Online Discussions: Improving Education in CS?

Radu P. Mihail
University of Kentucky
329 Rose St.
Lexington, KY 40509
r.p.mihail@uky.edu

Beth Rubin
Miam iUniversity
307B Laws Hall
Oxford, OH 45056
rubinb@miamioh.edu

Judy Goldsmith
University of Kentucky
329 Rose St.
Lexington, KY 40509
goldsmit@cs.uky.edu

ABSTRACT

Asynchronous online discussions are considered the cornerstone of online education. Many instructors of face-to-face courses are "web-enabling" their classes to improve learning through critical inquiry using online discussions. In this exploratory study, we collected and analyzed online discussion data from two dissimilar computer science courses (one technical Graphics for Gaming (G4G) course and a writing intensive Science Fiction and Ethics (SF&E) course). Our findings suggest that, overall, making more posts, posting more questions and engaging in Devil's Advocacy have positive effects on learning, while making more informational posts, explaining to others and making longer posts do not. In the SF&E course, all students perceive that posting helped their learning, while in the G4G course students do not, but posting behavior differentiates those who perform well from those who perform poorly.

Categories and Subject Descriptors

K.3.2 [**Computer and Information Science Education**]: Concept Learning Knowledge Acquisition

General Terms

Experimentation, Measurement, Human Factors

Keywords

Web-enabled courses, online discussions, asynchronous discussions, student blogs

1. INTRODUCTION

We present a case study on the use of asynchronous online discussions in two web-enabled upper level computer science courses. The two courses were different in both content and student evaluation, but shared an online discussion component, introduced by the instructors to enhance the learning experience through collaboration and peer support. Collaborative learning can be loosely defined as any situation where two or more people work together to learn something. The addition of networked computers to connect people led to the computer-assisted collaborative learning paradigm, where intricacies of mixing technology with learning has been subject to multidisciplinary research for years [19]. As opposed to *cooperative* learning, where a task is solved by a divide and conquer approach, in *collaborative* learning the group works together on the same task (e.g., problem solving, concepts, project, etc.) Our intended use of online discussions fell into the later category; posts were visible to the entire class and students collaborated to learn a common concept or helped one another to solve a problem.

Computer assisted collaborative learning implies some form of communication (usually verbal), and can be synchronous (e.g., chat or IM) or asynchronous, thanks to data persistence (e.g., discussion boards). This study is based on data collected from online discussions, in the form of posts on Blackboard® discussion boards and blogs during one semester and a research survey from students who opted to participate in the study.

One of the web-enabled courses was technical, designed to develop students' knowledge of graphics programming in video games; the other was a CS ethics course with a strong emphasis on writing. In both, online discussions were required and students were given credit for participation. It is almost universally accepted that higher education benefits from web enabled tools [3]. Online discussions, specifically asynchronous discussions, are considered imperative to online courses [21] and researchers agree that collaborations foster learning and facilitate student-content interactions.

The scope of this study is to compare and contrast the characteristics of online posting in two dissimilar CS classes and their effect on learning outcomes. When students are allowed to pick discussion topics of interest to them (related to class materials), we are interested in determining the relationship between learning outcomes and posting habits. *More specifically, we ask what type of posts are associated with actual and perceived increased learning.*

1.1 Course Descriptions

Science Fiction and Ethics (SF&E).

At present, our university has no regular CS ethics course. This was offered on a trial basis as a special topics course, open to all students. The syllabus [citation suppressed] was built on specific ethical topics, supplemented by readings in the ethics textbook, as well as short stories, movies, and two novels. Grades were based on online blog posts and responses (30%), in-class participation (10%), occasional short

SIGCSE'14, March 3–8, 2014, Atlanta, GA, USA.

http://dx.doi.org/10.1145/2538862.2538898.

essay responses to prompts (25%), and midterm and final papers/projects/creative writing exercises (15% and 20%, respectively).

