was able to facilitate in-depth discussion and knowledge co-construction processes. Several factors could explain why the majority of discussion posts were in the lower phases in the coding schema. One reason is that students were influenced by traditional cultural norms (Sing & Khine, 2006). Students likely considered it important to maintain a friendly relationship with colleagues in the community, which explains why most posts were compliments or statements of agreement. Further, it is likely that students tended to value the opportunity to socialize with peers more than the opportunity to co-construct new knowledge. As a result, students were careful in explaining the dissonance, even though the facilitator constantly reinforced the expectation for them to post quality responses to peers. Other researchers have pointed out that a lack of time might be another factor that affects the types and levels of students' online participation (Zhao & Rop, 2001, as cited in Sing & Khine, 2006). In order to discover disagreement and dissonance, students must spend time thinking critically about other posts and ideas. However, because most students were fulltime teachers, time became a major constraint. They had to maintain a certain degree of balance between their roles as both teachers and graduate students. Oftentimes, it may have seemed natural for them to consider accomplishing teaching tasks as more important than constructing new knowledge in their online graduate course.

Fung (2004) conducted a survey on the limiting factors of online interaction, and found that there was also "mutual influence" of other students' participation and nature of posts. Another possible reason might be that, in an online learning environment, students may be prone to pay less attention to or respond less to peers' ideas that are inconsistent with their existing knowledge (Kanuka & Anderson, 1998, as cited in Sigala, 2003). In addition, students' learning styles and comfort levels with using learning technologies could also explain the phenomenon. As Wozniak and Silveira (2004) pointed out, due to students' insufficient knowledge of learning technologies, it is sometimes difficult for them to engage in effective peer communication as they do in a traditional learning environment.

Conclusion

This study examined K-12 teachers' online interactions in order to understand whether Moodle is effective at supporting the social and cognitive processes that take place during online learning and interaction. The findings indicate that Moodle may be capable of providing opportunities for participants to interact and communicate. Thus, Moodle can help establish an online learning community where participants feel supported and safe, which is important for effective learning and knowledge construction. On the other hand, analysis and coding of teachers' discussion posts revealed that there was a lack of higher level knowledge construction. These findings are consistent with previous conclusions from past studies (e.g., Gunawardena et al., 1997; Kanuka & Anderson, 1998; Smith, 2009; Wang, 2005).

The results raise several questions. While course management systems such as Moodle are able to provide opportunities for online social interactions, are there any motivational or instructional factors that can facilitate higher levels of knowledge construction activities in an online environment? Even though the facilitator effectively intervened during the discussion process, it was still a challenge to achieve high quality online interaction. Thus, what additional actions could the online facilitator take to further encourage students to take the responsibility to challenge assumptions of others in their responses, enrich online discussion, and thereby build new knowledge together? Based on the results, it seems necessary for the online facilitator to help students challenge traditional cultural norms about politeness. Students need to understand that there is nothing wrong with expressing different points of view and that this will not disrupt harmonious relationships among peers. Further, students should be encouraged to develop positive attitudes toward creating new knowledge and take seriously this opportunity. Moreover, while teachers are traditionally knowledge *consumers*, it is important for them to undertake the new role as knowledge *creators* in a computer-mediated learning environment, even though this may take time and effort.

This study was based on a single, semester-long online graduate course. Future research should study longer timeframes and larger samples to gain a richer understanding of online learning. Research should also assess students' performance and learning outcomes in an online environment as compared to those same outcomes in a face-to-face or hybrid learning environment. Studies focusing on the impact of the online facilitator as well as other contextual and student factors—for example, students' experiences with online learning and their technology levels and learning styles—can also significantly contribute to the body of knowledge in the field of online teaching and learning.

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Appendix A

Prompt provided to make sure students knew what they were required to complete:

Consider ways to expand the application of both scaffolding and metacognition in your future teaching. Consider new ways to activate prior knowledge gleaned from the reading materials in your future teaching.

- How do you typically motivate students to read new material and/or experience new concepts in your classroom?
- Based on your assigned readings, has your idea of the role of prior knowledge in learning changed? If so, how? And how do you plan to apply what you've learned in your classroom? What specific strategies do you think you may use? Why?
- Extend the thinking and wisdom of the group by engaging with at least two of your classmates' responses.

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