Small Group Work and Whole Group Discussion Mediated Through Web Conferencing Software

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Abstract
This paper reports on a case study that explored the benefits and challenges of facilitating group work activities in a synchronous web-conferencing environment for advanced high school students in an undergraduate mathematics course. Results are based on data collected from online student surveys and a content analysis of synchronous online discussions among students during group work and whole group discussion activities. Findings of this study include that, relative to whole group discussions, small group work activities resulted in an increase in the involvement of students, and the comments students made were off-topic, less social-emotional, more academic, and more task-oriented. This case study also confirmed earlier findings that group work in a synchronous environment can facilitate social and cognitive support, foster student satisfaction, and help students share alternate solution pathways and receive individualized feedback. This study has implications for those educators who are involved in distance education programs for high school students, or are considering the use of group work activities in synchronous online environments.

Keywords: group work; collaboration; online; community; synchronous; mathematics; high school; web conferencing; mathematics; algebra

Introduction
Small group interaction has been long identified as an activity for learners to co-create knowledge and understanding through dialog and reasoning in online environments, and also to reduce participants' sense of isolation through fostering social presence and community (Fahy, 2006; Hrastinski, 2008, p. 505; Rovai, 2002). This dual perspective recognizes small group learning as an activity with both cognitive and social purposes, which must be balanced for group dynamics to be productive. Developing and facilitating learning activities in such a way to balance these functions has posed challenges to facilitators in synchronous learning environments mediated through web-conferencing (WC) software. Potential challenges in facilitating learning activities in these environments can include the emergence of off-topic conversation, and an amount of simultaneous student involvement that is overwhelming and exhausting to both students and instructors (Cornelius, 2014; Hou & Wu, 2011; Kear, Chetwynd, Williams, & Donelan, 2012). The identification of factors and teaching practices that can affect the balance between academic and social discourse in a web conferencing environment is an area of ongoing research.

The goal of the case study described in this report is to build on to the existing literature on synchronous online learning by comparing how students interact over a web conferencing environment during small group work activities (GWA) and whole group discussion (WGD). The methods and analysis of this study are guided by the following questions.
1. From the perspective of advanced high school students in an undergraduate level course, what are the benefits and challenges of engaging in small group work activities within a WC environment?
2. What impacts do small group work activities have on student involvement in synchronous learning sessions conducted through WC software?

These research questions aim to help characterize potential opportunities and challenges in developing community and facilitating group work in synchronous online sessions. It is hoped that findings from this study will contribute to the ongoing research on facilitating learner-centered environments over WC software.

**Literature Review**

The use of small group work and other learner-centered (Bransford & Brown, 1999, p. 134) activities facilitated over web conferencing software has been investigated through recent case studies. In a study involving 26 graduate students (Bower & Hedberg, 2010) learner-centered learning activities, many of which involved group work in Adobe Connect, resulted in higher rates of student discourse as compared to instructor-centered activities. Students took greater ownership over their learning and engaged in conversation was more focused on content when they were engaged in learner-centered activities. Cornelius (2014) found that some instructors avoided the use of breakout rooms that enable small group work activities: facilitating such activities in WC software can be challenging, and some instructors retreated towards teacher-led approaches (p. 269).

Cornelius & Gordon (2013) made a number of logistical recommendations on the use of breakout rooms based on the perspective of learners. Their suggestions included using a timer, choosing names for breakout rooms, and allowing learners to move in and out of breakout rooms. Bower (2011) found that student-centered activities required that students be more responsible for knowing how to operate WC technologies to interact and collaborate with others. He also observed that a “gradual, just-in-time approach to synchronous collaboration competency development enables students to practice their skills as they are required and reduces the risk that their capabilities are forgotten” (p. 80). Instructors also have a different set of technical competencies in student-centered activities, and that the instructor becomes more responsible for providing troubleshooting support when students experience technical problems. Altogether, these case studies that focused on learner-centered activities mediated over a WC environment, do give us insight into managing a complex process. But the external reliability of extrapolating these individual findings to other educational contexts is, as all of the authors have pointed out, to be carefully considered. Only a small sample of learning episodes with a limited set of instructors and courses were examined.

The way learners use synchronous online communication to build both social and cognitive support can also be understood through comparative studies that highlight differences between the way learners engage in synchronous and asynchronous computer-mediated communication (CMC). For example, Oztok, Zingaro, Brett, & Hewitt (2013) conducted a quantitative analysis on the content of synchronous and asynchronous messages made by 222 students enrolled in nine online education courses in Canada. They found evidence that synchronous and asynchronous media served purposes that were different and complimentary: synchronous communication filled a “social gap” for some students that may not have exited under asynchronous forms of communication alone, while asynchronous media offered higher levels of cognitive support (p. 15). Giesbers, Rienties, Tempelaar,
& Gijselaers (2014) conducted a study involving 110 students that explored the relationships between synchronous and asynchronous CMC in an online economics course. They found that engagement in synchronous communications positively affected engagement in asynchronous communications. Based on a qualitative analysis of two online distance education courses, Hrastinski (2008) also found that synchronous use of instant messaging (IM), as compared to the use of asynchronous discussion boards, provided more social support. Synchronous discussions “included quite a number of social support exchanges (13–18%) while the asynchronous ones included very few (1–2%)” (p. 504). Moreover, social statements occurred more often at the beginning and end of classes and during group work activities.