The semester was divided into weeks; students received 1 point (out of 100) per week for a blog post, and 1 point for a response. Some students wrote more than that, and one student was asked to limit their postings at the beginning, before others had begun to use the blogs.

Students used the posts to discuss ethical issues in the readings, viewings, and occasionally the news. They also shared critical opinions about the sf, and used the posts to explore their own ambivalence about societal responsibilities.

Teaching Graphics for Games using XNA (G4G).

This course was offered to create a bridge from graphics courses with a traditional focus on algorithms, to game development courses where both technical concepts and higher level game programming is taught. We designed this course with a focus on graphics programming for games using a library with low level algorithm implementations (Microsoft XNA) and designed the assignments so that visual feedback would help students assimilate the course material. We refer our most interested readers to [12] for a detailed description of the course and pedagogical methods used. The required mathematical skills were taught and assessed in a traditional face-to-face context.

Grades were based on 5 programming assignments (35%), quizzes (10%), midterm examination (15%), final project (30%) and online discussions (10%). Asynchronous online discussions were introduced in the class mainly as a peer-support tool, but also to strengthen student-content interactions. As opposed to traditional online or web-enhanced discussions with clear directives/topics for posts, the choice of topics were mostly left up to the student, constrained to remain within the topics covered in the respective week.

2. RELATED WORK

Asynchronous discussions are currently considered the foundation of most online and web-enhanced courses [4]. Discussions through a learning management system (e.g., Blackboard) allow students to discover different perspectives and to recognize personal knowledge gaps [4]. Students gain cognitive benefits by extending classroom discussions, posing questions to other students, answering questions and playing "Devil's Advocate". In other words, by communicating outside the physical classroom, students build a community. Synchronous online discussions (e.g., chat or private messaging) have been found to complement asynchronous discussions by Oztok et al. [13], who showed that the active forum posters are also active in private messaging.

A meta-analysis performed by Department of Education [11] compared online, blended and face-to-face instruction; one key conclusion was that face-to-face elements combined with online instruction result in better student learning outcomes, particularly for collaborative environments (i.e., students working together and/or with instructor presence). Wu et al. [21] indicated that students' perceived learning also improve when using asynchronous online discussions. Ginns et al. [9] found that student perceptions of online discussions have a significant association with grades by clustering students in blended courses into groups based on their perceptions and interactions.

The Community of Inquiry framework, proposed by Garrison, Anderson & Archer [6, 5, 7] offers one way to conceptualize deep learning in the concept of "cognitive presence." It presents critical inquiry as a key goal of online learning using asynchronous discussion. This process of critical inquiry occurs through asking and answering questions, exploring different perspectives and considering and integrating alternative viewpoints. However, it is difficult for students to achieve the higher levels of critical discourse, where they integrate and differentiate concepts, through online discussion [8, 16, 17]. Instructional techniques that have clearly defined roles and explicitly require students to confront other perspectives support higher order critical analysis [10]. Two of the activities students engage in during online discussion comprise lower level thinking processes of understanding and application: the processes of asking questions about the course ideas and applications, and answering those questions and providing information from the course. A third activity, exploring alternative perspectives through processes such as playing Devil's Advocate, produces deep learning [16].

Another key task that is accomplished in course discussion is the development of personal relationships, trust and a sense of connection with class members, which is accomplished in part through personal comments and recognition [15, 18, 20]. Another is class administration, including clarifying course requirements and deadlines [1, 2]. Last, when posting is required, some posts are made only to meet course requirements and have little substance to add to the learning.

The instructor plays an important role in the effectiveness of online discourse. Richardson et al. [14] investigated the effects of various instructional strategies as described in the Community of Inquiry framework. They found that the majority of students prefer open-ended discussions, but that doesn't necessarily help critical thinking. In our study, discussion topics were chosen by the students, mostly limited to material covered in the respective week. Threads were visible to everyone in the class.

3. DATA COLLECTION AND ANALYSIS

Data were collected from Blackboard posts throughout the semester, and a survey delivered at the end of the semester.

