IS THE WHOLE GREATER THAN THE SUM OF ITS PARTS? A COMPARISON OF SMALL GROUP AND WHOLE CLASS DISCUSSION BOARD ACTIVITY IN ONLINE COURSES

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ABSTRACT

Methods for characterizing asynchronous text-based discussions have received significant attention in the literature. In this study, we examine student and instructor posts made in seventeen undergraduate mathematics courses over the duration of a fifteen-week semester (n=6964 posts). We apply our previously developed multifactor discussion board metric to compare differences in student participation, quantities of student posts, quality of posts, extent of threading, and instructor presence in small group and whole class discussion board activities. Results from this study indicate that small group discussions contained greater levels of student participation, greater quantities of posts per student and greater numbers of educationally valuable (content-related) posts per student as compared to whole class discussions within these courses. Interestingly, small group discussions contained a greater proportion of less educationally valuable posts as compared to whole class discussions.

KEYWORDS

Distance Learning, Discussion Board, Asynchronous Learning, Cooperative Learning, Collaboration, Educationally Valuable Talk, Metric, Mathematics, Online Learning

I. BACKGROUND

Despite the body of literature that endorses cooperative learning strategies, particularly for face-to-face instruction in K-12 settings, the results from higher education and online courses are less conclusive. Most of these concerns have been raised from case study based research. Therefore, we sought to characterize trends on a larger scale by examining differences in participation, quantity of student posts, quality of posts and instructor presence in all online mathematics courses offered by Empire State College that contained both small group and whole class discussion formats. By examining differences within each course section, we observed how each group of students and their instructors differed in their posting behavior in the small group and whole class context.

Cooperative learning is a task that is often split into subtasks performed independently by team members and later assembled into a conjoined product. Collaborative learning is a process of mutual and shared concept building through socially mediated processes [1]. Collaborative approaches to learning and instruction have roots in constructivist theory and Vygotsky's theory of socially constructed knowledge. If we consider that a class discussion is a social exchange in which an understanding and framework for course concepts is negotiated, all discussion board activity may be considered a collaborative activity. In

this study we consider all types of discussions (small group and whole class) to be collaborative in nature, and note that small group activities are structured according to cooperative principles which are a subset of collaborative skills. Cooperative learning is considered to be a specialized subset of collaboration. It is characterized by small groups that work according to principles of positive interdependence, and, ultimately, receive a group evaluation which is equal to, if not more important than, an individual evaluation [2]. Positive interdependence is the perception that group members "succeed if and only if all learners succeed so that they must coordinate their efforts" [3, p. 56]. Interdependence may be facilitated by course design features and instructional practices that require groups to deliver a common product, perform interdependent tasks (division of labor), utilize shared resources, assume specific interdependent roles within the group, and receive individual rewards based on group performance [3,4].

The benefits of cooperative learning approaches that have been cited by education researchers include increased achievement, increased exposure to diverse perspectives, increased student participation in the educational process, and increased peer exchanges. A full review of cooperative learning theory is beyond the scope of this paper. Interested readers may wish to refer to works by Johnson and Johnson or Slavin for a comprehensive overview of theory in this area [5, 6,].

One of the greatest benefits of working in small groups is that students can engage in active learning modalities that allow for problem solving beyond the scope of any one individual [7]. Intuitively, it would seem that asynchronous discussion forums would enhance small group interaction. Such forums offer groups more flexibility and extended thinking time between contributions. In theory, this benefits the quality of exchanges [3]. In practice, however, many groups fall short of these aims, particularly in the online environment. Several researchers report barriers to cooperative learning in online environments, such as non-participating students [8, 9, 10], off-topic posts [1, 4, 8, 11, 12] and students' negative attitudes toward group work [13, 14]. Some researchers have found the addition of structure and guidelines improves students' perceptions of group work [14, 15, 16], while other researchers advocate heterogeneous groups [7], establishing individual and group accountability [17], and creating positive interdependence through roles or rewards [4].

Non-participating group members have been reported to pose significant challenges to small group activities in the online context. In a case study of twenty-five students in online courses in education, students reported that collaboration was problematic [10]. Students rarely communicated with each other via email, and in small group assignments teamwork was difficult due to uncooperative students. While simply participating in a discussion is not a sufficient condition for learning to occur, broad participation is certainly a necessary condition for the discussion to be of value [8]. Students who do not participate or do not participate fully lead to groups with partial knowledge exchange, in contrast to groups who exhibit a more distributed knowledge exchange [9].