In other studies, the audio and video channels that WC tools support have been described as particularly helpful for fostering social presence (Kear et al., 2012, p. 962; Peacock et al, 2012) and social bonding (Cornelius, 2014, p. 268; Nicholson, 2002). It would seem that WC software can offer a space where students can build online community and social presence, more so than through asynchronous tools. Indeed, these studies suggest that synchronous communication tools lend themselves for building both cognitive and social support through collaboration and community.

The benefits of building community and collaboration in online and distance learning have been explored in previous studies. Wellman & Gulia (1999, p. 177) described how the development of online community and collaboration have been found to have a positive synergy, in that learners who have a strong attachment to a group are more likely to participate to help others in the group, and interactions with peers can also foster community. There is also evidence that high school students want community in online courses, and synchronous online CMC can be used to foster community (Murphy, Rodriguez-Manzanares, & Barbour, 2011). In their review of supporting the distance education learner, Moisey & Hughes (2008) stress the importance building online community to ensure student success and persistence. Synchronous technologies, they argue, support interaction among learners that give them a sense of shared understandings, problems, or passion for a particular topic.

An area of ongoing research related to these findings is the development of teaching practices to manage the amount and quality of learner participation. To prevent learners from talking over each other, or to prevent certain learners from dominating the discussion, researchers have made several suggestions: maintaining control over the use of microphones, turn taking strategies, and allowing students to use IM in addition to audio communication (Martin, Parker, & Deale, 2012, p. 246; Kear et al., 2012, p. 961). On the other hand, teaching strategies that encourage input from learners whose participation is minimal have not been extensively studied. Cornelius & Gordon (2013, p. 279) describes some of the issues that can be created when there are some learners who do not participate in synchronous online learning sessions, and McBrien, Jones, & Cheng (2009) reported that synchronous communication can help shy students participate. Neither of these studies offer teaching strategies that engage students whose participation is minimal: there is still much to be learned in terms of how to best develop and facilitate group work activities in a web conferencing environment. The next section describes how, based on the existing and related literature, student participation data were collected.
Methods

Research Setting

The sample for this study consisted of twenty advanced high school students who were enrolled in a multi-section mathematics course offered through the Georgia Tech Distance Calculus Program (DCP) (Morley, Usselman, Clark, & Baker, 2009). The DCP is a distance education program that offers two consecutive semester-long multi-section mathematics courses to over 400 high school students per year. In the Fall 2014 semester, the first of these courses explored Calculus and Linear Algebra concepts, which will be the focus of this study.

DCP courses are simultaneously offered to undergraduates attending Georgia Tech and to high school students who are located throughout Georgia and unable to attend lectures on campus. DCP courses offer synchronous 50-minute sessions five mornings per week for sixteen consecutive weeks. Students view live lectures that are facilitated by an instructor on three of these mornings. On the other two mornings, students are divided into smaller sections to connect to recitations, during which teaching assistants (TAs) engage in activities that focus on areas that have been addressed in lectures and assignments.

Since the DCP began in 2005, high school students have connected to lectures and recitations through video tele-conferencing (VTC). In the 2012/13 academic year the DCP began offering an alternate format for a small group of high school distance students who could connect to recitations with WC software (Mayer & Hendricks, 2014). The purpose of introducing the WC format was to increase enrollment from schools that could not otherwise participate due to financial barriers introduced by the use of VTC equipment. Another goal of this alternate format was to offer an environment that would foster community and engagement among students who were geographically isolated from their peers in this program; a small number of high schools have only one or two students participating in the DCP per year.

All of the participants in this study were enrolled in the recitation section that used WC software. When applying to the DCP, all students were asked to indicate their gender and ethnicity. 17 identified as male, 3 as female. 10 students identified as being White, 7 as Asian, 1 as having two or more racial identities, 1 as African-American, and 1 as Latino/a. At the beginning of the program, all students were between the ages of 15 and 17 years (inclusive), six were in their junior year (11th Grade), and the remaining 14 were in their senior year (12th Grade).

All twenty-six recitation sessions were facilitated using Adobe Connect. Study participants were lent microphones and Wacom Bamboo splash tablets for the duration of the program to help them participate in recitation activities. All sessions were recorded so that students could watch these recordings at any time, if for any reason they could not attend a session, or wanted to review the content again.

The TA that facilitated these sessions had two years of prior experience facilitating WC sessions for this course. Session activities consisted of either whole group discussion (WGD) or group work activities (GWA). GWA always involved all learners in one discussion. One TA led a discussion that involved solving a set of problems similar to homework activities, or taken directly from old quizzes. Students could only interact through the WC system using the IM tool, and the TA encouraged
involvement by asking them questions that they could answer via IM or the polls tool. Group work was facilitated by assigning students into groups of three to five people using the “Random Distribution” tool that Adobe Connect offers. During GWA and WGD, learners solved mathematical problems that were similar to homework activities, or taken directly from old quizzes and exams. A screen capture of a moment during WGD is presented in Figure 1. Students could also see a video feed of their TA captured with a web camera, which is redacted in the figure for the purposes of ensuring a blind review. To minimize unnecessary distractions, they were not allowed to use web cameras during recitations after the first recitation session (Mayer, Lingle, & Usselman, 2015). Figure 2 shows a screen capture of a moment during a group work activity.