Subjects.

Subjects were students enrolled in the two computer science courses described above. 22 students in the SF&E class participated, as did 21 in the G4G course. The SF&E class had a more diverse set of respondents. Four out of 43 students were graduate students, all of whom took the SF&E course. Twelve students were female, most (nine) in the SF&E class where they comprised 40% of respondents versus 14% of the G4G respondents. In the G4G class, students ranged in age from 18 through 35 with a mean of 22.88 and Standard Deviation of 2.94, without significant differences between the classes in age.

Coding.

We downloaded and coded the student posts from Blackboard in 2 categories of initial post and response, each with one of 6 possible sub-categories:

1. asking for information or ideas
2. answering one or more questions or providing information
3. exploring alternatives (i.e., Devil's Advocate)
4. administrative issues
5. supportive or personal comments
6. off-topic or distracting

We applied the coding scheme to an initial set of 20 posts and calibrated their evaluation. The same process was followed after the next 50 posts, and we continued to verify coding practices thereafter to ensure consistency. We used the end of semester survey to gather information on students' opinions of the online discussion. We collected student demographic information: age, gender, class (e.g., undergraduate or graduate student) and which course they took.

The survey asked for Likert-type scale responses to questions about students' opinions of the online learning discussion (see Appendix). Questions ask about the usefulness of the online discussion to class learning, the helpfulness of other classmates' questions and responses to learning class concepts, and whether the survey responder helped other students by answering questions or providing information. The survey also collected information about the amount of time students spent on the online discussion, and if the online discussion led the student to think about class concepts outside of class time, and for how long.

Analysis.

Class grades were calculated for all work except posting. Because there was a restriction of range in class grades (Mean = 92.97, SD = 8.46), a dummy code was created to distinguish the top one-third of students from the bottom one-third.

The survey questions with a 5-point Likert-type scale were factor analyzed using Principle Components extraction and varimax rotation. Three factors were identified with eigenvalues greater than 1.0. Rotated factor loadings are shown in Table 1. Items were identified that had factor loadings $> .70$ on their factor, and $< .40$ on other factors. Eight items met this criterion for the first factor, three for the second and only one for the third. The questions were combined into scales for the first two factors. Cronbach's alpha scores were then calculated to assess the internal consistency reliability of the first two scales, and found alpha coefficients of .96 for the first (eight-item) scale and .76 for the second (three-item) scale. Both of these are high for the number of items, and indicate that students responded to the items similarly, and therefore they can be combined into scales. The first scale contains items describing how useful the online posting was, while the second scale included items describing the professor's support for online posting. The third single-item factor described how much students explained concepts to their classmates in the online discussion.

Very few students posted administrative, Devil's Advocate or personal posts. Therefore, the number of posts of each type (asking questions, providing information, Devil's Advocacy, administrative, personally supportive or off-topic/null) were combined across initial and responding posts, producing 6 categories.

Table 1: Rotated Factor Loadings

	1	2	3
Q1 Ask help	.43	-.24	.67
Q2 Ansr Qs	.51	-.09	.72
Q3 Learnd Lt	.87	-.32	.19
Q4 Helped Und	.85	-.14	.35
Q5 Helped Aply	.88	-.17	.23
Q6 Helped Hrd	.81	-.13	.44
Q7 I Explained	.14	-.14	.92
Q8 Enjoyable	.77	-.25	.27
Q9 Expl Hlpd Ln	.79	-.23	.21
Q10 Useful Lrn	.86	-.22	.26
Q11 Thnk Outsd	.81	-.39	.11
Q12 ClearExp	-.16	.78	-.15
Q13 Pts Appr	-.52	.58	-.08
Q14 Prof Rec	-.38	.71	-.01
Q15 Prof Resp mr	-.08	.82	-.20

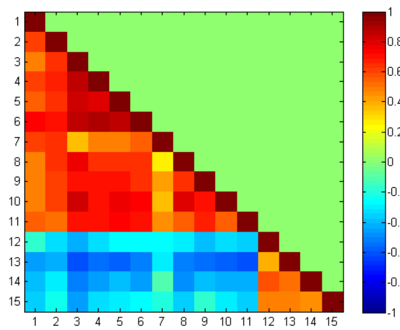

Figure 1: Correlation coefficient matrix of survey questions for both classes. $N = 36$.