A second area of concern relates to the content of students' posts in small group discussions. Theoretically, students and instructors can socially construct knowledge through asynchronous discussion. Students may confirm or modify pre-existing cognitive schema through interacting in their Zone of Proximal Development [18]. Scaffolding provides a means by which existing schema may be connected to new ideas related to course content. Problematically, several researchers have found that small group discussions tend to contain a significant portion of posts that are not related to the academic content. A discussion in which the majority of posts are not related to course content or cognitive process may have limited potential for the social construction of knowledge. In a cross-case study of nine online courses, students in collaborative writing activities spent significantly more time discussing division of labor instead of academic content, as compared to other discussion formats [11]. In other case studies, a similar pattern emerges with off-topic or logistical/planning posts often accounting for up to 50% of the

discussion board contributions [1, 4, 8, 12].

Therefore, it is not surprising that students report negative attitudes toward small group work in the online environment. In a large survey of the State University of New York's online course consortium (SUNY SLN), students' perceived learning was negatively correlated with the portion of course grades associated with group or cooperative assignments [13]. "Students' comments indicate that it was difficult to get group members to work together on projects in the few courses in which collaborative learning was tried" [13 p. 516]. This finding is also supported by the work of other researchers who report negative student reactions to small group cooperative learning activities [10, 14].

Several factors can influence the success or failure of a group's effectiveness for the social creation of knowledge, such as group characteristics (i.e. size, composition), group interactions and individual characteristics [7]. Factors such as the type of task, individual vs. group accountability and individual differences may influence the relative success of online collaboration [17]. Some researchers suggest that individual characteristics play a role in group cooperation insomuch as they assume that an individual's desire to be part of a group, to be valued by others, and to desire communication account for intrinsic motivation for group affiliation [4]. Problematically, these factors may not be at work in an online adult learning setting. Adults are often busy and value a direct path to learning. Thus, the task of group learning may be viewed as inefficient. Concerns over the impact of the group project on individual grades may also create anxiety. Similarly, instructional style may also play a role in how classes of students interact through discussion forums [11, 22]. We also acknowledge that course content may play a role in how students collaborate in online discussions. Results obtained from teacher education or language learning courses may or may not apply to more problem-based courses such as mathematics. Lastly, we also acknowledge that features of online learning management systems may also influence interaction patterns.

The problem with many studies is that a single case study or cross-case study approach is often used [1, 4, 7, 9, 10, 12, 14]. Thus, it is difficult to determine whether observations are specific to a group of learners, course content, instructional style, and/or learning management system. In this study, we used a paired measures design in which small group and whole class participation were paired in each course. In this manner, we measured the difference in participation in small group and whole class discussion in each of the seventeen courses we observed. Similarly, we also used a paired measures design to examine student quantity of posts. This allowed us to determine how talkative students were once they decided to participate in small group and whole class discussions. Thirdly, we sought to characterize the extent to which students discussed rather than reported on their learning. A key assumption of cooperative learning theory is that students in such activities will experience a greater number of exchanges and opportunities for discussion. We wondered, however, whether this assumption holds true in the online environment. In both whole class and small group asynchronous text-based discussion, there is no limit to the number of exchanges. The extent to which students may discuss material in the whole class setting may not be as limited in the online environment as it is in the face-to-face environment.

II. QUANTIFYING DISCUSSION BOARD ACTIVITY

Characterizing asynchronous text-based discussions has received significant attention in the literature. Although several strategies have been proposed [11, 19–23], they are not suitable for use with large data sets and often confound factors (student participation with student quantity of posts or instructor presence with class size).

In Bliss and Lawrence [24], we developed and applied a multi-factor discussion board metric that is suitable for comparative studies. This metric allows for comparison between classes with different enrollment sizes and allows for a quantitative description of student participation, quantities of student posts, quality of posts, extent of threading, instructor presence, presence of expectations and guidelines for feedback, and presence of feedback.

In this study, we examine 17 online mathematics courses that contained both whole class and small group discussions. We define small group discussions as those in which groups of two to five students participate in an asynchronous text-based discussion to which only they and the instructor have access. In contrast, we define whole class discussions as asynchronous text-based discussions that are open to the entire class and for which participation is expected. We did not include optional discussions, such as the "Ask a Question" board. By basing our comparisons within each class, we are able to hold the following factors constant: course content, and individual student and instructor differences. Thus, we are able to examine the effect of discussion fragmentation on discussion board activity patterns.

A. Student Participation

In our previous research [24], we argue that while we might hope that all enrolled students will engage in all learning activities (including discussions), this is often not the case in practice. We defined participation as the proportion of enrolled students who decide to post to a discussion board. This definition allowed for comparisons to be made between course sections of different sizes. Student participation is an important item to quantify and is not synonymous with the quantity of posts. Participation describes the proportion of enrolled students who post to a discussion board whereas quantity of posts describes how talkative students are once they decide to participate.