Figure 1: A screen capture of a moment during a whole group discussion

Figure 2: A screen capture of a moment during a group work activity
During group work, students were encouraged to select different pen colors, so that they could better distinguish who was writing at any given time. The TA circulated between the groups every few minutes. There were 3 to 5 students per group, and 3 to 5 groups, depending on attendance.

**Data Collection**

One of the strengths of case-study research is that it can identify variables in complex processes that are of greatest interest, and allow researchers to move toward an abstract theory (Neuman, 2011, p. 42). Indeed, an assumption of this research was that participation in a WC environment is a complex process, requiring the use of several data collection methods in order to gain a deeper understanding of relevant conversation dynamics and triangulate study findings. To this end, the underlying research questions of this study were explored using a combination of online surveys, a qualitative content analysis of comments made during recitation, video recordings of the recitation sessions, and log data that specified when students accessed Adobe Connect.

An online survey was developed to collect descriptive statistics to measure students’ sense of satisfaction, collaboration, and community. The questionnaire was developed by adapting and combining items from three validated survey instruments. Four items from the College and University Classroom Environment Inventory (CUCEI) (Fraser & Treagust, 1986) were incorporated. The CUCEI consists of 49 items in two formats (preferred and actual), on a 4-point Likert scale, divided into seven sub-scales. One sub-scale was selected: satisfaction (the extent of enjoyment of classes). Items were modified by replacing “class,” “classes,” and “instructor,” with “recitation,” “recitations,” and “teaching assistant.” Five items from a scale in the Online Student Connectedness Survey (Bolliger & Inan, 2012) were also incorporated to measure the level of online community that the students felt they had with their peers in the recitation. Six items from the Distance Education Learning Environments Survey (Walker & Fraser, 2005) were also incorporated to measure the extent to which students wanted to collaborate with each other, and another five items were used to measure the extent to which students feel that they were collaborating with each other. All items were measured on five-point ordinal scales.

A number of open-ended questions were asked on the survey to explore student perspectives on the benefits and challenges of engaging in online collaboration and developing online community. Online surveys took approximately 15 minutes to complete, remained open for two weeks, and was administered in August 2014 at the end of the first week of the course, and in January 2015 at the start of the second course in the DCP.

Students were able at all times to use instant messaging (IM) in Adobe Connect to send messages that all participants can read at any time during the recitation. All comments sent between students were archived and time-stamped by Adobe Connect. These transcripts were used to calculate comment rates and to apply a qualitative content analysis. Adobe Connect also recorded the times that students logged in and out of recitations sessions. This log report was used, along with the recitation transcripts, to calculate comment rates (Martin et al., 2012; Lobel, Swedburg, & Neubauer, 2002; Oztok et al., 2013).

The purpose of the content analysis was to explore how the distribution of comments made by students varies according to activity type. In the interest of drawing comparisons to existing findings in the
distance education literature, transcript data was coded using both two existing qualitative frameworks: Interaction Process Analysis (IPA), and the coding scheme for the content analysis of Knowledge Construction Social Interaction (KCSI) in synchronous learning activities.

The IPA framework was developed to study interactions in small groups (Bales, 1950). The original IPA consists of 12 complementary-paired group processes; these are further subdivided into four major functions, describing communications issues or problems. Bales (1950) found that groups struggled to find a balance between the need to accomplish their work, and the desire to achieve a harmonious interpersonal climate. IPA has been used to study face-to-face learning environments (Lockheed & Klein, 1985), and also in online environments to compare interactions between moderators and students, between male and female learners, and between synchronous and asynchronous communication (Chou, 2002; Duin & Archee, 1996; Fahy 2006; Finegold & Cooke, 2006; Kumar, Beuth, Rosé, 2011; Tomai, Mebane, Rosa, & Benedetti, 2014). The KCSI framework (Hou & Wu, 2011) incorporates Gunawardena, Lowe and Anderson’s (1997) coding scheme of social knowledge construction, and consists of four dimensions: knowledge construction, task coordination, social interaction, and off-topic discussion. This scheme was used to characterize the nature of unsupervised discourse conducted over synchronous IM tools in an undergraduate course. IPA and KCSI are defined in Appendix I.

IM transcripts of seven of the twenty-six recitation sessions of the Fall 2014 semester were selected for coding. Three TAs coded every comment made from 8:05 am to 8:55 am in the selected transcripts, separately, and met once after each transcript was coded to discuss discrepancies. Whiteboard interactions were not coded, but coders watched the video recordings of recitations to better understand the context under which comments were made. In the interest of focusing on the research questions and increasing inter-rater reliability, transcript data was only coded according to the four KCSI dimensions and the four IPA functions: IPA processes and KCSI phases were not coded. The comment was taken to be the unit of analysis and every comment was assigned exactly two codes by each of the three coders: an IPA code and a KCSI code.