4. RESULTS

Overall, students posted many more questions ($M = 21.48$, $SD = 9.31$) than they provided information ($M = 8.12$, $SD = 6.17$). On average, they perceived that posting helped them ($M = 3.67$, $SD = 1.15$), and they explained things to others ($M = 3.44$, $SD = 1.14$), but had lower perceptions of professors' support for their posting ($M = 2.26$, $SD = 0.71$).

As expected, there were many differences between the classes, as shown in the Analysis of Variance (Table 2). Students in the SF&E course posted more frequently and much longer (word count), and reported spending more time posting online. The students in the SF&E course posted more in nearly every category, including initiating posts, asking questions and sharing information. This likely reflected both the content of the courses and the greater emphasis on posting in the grade (30% vs. 10%). The only exceptions, where students in the G4G course posted more, were administrative and personal posts. The students in the SF&E course perceived that the posting was quite useful, while overall the students in the G4G course did not. On the other hand, students in the G4G course felt that the instructor support/response was higher than did those in the SF&E course. Grades were similar in both courses, as was the length of time the spent thinking about the course.

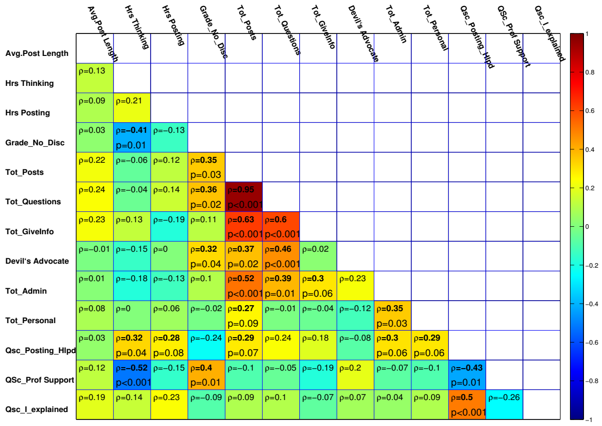

Figure 2: Partial correlation matrix with class as control variable. Color codes as in Fig. 1.

To examine whether posting behavior affected learning, Analysis of Variance compared the behavior of those students who scored in the top third of the classes with those who scored in the bottom third, exclusive of grades for posting; this is presented in Table 3. Students who scored better posted more than those who scored worse. They also responded more to others than did low-scorers. There was a strong trend that did not quite reach statistical significance for them to ask more questions and engage in more Devil's Advocacy.

On the other hand, there were no significant differences between the high-scoring and low-scoring students on how much information they provided to others, the number of hours they reported spending online, nor on how long their posts were. There were no differences in the posting about administrative or personal topics. In addition, there were no differences between the students' perceptions of how much posting helped them, how much the professor supported their posting, how much they explained to others, nor how much time they reported spending posting.

Table 3 also presents Analysis of Variance results within each class. Within the G4G course, students who scored higher posted more overall, including slightly more initial posts and many more responding posts. They also asked many more questions and made more Devil's Advocate posts. However, within the SF&E course, none of these factors differentiated students by their class performance. The only difference between the top versus the bottom third was that the better-scoring students perceived more support from their professor for posting.