B. Quantity of Student Postings

Several strategies for measuring the quantity of student posts have been proposed. One approach is to divide the number of total posts made in a course by the number of discussion forums [11]. This measure does not allow for accurate comparisons between classes of different sizes and also does not reveal trends between different discussion board types within the same course (i.e. small group vs. whole class). A measure that accounts for this is advantageous for comparative studies. Another common measure in the literature is to report the number of student posts per discussion forum divided by the number of students enrolled in the course [22, 25–28]. The problem with this approach is that not all students who are enrolled in a course participate in every discussion. To adjust for this, we define quantity of student postings as the number of student responses divided by the number of active students in a discussion. This measure provides us with a glimpse of how talkative our students are once they have decided to participate.

C. Quality of Student Postings

Several strategies for measuring quality of posts have been provided in the literature. Most of these are either too detailed or too general to provide sufficient data for quantitative comparisons. For an analysis of a small number of courses, a highly detailed rubric for content analysis can be an appropriate tool for fine-grain analyses of message content [3, 20, 28, 29, 30, 31]. Using this type of analysis on a large data set (i.e. an entire department's online course offerings) would most likely require two researchers working full-time (40 hours/week) for several months. Most academic units who wish to review discussion board interaction patterns do not have the human resources for such analysis. At the other end of the spectrum, more generalized approaches do not often yield quantifiable and tractable data [19, 21]. One general definition of 'quality' of student posts is "the extent to which the message covers the topic that the course

experts have identified as significant and the depth (granularity) to which the topics have been explored" [19, p. 266]. Problematically, this definition is highly subjective and difficult to quantify. Another attempt defines quality as clear or unclear [21]. Problematically, a post may be clear, but clearly off-topic. In our previously developed discussion board metric, we therefore proposed the inclusion of a new paradigm for measuring the quality of student postings.

Uzuner has proposed a dichotomous categorization of educational talk: Educationally Valuable Talk and Educationally Less Valuable Talk [32]. Educationally valuable talk (EVT) is "a particular interaction pattern in online discussion threads characterized as dialogic exchanges whereby participants collaboratively display construction, and at times, critical engagement with the ideas or key concepts that make up the topic of an online discussion, and build knowledge through reasoning, articulations, creativity and reflection" [32 p. 402]. Educationally less valuable talk (ELVT) may be defined as "talk that lacks substance in regard to critical and meaningful engagement with the formal content or ideas that are discussed in the posts of others in an online discussion" [32 p. 404]. ELVT posts are typically short posts that do not add new content related to the academic discussion. It is worth noting that although such posts are termed educationally less valuable, they are still valuable in terms of developing social presence and a community of learners.

Using the dichotomous categorization (EVT vs. ELVT) allows for a clear, intuitive and efficient manner by which to classify posts as being related to course versus posts which are off-topic or add little depth or breadth to the forum. Coding discussion board transcripts in this manner requires one researcher approximately one hour to code seventy-two posts. Depending on the length of the discussion, the coding time for one discussion board may range from thirty minutes to two hours. More authentic methods of measuring posts' perceived educational value exist (i.e. interviews, journaling), however, the EVT/ELVT method provides a metric by which one can measure the quantity (and proportion) of discussion posts which are related to the educational content of the course.

D. Extent of Threading

Threading is defined as the level to which discussion has been generated in asynchronous text-based discussion boards. Previous studies have quantified the extent of threading by measuring the average thread length [11, 22, 27]. Since this is an average, this index tends to blur the distinction between posts which are unanswered, those which generated only a single reply and those which generated discussion. We characterize the extent of threading by three broad categories: unanswered posts, acknowledged posts (posts with only first level replies), and posts which lead to discussion (posts with two levels or more of replies). Knowing the relative number of posts in these distinct categories would provide useful information on the extent to which discussion and peer interactions occurred within a discussion.

E. Instructor Presence

Significant debate exists in the literature over the role of instructors in online discussions [11, 27, 33, 34]. The debate is more fully discussed in the development of our multi-factor discussion board metric [24]. For a suite of courses taught by different instructors, techniques for quantifying instructor responsiveness to student posts on discussion boards become important tools for characterizing discussion board interaction patterns. We measure instructor participation as the raw count of instructor responses per participating students in the discussion forum. This is a particularly useful way to quantify instructor presence for discussion boards with unequal numbers of participating students. For example, this measure would report a low level of presence for an instructor who makes four posts on a message board of twenty students as compared to a message board of four students. We are primarily interested in whether

instructors are more or less present in small group discussions as compared to whole class discussions.

III. METHODS

Seventeen online undergraduate mathematics courses offered by the Center for Distance Learning at Empire State College were observed for the entire duration of their delivery. Courses were delivered over a fifteen-week semester in an entirely online asynchronous format, beginning in January 2008. Discussion boards, course syllabi, private folders and grade books were observed during this time period. The result was an analysis of 6,964 posts made over 239 message boards. Only courses which contained small group and whole class discussions were included in this study. Not included in the analysis were the "Ask a Question" board, "Student Lounge" and the "Icebreaker" discussion. Discussion boards were observed and quantified two weeks after their due date to capture late posting students' contributions. Transcript analysis was performed by the principal investigator who developed the method described in our previous paper [24].