There remains some debate in the education literature over how to best measure internal consistency (Bower & Hedberg, 2010, p. 469; De Wever, Schellens, Valcke, & Van Keer, 2006, p. 10). De Wever et al. (2006) recommends that for a synchronous CMC discussion, analyzed with three coders, that the percentage agreement, $A$, and the Krippendorff’s alpha statistic for ordinal data, $\alpha$, be used. These statistics are reported for both coding schemes separately. The agreement, $A$, is the ratio of the number of agreements and the number of comments. An agreement is a comment that has been labeled as the same code by all three coders.

**Results and Discussions**

**Survey data**

Of the 20 participants, 16 students responded to the August 2014 administration of the online survey, and 12 to the January 2015 administration. Items from the survey were converted to numerical values, and then averaged to obtain the results that are presented in Table 1.
Table 1: Average scores on the online survey. Items are rated on a scale from 1 to 5.

<table>
<thead>
<tr>
<th></th>
<th>Aug, N=16</th>
<th>Jan, N=12</th>
<th>Difference</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>satisfaction</td>
<td>4.44 (0.67)</td>
<td>4.60 (0.54)</td>
<td>0.16</td>
<td>0.09</td>
</tr>
<tr>
<td>collaboration, desired</td>
<td>3.94 (0.81)</td>
<td>4.10 (1.00)</td>
<td>0.16</td>
<td>0.13</td>
</tr>
<tr>
<td>collaboration, perceived</td>
<td>4.06 (0.64)</td>
<td>4.28 (0.69)</td>
<td>0.22</td>
<td>0.03*</td>
</tr>
<tr>
<td>community, perceived</td>
<td>3.25 (1.05)</td>
<td>3.65 (1.26)</td>
<td>0.27</td>
<td>0.02*</td>
</tr>
</tbody>
</table>

All four constructs were well above the midpoint of 2.5 at the August 2014 administration and showed small increases after the conclusion of the first semester. Statistically significant increases were only found in the perceived levels of Community (t-test, p = 0.02) and Collaboration (t-test, p = 0.03). Potential factors that may have led to these observed differences are discussed in Section 5.1.

Open-ended questions on these surveys asked students to describe the benefits of collaboration activities and developing online community. These data were analyzed for thematic content. Codes were constructed first by identifying themes in the transcript, which were then organized and linked to define key categories (Neuman, 2011, p. 512). Table 2 summarizes the coding categories, their definitions, examples, and category frequencies in the August 2014 and January 2015 survey data.

Table 2: Coding categories and results to the open-ended question “What are some of the benefits, if any, of working with other students during recitations?”

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Example</th>
<th>Aug</th>
<th>Jan</th>
</tr>
</thead>
<tbody>
<tr>
<td>personalized instruction</td>
<td>the student benefits from receiving assistance that targets specific areas they are struggling with</td>
<td>“if you don’t know how to solve a problem, then someone else you work with might be able to”</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>alternate solution strategies</td>
<td>students have the opportunity to share alternate solution strategies with other students</td>
<td>“people can present their methods of solving a problem that are different”</td>
<td>38%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Table 2 indicates that 8 out of 16 respondents (50%) in the August 2014 survey data, and 6 out of 12 (50%) of the respondents in the January 2015 survey, described how small group work activities allowed them to receive personalized instruction that targeted areas they needed assistance. The sharing of alternate solution methods was also perceived to be a benefit to students reported at both time points. Results in tables 1 and 2 help characterize potential benefits of creating opportunities for collaborative activities in WC environments.

Another open-ended question asked students to describe the benefits of developing online community. Table 3 summarizes results obtained from the coding of their responses.
Table 3: Responses to the open-ended question “What are some of the benefits, if any, of getting to know other students in your recitations?”

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Examples</th>
<th>Aug</th>
<th>Jan</th>
</tr>
</thead>
<tbody>
<tr>
<td>easier to collaborate</td>
<td>getting to know other students made it easier to be involved in recitation activities</td>
<td>“It would be easier to share thoughts and opinions”</td>
<td>44%</td>
<td>25%</td>
</tr>
<tr>
<td>networking</td>
<td>connecting with other students to either develop new friendships or contacts</td>
<td>“Connections with other people my age who might end up going to the same school as me”</td>
<td>44%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Students found that developing online community had two benefits; it made it easier to contribute to collaborate with others, and it helped them network. These data have relevance to determining the extent to which high school students have opportunities to develop online community in DCP courses. The interest that students expressed in networking with their peers may have to do with contextual parameters specific to this study: half of the study participants had no other peers in the DCPs at their school. Results in tables 1 and 2 help characterize potential benefits of creating opportunities for creating online community among advanced high school students.

Students were also asked open-ended questions in the survey regarding the use of text chat in recitations. When asked “What are some of the reasons, if any, that you DO NOT like the discussion in the chat pod”, 4 students out of the 16 survey respondents (25%) in the August survey, and 8 students out of 12 respondents in the January survey (75%) mentioned off-topic discussion. An example response was “some students will be talking about something unimportant and it drowns out or interrupts an explanation to a good question”. In other words, some students perceived off-topic discussion as something that can inhibit learning. This finding has relevance to deciding how to best moderate learning activities.