Relationships between posting behaviors, perceptions and outcomes were examined by means of partial correlations to statistically remove the effect of the course taken; these are shown in Figure 2. With the course constant, the grade *is* related to the number of posts and, in particular, the number of questions and Devil's Advocate posts, and also students' perceptions of professor's support for posting. The grade is negatively related to self-described hours spent thinking about the course. However, the grade is not related to the average length of the posts, or to students' perception that posting was useful to their learning, or to how much they report explaining to others. This indicates that students' perceptions of how much posting helped was not reflected in their grades. Providing information was not correlated to grade, nor was writing more. But asking questions and exploring by playing Devil's Advocate, directly challenging ideas — those posts led to greater mastery. This provides evidence that in web-enhanced courses, online discussion involving critical inquiry supports more learning in CS courses, while simply providing information does not.

It seems that "hours thinking" about the class served as a measure of how difficult the courses were, subjectively. That would explain why it had a negative correlation with grade (-.41) and perceived professor support for posting (-.52), and positive with how much posting helped (.32). One possible interpretation for this finding is that students found the work to be difficult, and the professor did not answer all questions or give them the correct answers, so they perceived that they spend a lot of time on it — although that time was not necessarily productive.

Table 2: Analysis of Variance by Class.

Variable	Course[1,2]	Mean	SD	F	Sig.
Gender[a]	GP	1.86	(0.36)	3.96	#
	SFE	1.59	(0.50)		
Age[a]	GP	23.1	(2.10)	0.21	
	SFE	22.68	(3.58)		
Class (G or UG)[a]	GP	1	(0.00)	4.45	*
	SFE	1.18	(0.39)		
Q're Posting Helped[a]	GP	2.76	(1.24)	15.25	***
	SFE	3.94	(0.68)		
Q're Prof Support[a]	GP	2.52	(0.69)	6.1	*
	SFE	2.02	(0.66)		
Q're I Explained[a]	GP	3.38	(1.16)	0.11	
	SFE	3.5	(1.14)		
Hrs Thinking[a]	GP	6.41	(4.80)	2.16	
	SFE	4.39	(4.22)		
Hrs Posting[a]	GP	1.31	(0.65)	5.07	*
	SFE	1.89	(0.98)		
Total Number of Posts[b]	GP	21	(9.87)	7.86	**
	SFE	28.36	(7.03)		
Avg. Post Length[b]	GP	125.27	(60.74)	295.35	***
	SFE	1222.16	(279.20)		
Total Initial Posts[b]	GP	7.7	(3.05)	38.15	***
	SFE	12.91	(2.41)		
Total Response Posts[b]	GP	13.3	(7.15)	1.27	
	SFE	15.45	(5.16)		
Total Question Posts[b]	GP	15.35	(8.16)	26.99	***
	SFE	27.05	(6.40)		
Total Informational Posts[b]	GP	3.65	(3.87)	38.14	***
	SFE	12.18	(4.95)		
Total Admin Posts[b]	GP	1.25	(0.72)	48.67	***
	SFE	0.09	(0.29)		
Total Pers'l posts[b]	GP	2.75	(2.65)	20.69	***
	SFE	0.14	(0.47)		
Total Devil's Advoc. Posts[b]	GP	0.15	(0.37)	3.7	#
	SFE	0	(0.00)		
Total Other/ Off-Toipic Posts[b]	GP	0.6	(0.94)	0.23	
	SFE	0.45	(1.01)		
Grade 1/3 Dummy[c]	GP	0.53	(0.51)	0.006	
	SFE	0.55	(0.52)		

Notes: Sig=significance, df = degrees of freedom

F = F-test of the equality of variances

*** $p < .001$; ** $p < .01$; * $p < .05$; # $p < .10$;
[1]GP: Graphics in G4G; [2]SFE: SF&E
[a]$N = 20$ and 22, with df$(1, 41)$; [b]$N = 21$ and 22, with df$(2, 40)$
[c]$N = 17$ and 11, with df$(1, 26)$

5. CONCLUSIONS AND FUTURE WORK

In this exploratory study, the authors examined student posting behaviors in two dissimilar courses (writing intensive and technical). The results of this experiment provide