A. Student Participation

Student participation was calculated by the number of students participating in a message board, divided by the number of students enrolled in the course at the time of the message board. For each course, we also recorded the number of students who participated in whole class discussions and the number of students who participated in small group discussions.

$$Student\ participation\ = \frac{\#\ of\ students\ participating\ in\ discussion}{\#\ of\ students\ enrolled\ in\ the\ course}$$

B. Quantity of Student Postings

The quantity of student posts for each discussion board was calculated as the number of student posts on a message board divided by the number of students participating in the message board.

$$Quantity\ of\ student\ posts = \frac{\#\ of\ student\ posts}{\#\ Students\ participating\ in\ the\ discussion}$$

This formula indicates how many posts students were making on discussion boards and in the course overall when they chose to participate.

C. Quality of Student Postings

Transcript analysis was conducted to assess the quality of posts. Student and instructor posts were coded as Educationally Valuable Talk (EVT) or Educationally Less Valuable Talk (ELVT) according to the definitions set forth by Uzuner [32]. The percent of EVT was calculated by dividing the number of EVT posts by the total number of posts.

$$Quality = \frac{\#\ of\ EVT\ posts}{Total\ \#\ of\ posts}$$

D. Extent of Threading

For the purposes of this study, three conversation styles were defined (Fig. 1). The "speak" style was

defined by an original post to which there was no reply. The "speak-reply" style was defined by an original post which receives only one reply or several replies only one layer deep. The "discuss" style was defined by an original post, which contained replies at least two layers deep.

Conversation Style	Example
Speak (Unanswered posts)	Math is Great…Posted by Mary

Speak-reply (Level 1 replies)	Math is Great…Posted by Mary
	   Re: Math is Great…Posted by Bob
	   Re: Math is Great…Posted by Cindy

Discuss (> Level 2 replies)	Math is Great…Posted by Mary
	   Re: Math is Great…Posted by Bob
	     Re: Math is Great…Posted by Mary
	   Re: Math is Great…Posted by Cindy

Figure 1. Conversation Style Categories

E. Instructor Presence

Instructor presence is calculated by dividing the quantity of posts to a discussion board made by an instructor by the number of active students. This was done in order to facilitate comparisons between classes with different enrollments. Using participating students in this calculation was a more accurate measure of how "responsive" instructors were to student posts.

$$Instructor\ presence = \frac{\#\ of\ instructor\ posts}{\#\ of\ students\ participating\ in\ discussion}$$

IV. RESULTS

The results of this study indicate that there were significant differences in participation, quantity of posts, quantity of educationally valuable posts, and proportion of educationally valuable talk in small group as compared with whole class discussions.

A. Student Participation

The proportion of students who participated in discussion boards varied between courses and between different sections of the same course (Fig. 2). Overall, we were interested in whether a larger or smaller number of students participated in whole class discussions or small group discussions. For each course, the number of students who participated in whole class discussions and small group discussions was recorded. The mean number of students who participated in whole class discussions was 6.68, compared to a mean of 13.99 students who participated in small group discussions. Using a paired t-test for sample means, student participation was found to be significantly greater in small groups than in whole class discussions (t= -6.65626, p<.001, df=16).
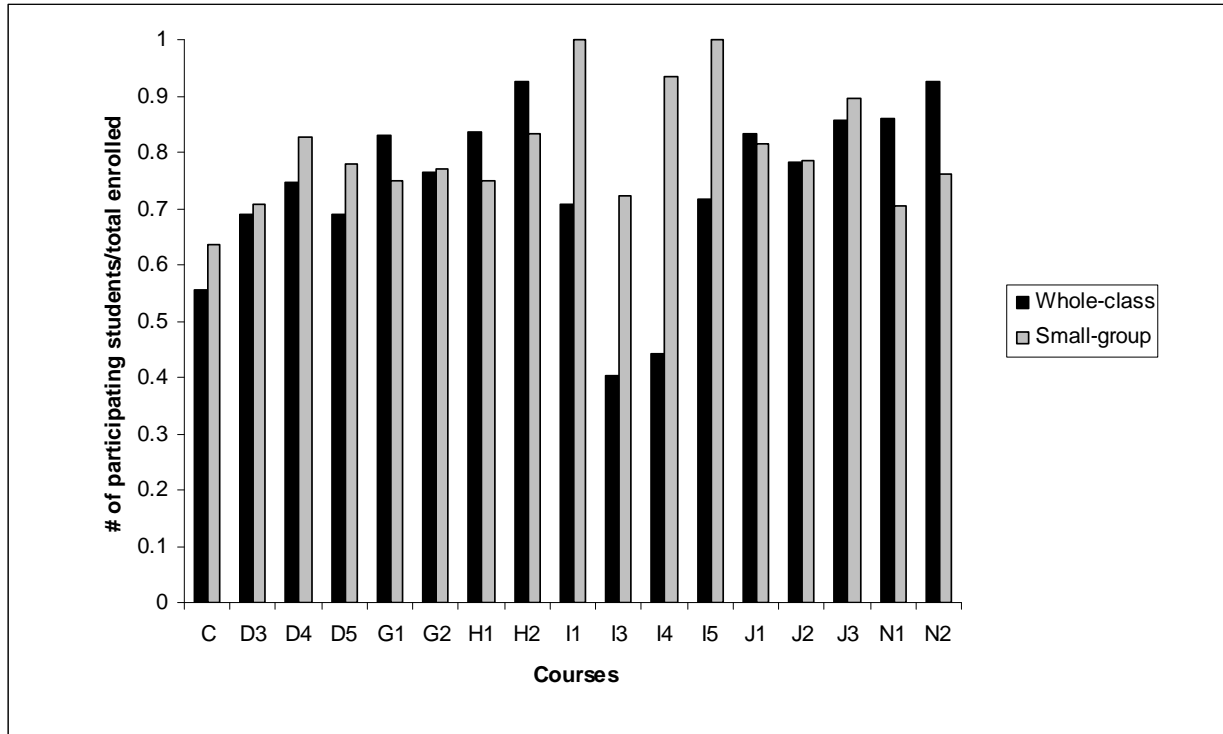
Figure 2. The Proportion of Students Participating in Whole Class and Small Group Discussion Boards. Courses are designated by letters and course sections are designated by numbers. For example, G1 represents section 1 of course G. Course codes match course code presented in [24]. Since not all courses from the larger study contained small-group discussions, some courses (i.e. course sections A1 and A2) are omitted.