Comment Counts and Comment Rates
Table 4 presents the total number, and rate at which, students wrote comments during WGD and GWA. Using comment counts and activity durations, comment rates were calculated by dividing the total number of comments by the total duration of each activity.

Table 4: Descriptive statistics of entire IM transcript data

<table>
<thead>
<tr>
<th></th>
<th>WGD</th>
<th>GWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>total number of comments</td>
<td>7,979</td>
<td>7,722</td>
</tr>
<tr>
<td>number of comments made between 8:05 to 8:55</td>
<td>6,001</td>
<td>5,876</td>
</tr>
<tr>
<td>number of comments made outside of 8:05 to 8:55</td>
<td>1,978</td>
<td>1,846</td>
</tr>
<tr>
<td>% comments made outside of recitation hours</td>
<td>25%</td>
<td>24%</td>
</tr>
<tr>
<td>average number of words per comment</td>
<td>4.06</td>
<td>4.34</td>
</tr>
<tr>
<td>total time spent during recitation (in hours)</td>
<td>17.7</td>
<td>6.3</td>
</tr>
<tr>
<td>comment rate between 8:05 to 8:55 (in comments per hour)</td>
<td>339</td>
<td>933</td>
</tr>
</tbody>
</table>
Roughly 75% of the comments students typed were made during official recitation session (between 8:05 am and 8:55 am): students voluntarily attended recitations before/after they end to ask questions related to their course, finish worksheet problems they were given during recitation, or to socialize. Table 4 also indicates that the comment rate increased during group work. This finding is consistent with another recent case study (Bower & Hedberg, 2010), which found that student-centered learning activities increased student involvement rates.

Figure 3 shows the total number of comments that students wrote, as a function of time, across all recitation sessions held over the sixteen-week semester.

![Figure 3: Total # of comments made by students using IM during recitations over the entire semester.](image)

Figure 3 helps clarify the nature of the learning activities and comment rates in this environment. Recitations often began with WGD, and some students were involved in discussions outside of the official time of the recitation session. GWA were held in fourteen of the twenty-six 50 minute recitation sessions. Over the entire semester, a total of 17.68 hours were spent in GWA and 6.32 hours in GWA, between 8:05 and 8:55.

**Content Analysis**

All student IM comments made in seven recitation sessions, randomly selected, were combined to create a single transcript of 2872 comments. The transcript was coded using the KCSI and IPA schemes. Internal consistency results are shown in Table 5. Krippendorff Alpha values, $\alpha$ were calculated with a MATLAB routine for nominal data (Eggnik, 2012).

<table>
<thead>
<tr>
<th>Framework</th>
<th>Number Agreements</th>
<th>Number Disagreements</th>
<th>$A$</th>
<th>$\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCSI</td>
<td>2433</td>
<td>439</td>
<td>84.8%</td>
<td>0.8300</td>
</tr>
<tr>
<td>IPA</td>
<td>2307</td>
<td>565</td>
<td>80.2%</td>
<td>0.8004</td>
</tr>
</tbody>
</table>

Table 5: Internal consistency of coded data for both schemes using percentage agreement, $A$, and Krippendorff alpha, $\alpha$
Figure 4 and Table 6 summarize coding results for the two coding schemes separately. Findings from other case studies are provided for comparison purposes, and two-way contingency tables that combine data obtained from both the IPA and KCSI instruments are provided in Appendix II.

![Figure 4: Fall 2014 and Spring 2014 KCSI frequency data and those reported in Hou & Wu (2011)](image)

### Table 6: Summary of IPA frequency data, comparing study data in WGD and GWA, and to those found in other studies that employed IPA in online learning environments

<table>
<thead>
<tr>
<th>Study</th>
<th>Modality</th>
<th>Facilitator(s)</th>
<th>Group size</th>
<th>% task-related</th>
<th>% social-emotional</th>
</tr>
</thead>
<tbody>
<tr>
<td>present study, WGD</td>
<td>synchronous WC</td>
<td>one TA</td>
<td>20</td>
<td>66%</td>
<td>34%</td>
</tr>
<tr>
<td>present study, GWA</td>
<td>synchronous WC</td>
<td>one TA</td>
<td>3 to 5</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>Duin &amp; Archee (1996)</td>
<td>synchronous text chat</td>
<td>no facilitator</td>
<td>2</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>Chou (2002)</td>
<td>synchronous text chat</td>
<td>student groups</td>
<td>90</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>Chou (2002)</td>
<td>asynchronous forum</td>
<td>no facilitator</td>
<td>90</td>
<td>92%</td>
<td>8%</td>
</tr>
<tr>
<td>Fahy (2006)</td>
<td>asynchronous forum</td>
<td>one instructor</td>
<td>25</td>
<td>89%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Chi-square test for homogeneity revealed a significant difference between the overall proportions of WGD and GWA contributions across the four KCSI dimensions, $\chi^2(4, N = 2872) = 1890, p < 0.01$, and across the four IPA functions, $\chi^2(4, N = 2872) = 76, p < 0.01$. Relative to WGD, an increase in the proportion of IPA task-related and KCSI academic comments in GWA was observed. The proportion of off-topic comments made by students was 22% lower in GWA than in WGD, and the proportion of academic comments was 15% higher. These changes may have occurred because during GWA, learners needed to coordinate their efforts to collectively solve a given problem, and because students were given a limited amount of time to do so. These changes may also have been found because students were randomly assigned to groups, and so were not necessarily working with people that they knew as well as their peers from the same school. Observed increases in the proportion of
logistical comments may have occurred because students were engaging in a learner-centered activity, which gave students opportunities to discuss how to use technology to solve their work, which would be consistent with Bower’s (2011) case study.