Table 3: Analysis of Variance by Grade

		Both Classes				G4G				SF&E			
Variable	**Grade**	**Mean**^{a,b}	**SD**^{a,b}	**F**	**Sig**	**Mean**^{c,d}	**SD**^{c,d}	**F**	**Sig**	**Mean**	**SD**^{e}	**F**	**Sig.**
Gender	Bottom 1/3	1.77	(0.44)	0.04		1.88	(0.35)	0.01		1.6	(0.55)	0.09	
	Top 1/3	1.73	(0.46)			1.89	(0.33)			1.5	(0.55)		
Age	Bottom 1/3	23	(2.48)	0.01		23.75	(2.82)	1.12		21.8	(1.30)	0.87	
	Top 1/3	22.93	(2.30)			22.63	(1.06)			23.33	(3.44)		
Class (G or UG)	Bottom 1/3	1.08	(0.28)	0.01		1	(0.00)	0		1.2	(0.45)	0.02	
	Top 1/3	1.07	(0.26)			1	(0.00)			1.17	(0.41)		
Class	Bottom 1/3	1.38	(0.51)	0.01									
	Top 1/3	1.4	(0.51)										
Q're Posting Helped	Bottom 1/3	3.38	(1.33)	0.01		2.83	(1.43)	0		4.25	(0.45)	0.01	
	Top 1/3	3.42	(1.35)			2.83	(1.41)			4.29	(0.66)		
Q're Prof Support	Bottom 1/3	2.13	(1.02)	1.11		2.54	(1.02)	0		1.47	(0.65)	4.84	#
	Top 1/3	2.44	(0.51)			2.56	(0.47)			2.28	(0.57)		
Q're I Explained	Bottom 1/3	3.31	(1.38)	0.55		3	(1.41)	1.78		3.8	(1.30)	0.12	
	Top 1/3	3.67	(1.18)			3.78	(0.97)			3.5	(1.52)		
Hrs Thinking	Bottom 1/3	7.58	(6.85)	2.32		8.08	(6.88)	1.5		6.8	(7.53)	0.67	
	Top 1/3	4.63	(2.89)			5	(2.96)			4.08	(2.97)		
Hrs Posting	Bottom 1/3	1.62	(0.92)	0.01		1.14	(0.62)	0.81		2.4	(0.82)	0.37	
	Top 1/3	1.67	(0.99)			1.44	(0.77)			2	(1.26)		
Total Number of Posts	Bottom 1/3	19.77	(9.79)	4.96	*	14.13	(6.53)	8.98	**	28.8	(6.87)	0.1	
	Top 1/3	28.13	(10.01)			26.56	(9.96)			30.5	(10.50)		
Avg. Post Length	Bottom 1/3	546	(551.20)	0.02		148.86	(77.62)	0.93		1181.43	(284.20)	0.2	
	Top 1/3	574.95	(602.91)			119.64	(44.53)			1257.92	(285.90)		
Total Initial Posts	Bottom 1/3	8.92	(4.37)	1.34		6.13	(1.96)	3.95	#	13.4	(3.13)	0	
	Top 1/3	10.73	(3.90)			9	(3.64)			13.33	(2.80)		
Total Response Posts	Bottom 1/3	10.85	(5.73)	7.04	*	8	(4.78)	10.98	**	15.4	(4.04)	0.19	
	Top 1/3	17.4	(7.13)			17.56	(6.78)			17.17	(8.28)		
Total Question Posts	Bottom 1/3	16.31	(10.86)	3.98	#	9.25	(5.01)	11.07	**	27.6	(7.13)	0.13	
	Top 1/3	23.87	(9.20)			20.22	(8.03)			29.33	(8.62)		
Total Informational Posts	Bottom 1/3	6.69	(6.69)	0.24		2.38	(3.93)	1.37		13.6	(3.21)	0.02	
	Top 1/3	7.93	(6.61)			4.44	(3.36)			13.17	(7.03)		
Total Admin Posts	Bottom 1/3	0.77	(0.60)	0.25		1.13	(0.35)	0.71		0.2	(0.45)	0.02	
	Top 1/3	0.93	(1.03)			1.44	(1.01)			0.17	(0.41)		
Total Pers'l Posts	Bottom 1/3	1.77	(2.31)	0.01		2.88	(2.36)	0.03		0	(0.00)	0.82	
	Top 1/3	1.67	(2.32)			2.67	(2.55)			0.17	(0.41)		
Total Devil's Advoc. Posts	Bottom 1/3	0	(0.00)	3.02	#	0	(0.00)	3.53	#	0	(0.00)	0	
	Top 1/3	0.2	(0.41)			0.33	(0.50)			0	(0.00)		
Total Other/Off-Topic posts	Bottom 1/3	0.38	(0.65)	1		0.38	(0.52)	1.14		0.4	(0.89)	0.04	
	Top 1/3	0.73	(1.10)			0.89	(1.27)			0.5	(0.84)		