B. Quantity of Student Postings

A greater quantity of student posts was found in small group discussions as compared to whole class discussions (Fig. 3). The mean number of student posts in small groups was 7.28 posts per student per discussion board, while the mean quantity of student postings for whole class discussions was found to be 2.87 posts per student per discussion. Using a paired t-test for two sample means, this difference was found to be significant (t= - 10.14, p<.001, df=16).
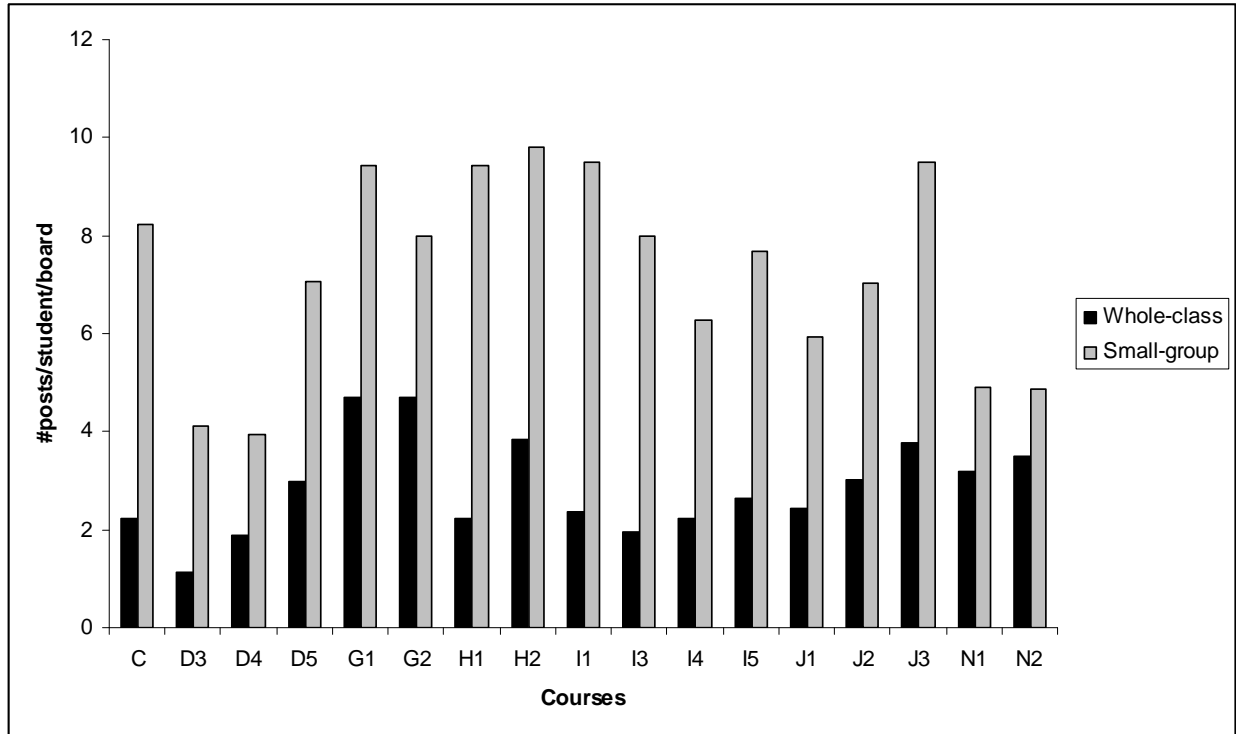
Figure 3. The Mean Number of Posts Per Participating Student Per Discussion Board in Whole Class and Small Group Discussions. Course codes match course code presented in [24]. Since not all courses from the larger study contained small-group discussions, some courses (i.e. course sections A1 and A2) are omitted.