Interpretation of IPA findings in Table 6 can be aided by drawing comparisons to those found in other studies that utilized IPA in synchronous online learning environments. The proportion of task related comments made by students in WGD was 8% higher than that reported in a study that investigated communication patterns made by two learners in synchronous chat (Duin & Archee, 1996). The students in that study had no facilitator and the learners determined the duration of the session. The proportion of task related comments made by students in WGD was similar to that found in Chou’s case study (2002), where student groups took turns facilitating discussions with a large group of learners. The facilitator-to-learner ratio and the extent to which the activity was instructor-centered may help explain these similarities.

The proportion of task related comments made by students in WGD was more than 20% lower than those reported in two case studies that employed IPA to investigate asynchronous communication (Chou, 2002; Fahy, 2006). This finding is supported by other evidence that asynchronous CMC tends to be more formal, more academic, and less social than synchronous CMC (Oztok et al., 2013; Hrastinski 2008; Johnson, 2006). Combining the findings from these studies together suggests a number of factors that could affect the proportion of task-related and social-emotional conversation, including whether the communication is synchronous or asynchronous, the number of students involved in the activity, the activity duration, and input from a facilitator. Gender may also play a role in affecting this ratio (Tomai et al., 2014).

The scatterplot in Figure 5 gives us another perspective on the differences between communication patterns during GWA and WGD. Each dot in the scatterplot below represents a given student (there are 20 participants, so there are 20 dots in Figure 5). The comment rate for a given student, for both activities, was calculated by dividing the total number of comments the given student made in each learning activity, and then dividing by the total number of hours they spent in that activity. Recall the Adobe Connect log report provided the times students that were logged in for every session.

![Figure 5: Scatter plot showing comment rates (in comments per hour) made by students in WGD and GWA](image)
Figure 5 suggests that almost all students were more active during WGD than during GWA. A more detailed understanding of the nature of these interactions can be found when we explore results from the content analysis.

Each dot in Figure 6 represents a given student, for a given learning activity and KCSI dimension. There are 20 participants and 4 dimensions, so there are 20 dots in Figure 6A and another 20 dots in Figure 6B. Comment rates were calculated by first counting the total number of comments each student made in each dimension and each learning activity for the seven recitations that were selected for coding. Those numbers were then divided by the total number of hours they spent in that activity, in the seven recitations.

![Figure 6: Scatter plot showing comment rates made by students that were identified using the KCSI framework as either A) academic (orange), or off-topic (purple), or B) task coordination (green) or social (blue).](image-url)
Figure 6 sheds further light into findings presented in Table 4 and figures 4 and 5. Firstly, most students did not contribute to off-topic conversation in either activity, and most of the off-topic comments were made by a small group of students in WGD. Secondly, the seven students who wrote the most off-topic comments during WGD were less involved in this conversation dimension during GWA. Furthermore, most students increased the rate at which they made academic, logistical, and social comments during GWA. A small group of students decreased their academic comment rate in GWA, but students also acquired access to a whiteboard in GWAs, so these students may have been more focused on whiteboard interactions. Essentially, the changes that are summarized in Figure 4 between these two learning activities were not accomplished by all students changing their interaction patterns equally. Factors that may have led to these changes are explored in Section 5.2.

Discussion

The Benefits of Online Community and Group Work Activities

The level of Online Community measured through the online survey (Table 1) may have increased over the duration of the semester because the 20 study participants were attending 10 different high schools from across Georgia, and participated in learning activities that involved student-student interactions. The increase in the Online Community construct (Table 1) is supported by findings from other case studies that also found that students are able to develop a sense of community over online synchronous communication platforms (Nicholson, 2002; Oztok et al., 2013, p. 15; Schwier & Balbar, 2002; Hrastinski 2006; McBrien, Jones, & Cheng, 2009). Although the desired level of collaboration did not change significantly, it was well above the midpoint. Johnston & Barbour (2013, p. 237) found, as in this study, that there were advanced high school students interested in online collaborative tasks with their peers. One of the advantages students expressed in developing community is that it made it easier for them to participate in discussions with their peers. This particular dynamic confirms earlier findings (Wellman & Gulia, 1999, p. 177) and may have led to the small but significant increase in the actual collaboration scores (Table 1). Finally, benefits that students may realize from sharing alternate solution pathways in solving complex problems is consistent with findings from the mathematics education research that has focused on collaborative learning (Hurma & Järvelä, 2005; Swan, 2006). Educators using synchronous platforms who are interested in increasing student community may wish to consider the use of synchronous communication and the use of group work activities, but should note that case studies at the higher education level have found that not all students are enthusiastic in engaging in this kind of activity (Guzdial et al., 2002; Martin et al., 2012, p. 237). Best practices in the development and facilitation of synchronous online collaboration activities is an ongoing area of research.