Notes: Sig=significance, df = degrees of freedom , F = F-test of the equality of variances

*** $p < .001$; ** $p < .01$; * $p < .05$; # $p < .10$;

$^{a}N = 13$ and 15, with df$(1, 26)$ for all variables except age $^{b}N = 13$ and 14, with df$(1, 25)$ for age

$^{c}N = 8$ and 9, with df$(1, 15)$ for all variables except age $^{d}N = 8$ and 8, with df$(1, 14)$ for age

$^{e}N = 5$ and 6, with df$(1, 9)$

insights about posting behavior and initial evidence which supports that certain posts lead to increased learning. The online student interactions, particular information-seeking and devil's advocacy challenges, correlate with good grades. We conjecture that giving students assignments which require questioning and challenging other ideas leads to increased learning. We relate this to Kanuka and Rourke's findings [16] that some types of activities (e.g., debates) lead to more higher order learning than others (e.g., case analysis). We believe that the act of formulating questions suitable for sharing with peers was a significant part of the learning process.

We also noticed, in both classes, that students who were unwilling or unable to speak up in class were able to post. The SF&E class discussed this, prompted by a self-identified introvert, and some students reported that they appreciated the time they took to formulate their posts and responses.

It may be that the association between asking questions and achievement reflected different kinds of questions. Some questions support basic understanding of concepts and applications, while others reflect higher-order critical inquiry by seeking alternative explanations or viewpoints. We differentiated this "higher order" category in providing information, but not in asking questions. In future work, we will revise the coding scheme to differentiate questions that support basic learning from higher-order analysis. We will also revise the coding scheme to differentiate answering questions from providing information without answering others. It may be that stronger students did help others by answering their questions, but the effect was washed out by the many posts that provided basic ideas or information.

6. REFERENCES

[1] T. Anderson, L. Rourke, D. R. Garrison, and W. Archer. Assessing teaching presence in a computer conferencing context. *Journal of Asynchronous Learning Networks*, 5(2):1–17, 2001.

[2] J. B. Arbaugh, M. Cleveland-Innes, S. R. Diaz, D. R. Garrison, P. Ice, J. C. Richardson, and K. P. Swan. Developing a community of inquiry instrument: Testing a measure of the Community of Inquiry framework using a multi-institutional sample. *Internet and Higher Education*, 11:133–136, 2008.

[3] W. G. Bowen and S. Ithaka. *Interactive learning online at public universities: Evidence from randomized trials*. Ithaka S+ R, 2012.

[4] P. A. Ertmer, A. Sadaf, and D. J. Ertmer. Student-content interactions in online courses: The role of question prompts in facilitating higher-level engagement with course content. *Journal of Computing in Higher Education*, 23(2-3):157–186, 2011.

[5] D. R. Garrison, T. Anderson, and W. Archer. Critical inquiry in a text-based environment: Computer conferencing in higher education. *The internet and higher education*, 2(2):87–105, 1999.