C. Quality of Student Postings

Small group discussions contained a lower proportion of total posts devoted to educationally valuable talk as compared to whole class discussions (Fig. 4a). Interestingly, this trend was not revealed when looking at the numbers of EVT posts per student per discussion (as compared to the proportion). The mean number of EVT posts per student per discussion was 1.77 for whole class discussions as compared to 2.46 for small groups (Fig. 4b). Using a paired t-test, the quantity of EVT posts was found to be significantly higher in small group discussions than in whole-class discussions ($t = -2.712$, $p < .05$, $df=16$).   This indicates that although students did post more EVT posts in small groups, the activity was accompanied by a disproportionate increase in the number of ELVT posts (i.e. posts related to group processes such as delegation of duties and procedural planning, brief statements of agreement and brief statements of appreciation to each other). The disproportionate increase in the number of ELVT posts resulted in a greater proportion of ELVT in small-group discussions, even though the quantity of EVT posts was significantly greater in small-group discussions.
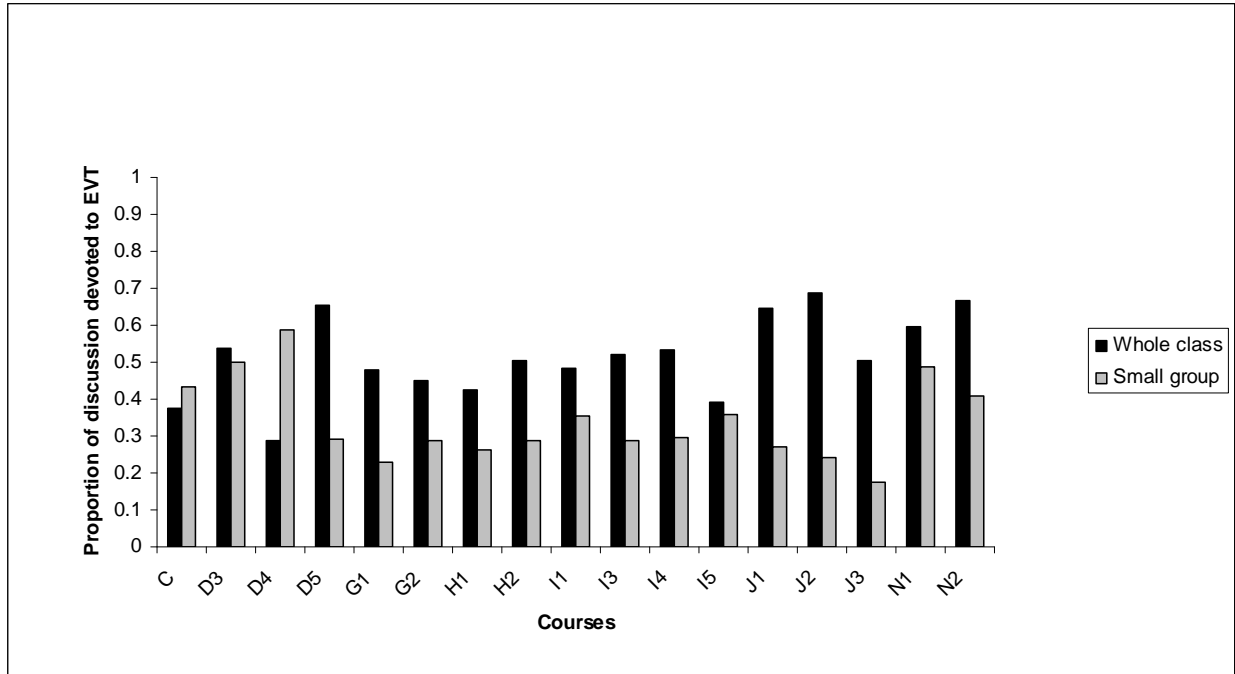
Figure 4a. The Proportion of EVT Posts Made Per Participating Student Per Discussion Board in Whole Class and Small Group \Discussions. Course codes match course code presented in [24]. Since not all courses from the larger study contained small-group discussions, some courses (i.e. course sections A1 and A2) are omitted.