Differences in the Nature of Discourse in GWA and WGD

The IPA and KCSI frameworks employed in this study enabled significant differences between discourse across two learning activities to be quantified and compared to other case studies. Statistically significant differences between the proportion of task-related, off-topic, and academic comments between the two activities were found. Although off-topic comments may provide a pathway for students to develop online community, they were also perceived as an unwanted distraction during WGD. Limiting access to the IM could be used as a method to limit off-topic discussion, but study findings suggest that facilitators may be also accomplish this goal through using group work in breakout rooms.
Differences in the comment distributions between the present study and those reported by Hou & Wu (2011) can be attributed to several factors. In the present study, the duration of the group work activities were limited, groups sizes were limited to three to five students, all sessions had a teaching assistant who circulated between rooms to assist students, the participants were advanced high school students, and the content analysis did not include comments before or after the official time that the sessions were held. The synchronous sessions in Hou & Wu’s (2011) study allowed students to freely meet at any time for any duration, groups consisted of seven to ten undergraduate students, discussions were unsupervised, and all comments made in these sessions were used for their qualitative analysis. Likewise, the proportion of task related comments in the present study and those obtained in asynchronous learning environments (Fahy, 2006; Chou, 2002) are consistent with findings from the literature that has shown that discussions over asynchronous media tend to be less social than those offered by synchronous tools (Oztok et al., 2013; Hrastinski, 2006). All together, this case study and others that used the same content analysis frameworks provides us with a better understanding of what variables can influence the balance between cognitive and social support in online learning environments. The extent to which an activity is student-centered, the input of a facilitator, the duration of the learning activity, and the number of students per group are just some of the parameters that can be adjusted to control the focus of a conversation in a given learning activity.

Study Limitations and Further Research

Findings presented in this case study are not generalizable to all contexts for several reasons. Results are based on a small population of advanced high school students. Observed group dynamics may lie in the particular activities and structure that the teaching assistant facilitated: observed communication patterns would have been different with other teaching assistants. Interactions observed in this particular model are constrained by the features afforded by particular WC tools that were used. Non-observable communication would likely have occurred during recitations through face-to-face interactions between students attending the same school, via private messaging through the WC software, or through other means. Moreover, due to limitations of the software being used, whiteboard interactions are anonymous to both instructors and students: a more complete picture would be obtained if a WC system were able to identify and record who is writing at any given time. Finally, comments made before and after the recitation times were not studied. The nature and purpose of these conversations could be very different from those interactions held during the recitation, and could be the subject of a further study. Indeed, findings in this report point to areas that suggest further study. IPA has been applied in over a dozen studies (eg - Lockheed & Klein, 1985, p. 201; Fahy, 2006; Chou 2002; Tomai et al., 2014), an analysis that summarizes their findings may help give us a better understanding of the complex interrelationships among the many variables that influence the nature of discourse in a synchronous learning event. Secondly, although our findings characterized some of the potential benefits of developing online community, further analysis is needed to explore the many ways that it can be best developed in an online course, in particular among advanced high school students.

Conclusions

This study offers supporting evidence that students are more active in learner-centered activities (Bower & Hedberg, 2010), that the creation of online community can help students become more active in collaborative activities (Wellman & Gulia, 1999, p. 177), and that students can benefit from synchronous collaboration from sharing alternate solution pathways in solving complex problems and
receiving personalized instruction (Hurme & Järvelä, 2005; Swan, 2006). This study also found evidence that, when engaging in small group work activities, student conversations were more academic, task-oriented, and less off topic, than during whole group discussion. Off-topic discussion in whole group discussion was perceived by many students in this study as a barrier to their learning during WGD.

Study findings are relevant to the administration of distance education programs for high school students (Astani, Ready, & Duplaga, 2010; Barbour, 2012; Rice, 2006), specifically in the area of fostering of online community and collaboration (Johnston & Barbour, 2013; Mulcahy, 2002). Specific to the DCP, given that students expressed high levels of satisfaction with their recitation format and interest in collaborating with their peers, it would seem likely that group work activities is likely to continue to be supported in DCP recitations moving forward. As novice educators in online environments tend to need greater guidance on how to implement online collaborative learning (Koo, 2008; Kear et al., 2012), it may be that a focus needs to be placed on identifying ways to support teaching assistants in facilitating collaborative learning activities so that they are not absent from recitations.

Finally, by comparing results found in the present study and with others that used the same content analysis instruments, several parameters were identified that may control the nature of the development between social cohesion and knowledge construction in online synchronous learning environments. As further studies clarify the role of these parameters, educators in distance learning may be better positioned to build both pedagogically sound and cost-effective distance education programs.

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**Appendix I: IPA and KCSI Frameworks**

Definitions of the IPA and KCSI frameworks are provided here for convenience. Example comments are taken from the recitation transcript data, and multiple examples are separated by semi-colons.