[6] D. R. Garrison, T. Anderson, and W. Archer. Critical thinking, cognitive presence, and computer conferencing in distance education. *American Journal of Distance Education*, 15(1):7–23, 2001.

[7] D. R. Garrison, T. Anderson, and W. Archer. The first decade of the community of inquiry framework: A retrospective. *The Internet and Higher Education*, 13(1):5–9, 2010.

[8] D. R. Garrison and M. Cleveland-Innes. Facilitating Cognitive Presence in Online Learning: Interaction Is Not Enough. *The American Journal of Distance Education*, 19:133–148, 2005.

[9] P. Ginns and R. Ellis. Quality in blended learning: Exploring the relationships between on-line and face-to-face teaching and learning. *The Internet and Higher Education*, 10(1):53–64, 2007.

[10] H. Kanuka. Interaction and the online distance classroom: Do instructional methods effect the quality of interaction? *Journal of Computing in Higher Education*, 23(2-3):143–156, June 2011.

[11] B. Means, Y. Toyama, R. Murphy, M. Bakia, and K. Jones. Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. Technical report, US Department of Education, 2010.

[12] R. P. Mihail, J. Goldsmith, N. Jacobs, and J. Jaromczyk. Teaching Graphics for Games using Microsoft XNA. In *International Conference on Computer Games*, 2013.

[13] M. Oztok, D. Zingaro, C. Brett, and J. Hewitt. Exploring asynchronous and synchronous tool use in online courses. *Computers & Education*, 2012.

[14] J. C. Richardson and P. Ice. Investigating students' level of critical thinking across instructional strategies in online discussions. *The Internet and Higher Education*, 13(1):52–59, 2010.

[15] L. Rourke, T. Anderson, D. R. Garrison, and W. Archer. Assessing social presence in asynchronous text-based computer conferencing. *Journal of Distance Education*, 14:50–71, 1999.

[16] L. Rourke and H. Kanuka. Barriers to online critical discourse. *The International Journal of Computer-Supported Collaborative Learning*, 2:105–126, 2007.

[17] L. Rourke and H. Kanuka. Learning in Communities of Inquiry: A Review of the Literature . *The Journal of Distance Education/Revue de l'Éducation à Distance*, 23(1):19–48, 2009.

[18] A. P. Rovai. Facilitating online discussions effectively. *The Internet and Higher Education*, 10(1):77–88, Jan. 2007.

[19] G. Stahl, T. Koschmann, and D. Suthers. Computer-supported collaborative learning: An historical perspective. *Cambridge Handbook of the Learning Sciences*, 2006, 2006.

[20] K. Swan. Building Learning Communities in Online Courses: the importance of interaction. *Education, Communication & Information*, 2(1):23–49, 2002.

[21] D. Wu and S. R. Hiltz. Predicting learning from asynchronous online discussions. *Journal of Asynchronous Learning Networks*, 8(2):139–152, 2004.

APPENDIX

Survey Questions.

5 point Likert scale (Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Agree):

1. I regularly asked for help understanding concepts in the online discussion/blog.
2. I regularly answered classmates' questions in the online discussion/blog.
3. I learned a lot from my classmates in the online discussion/blog.
4. My classmates' responses to questions in the online discussion/blog helped me understand the topics in this course.
5. My classmates' online posts helped me accurately apply the concepts in this course.
6. My classmates' online posts helped me figure out hard concepts in this course.
7. I explained concepts to my classmates in the online discussion/blog.
8. Responding to my classmates in the online discussion/blog was enjoyable.
9. Explaining something to my classmates in the online discussion/blog helped me learn.
10. The online discussion/blog was very useful to my learning in this course.
11. Posting in the online blog/discussion led me to think about course concepts outside of class time.
12. The professor's expectations about how to post in the online discussion/blog were clear.
13. The points assigned for online posting were appropriate.
14. The professor recognized how much I posted in the online discussion/blog.
15. I received more response from the professor during class because of my online posting.