Figure 4b. The Mean Number of EVT Posts Made Per Participating Student Per Discussion Board in Whole Class and Small Group Discussions. Course codes match course code presented in [24]. Since not all courses from the larger study contained small-group discussions, some courses (i.e. course sections A1 and A2) are omitted.
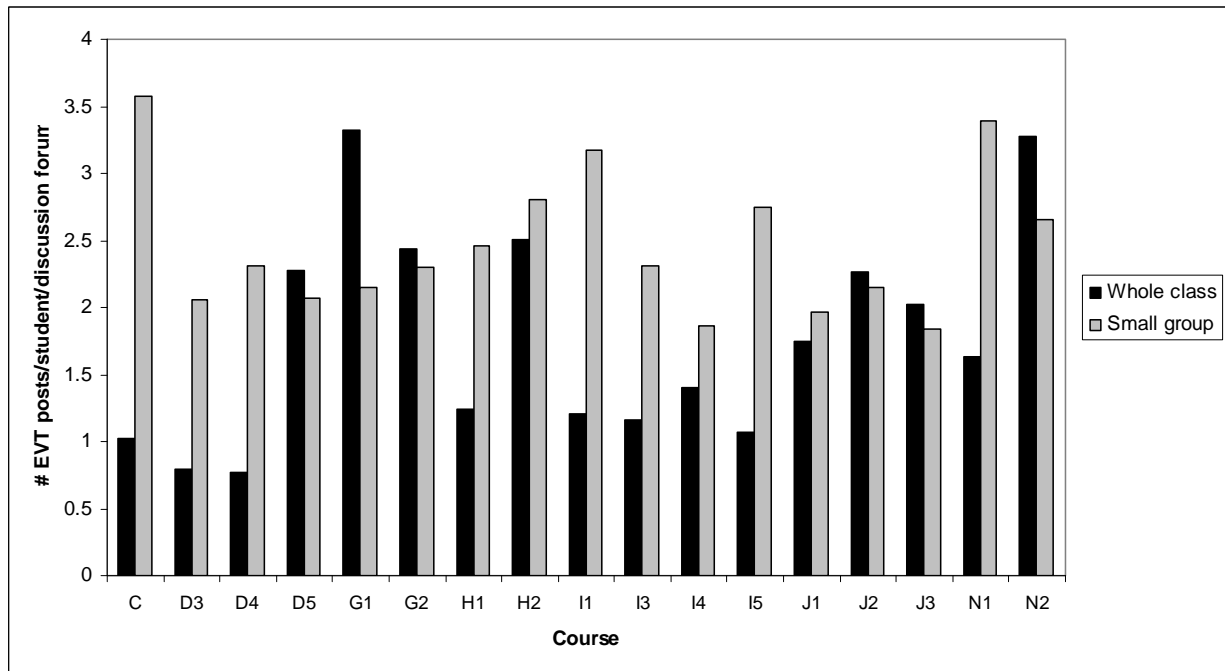
D. Extent of Threading

No significant difference was found in the number of original threads that led to discussion in small group as compared to whole group discussions.

E. Instructor Presence

No significant difference was found in the number of instructor posts per student per discussion board in small groups as compared to whole class discussion.

V. DISCUSSION

Our study measured student participation, quantity of posts, quality of posts, threading and instructor presence, and compared these measures between whole class and small group discussions within seventeen courses. Our intent was to hold constant individual and course content differences. Rather than look at small group and whole class discussions in different courses or single courses (as in a case study), we measured differences in the same learners grouped in whole class and small groups. The results of this study support some claims that small group activities afford such benefits as increased student participation, peer interactions and the development of socially constructed knowledge.

Theory suggests that cooperative learning activities will increase peer interactions and can lead to the development of socially constructed knowledge. Participation in discussions is a necessary requirement for discussion activities to serve their intended role in online courses. Similarly, a sufficient number of posts that are related to course content and generate student interaction must be made in order for the creation of socially constructed knowledge. Student posts and participation may be viewed as requisites for peer interaction. Likewise, posts which are related to the academic content (quality posts) and discussion style interactions can also be viewed as necessary, but not necessarily sufficient conditions for the development of socially constructed knowledge.

Work by other researchers suggested that student participation was problematic in small group discussions in online classes [8,9,10]. However, these studies were highly qualitative and not quantitative. Ad hoc evidence gathered at Empire State College also suggested that student participation in small group activities was waning. Both students and instructors reported that one of the biggest barriers to cooperative learning was non-participating students. For example, if a small group of four students is creating a group product, one missing student can stall the group's ability to move forward. Despite these comments, the results of our study indicate that student participation was actually higher in small group discussions than in whole class discussions. Therefore, one may conclude that a non-participating student is noticed more in the small group setting. The results of our study show that small group discussion boards contained greater quantities of student posts (as measured by posts per participating student per discussion board) as compared to whole class discussions. This indicates that students were more vocal in small group discussions, once the decision to participate was made. This supports the idea that small group settings may promote student participation and contributions.