<table>
<thead>
<tr>
<th>Function</th>
<th>Process</th>
<th>Paired Process</th>
<th>Example Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social-Emotional: Positive Reactions</td>
<td>Shows solidarity, raises other’s status, gives help, reward</td>
<td>Integration</td>
<td>GG guys; we da best; Hi</td>
</tr>
<tr>
<td></td>
<td>Shows tension release, jokes, laughs, shows satisfaction</td>
<td>Tension-management</td>
<td>lol; easy peasy; :P</td>
</tr>
<tr>
<td></td>
<td>Agrees, shows passive acceptance, understands, concurs, complies</td>
<td>Decision</td>
<td>i see it now</td>
</tr>
</tbody>
</table>
| Task Area: Answers | Gives suggestion, direction, implying autonomy for other | Control | Try checking your answer with $a = 1$
| Gives opinion, evaluation, analysis, expresses feeling, wish | Evaluation | $24/x^5$; no, I don't think; Ya; guys be responsible human beings
| Gives orientation, information, repeats, clarifies, confirms | Orientation | it does; it switches the chat channel
| Task Area: Questions | Asks for orientation, information repetition, confirmation | Orientation | so do you guys have mics?
| Asks for opinion, evaluation, analysis, expression of feeling | Evaluation | How did you get 14.2?; wait isn't it inconclusive?
| Asks for suggestion, direction, possible action | Control | want to move on?; Who wants to write on the board for #3 A?
| Social-Emotional: Negative Reactions | Disagrees, shows passive rejection, formality, withholds help | Decision | im lost; it's kind of confusing.
| Shows tension, asks for help, withdraws out of field | Tension-management | Nooo I can't private chat; derp; hate anything by parts; i have no idea how to taylor series
| Shows antagonism. Deflates other's status, defends/asserts self | Integration | noob; we dum; cuz your face broke it;

Table 8: The KCSI coding scheme

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Phase</th>
<th>Description</th>
<th>Example Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic-related</strong></td>
<td>Sharing/comparing of information</td>
<td>A statement of observation or opinion; a statement of agreement between participants</td>
<td>2 - 2/110 is what I got; B x B-1</td>
</tr>
<tr>
<td>Discovery and exploration of dissonance or inconsistency among participants</td>
<td>Identifying areas of disagreement; asking and answering questions to clarify disagreement</td>
<td>would you integrate by parts?; is 7/3333 right?; i feel like first term can't be 1</td>
<td></td>
</tr>
<tr>
<td><strong>Negotiation of meaning/co-construction of knowledge</strong></td>
<td>Negotiating meanings of terms and negotiation of the relative weight to be used for various agreement.</td>
<td>wait the series diverges based on the ___ ?; wait how did you get that?</td>
<td></td>
</tr>
<tr>
<td><strong>Testing and modification of proposed synthesis or co-construction</strong></td>
<td>Testing the proposed new knowledge against existing cognitive schema,</td>
<td>does that make sense to everyone?; so a thing didn't cancel that should; does that look good so far yall?</td>
<td></td>
</tr>
</tbody>
</table>
Appendix II: Contingency Tables
The two-way contingency tables below summarize findings obtained from the IPA and KCSI instruments. A total of 1549 comments made during WGD, and 1323 comments made during GWA, were coded.
Table 9: Comments made during WGD.

<table>
<thead>
<tr>
<th>Task</th>
<th>Academic</th>
<th>Coordination</th>
<th>Social</th>
<th>Off-Topic</th>
<th>Row Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>3.6%</td>
<td>2.4%</td>
<td>4.6%</td>
<td>12.8%</td>
<td>23.4%</td>
</tr>
<tr>
<td>Answers</td>
<td>32.0%</td>
<td>4.8%</td>
<td>4.7%</td>
<td>3.4%</td>
<td>45.0%</td>
</tr>
<tr>
<td>Questions</td>
<td>12.7%</td>
<td>3.7%</td>
<td>1.1%</td>
<td>3.3%</td>
<td>20.7%</td>
</tr>
<tr>
<td>Negative</td>
<td>1.4%</td>
<td>1.0%</td>
<td>1.7%</td>
<td>6.7%</td>
<td>10.9%</td>
</tr>
<tr>
<td>Column Sum</td>
<td>49.6%</td>
<td>11.9%</td>
<td>12.2%</td>
<td>26.2%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Table 10: Comments made during GWA.

<table>
<thead>
<tr>
<th>Task</th>
<th>Academic</th>
<th>Coordination</th>
<th>Social</th>
<th>Off-Topic</th>
<th>Row Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>3.4%</td>
<td>2.3%</td>
<td>8.5%</td>
<td>2.5%</td>
<td>16.8%</td>
</tr>
<tr>
<td>Answers</td>
<td>42.7%</td>
<td>7.3%</td>
<td>4.0%</td>
<td>0.7%</td>
<td>54.8%</td>
</tr>
<tr>
<td>Questions</td>
<td>15.2%</td>
<td>3.0%</td>
<td>1.1%</td>
<td>0.4%</td>
<td>19.7%</td>
</tr>
<tr>
<td>Negative</td>
<td>3.4%</td>
<td>1.7%</td>
<td>3.0%</td>
<td>0.6%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Column Sum</td>
<td>64.8%</td>
<td>14.4%</td>
<td>16.7%</td>
<td>4.2%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>