We do not attempt to discern whether knowledge was created by learners through the process of posting and reflecting on message boards. We do claim, however, that quality posts (as defined by educationally valuable or 'content related' posts) are a requisite. Interestingly, small group discussions contained a significantly greater number of educationally valuable posts per student; however the proportion of the total conversation devoted to educationally valuable talk was lower in small groups compared to whole class discussions. This finding is in line with the findings of other researchers who also found a large

percentage of posts not related to academic content [1,4,8,9,11,12]. We note that even though greater numbers of EVT posts per student were made in the small group setting, this increase appears to have been surpassed by even greater numbers of ELVT posts per student in these small groups.

In reviewing the pattern of interaction, we became concerned with the type of posts made in small group discussions. We observed that students frequently divided a task among group members, completed this portion and then reported back to the group with their portion of the task completed. Significant numbers of ELVT posts at the beginning of the small group discussions were devoted to planning and task assignment. At the end of the small group discussions, significant numbers of ELVT posts were again devoted to planning details such as how to compile each member's piece into one document, who would be responsible for posting the final product, and the timeline by which this should be accomplished. If higher order cognitive processing were occurring, we would have expected to see a greater proportion of posts which contained evidence of reflection, heuristics, critical analysis, and argumentation. We did not see evidence of these types of posts.

Ideally, we would like to see small-groups engage primarily in content related discussion and have the opportunity to fully construct, critique and evaluate their conceptualization of course content. In reality, though, researchers have observed that a substantial proportion of small-group discussions are often devoted to group processes and group coordination [9]. One study found that small group discussions were composed of 26.72% planning, 25.86% contributing, 27.59% seeking input, 15.52% reflection/monitoring, and 4.31% social interactions [1]. Assigning roles or having students choose roles may be one strategy to help reduce frustration and increase efficiency in group process interactions. Some evidence suggests that groups with role assignments have a higher percentage of on-task communication not correlated with an effect on grades [16]. Other researchers found that out of students assigned to the roles of summarizer, moderator, theoretician, and source searcher, the students in summarizer roles exhibited higher levels of knowledge acquisition [15]. Interestingly, however, other work found that groups with no role structure and no reward (grading) contained significantly more cognitive interactions than the role group and significantly more cognitive interactions than the reward (grade) group [4]. Groups with reward and role structure had more interactions than other groups and significantly more group process interactions than other groups. Adding structure to groups, either through roles or rewards (i.e. grades), is correlated with additional posts about group processing. We encourage more work in this area, particularly in relation to small-group discourse in online mathematics courses.

A requisite for increased peer interaction is increased threading. While there were significantly more posts per student per message board in the small group setting, there was not significantly more threading. Thus, it is possible that students are making more contributions in the small groups, but not necessarily interacting with each other more.

The results of our work indicated no significant difference between instructors' participation in small group and whole class instruction. Instructors who maintained a presence in the group helped to encourage and restructure groups in the event of non-participating members and also helped to encourage groups to reach consensus. This led some groups to then explore and critically analyze the task at hand.

Interestingly, we found it difficult to measure expectations and guidelines for small group and whole class discussions. We found that guidelines, when present, were not different for small group discussions as compared to whole class discussions. This lack of information points to a need for increased guidelines and structure for small group work. If small groups are used to meet pedagogical objectives that are distinct from, if not complementary to, whole class discussion, then they should be structured as such and

students should be informed of the expected outcomes.

In summary, our results provide us with a mixed view of the benefits of cooperative learning activities in the courses that we examined. While there do appear to be some benefits in terms of student participation and quantities of student posts, there do not appear to be added benefits in terms of the level of threading of discussions. The extent to which knowledge may have been socially constructed in small group settings and whole class discussions remains our primary concern. We wonder, given the 'divide and conquer' approach of small group work evidenced by many of the groups in our study, whether the whole class discussions may foster deeper levels of cognitive processing. As a result of fragmentation, there may be a loss of synergy required to move discussions to greater depths of understanding, thus creating a 'whole is greater than the sum of its parts' phenomenon. Further research in this area, particularly within the realm of undergraduate mathematics courses would be particularly fruitful.

VI. CONCLUSIONS

A multi-factor metric that was previously developed was applied to seventeen undergraduate mathematics courses. This work suggests that small group work may facilitate student participation, greater quantities of posts and greater quantities of educationally valuable posts. Concerns regarding the extent to which educational content is discussed, as opposed to presented and compiled, deserve attention and may be mediated by adequate structuring and facilitation strategies. This paper demonstrates how our previously developed metric [24] may be applied, and begins to establish parameters by which future comparisons may be made.

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