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Experiences of Advanced High School Students in Synchronous Online Recitations

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ABSTRACT

The question of how to best design an online course that promotes student-centred learning is an area of on-going research. This mixed-methods study focused on a section of advanced high school students, in college-level mathematics courses, that used a synchronous online environment mediated over web-conferencing software, and whether the affordance of multiple communication channels and student-centred activities affected involvement, cohesion, and satisfaction. Study participants reported that anonymous input and group work activities encouraged their involvement in learning activities, increased their satisfaction, and fostered social cohesion. Although the on-going management of technical issues limited student involvement and satisfaction, there were no differences in final grades obtained by students participating in this delivery format and their peers participating in an alternate learning environment facilitated by video-teleconferencing. This study offers supporting evidence that a student-centred learning environment mediated over web conferencing software can foster social cohesion, student involvement, and student satisfaction.

Keywords

Web conferencing, Synchronous learning, High school

Introduction

Distance learning can take many formats, ranging from live but non-interactive radio broadcasts, to highly facilitated and interactive web-based courses, to completely asynchronous large scale Massive Open Online Courses. Each affords different benefits and is appropriate for different audiences, and the challenge for course designers and instructors is to best utilize the different platforms to maximize participant learning.

This study is part of the evaluation of the Georgia Tech Distance Calculus Program (DCP), which is an Advanced Calculus and Linear Algebra course sequence offered to a live audience of traditional on-campus college students and simultaneously to approximately 450 high school students via synchronous video tele-conferencing (VTC). In an effort to increase a sense of community among those high school students that have exceptionally strong math skills but, who attend schools without a solid peer group of like-minded students, Georgia Tech initiated an experimental DCP recitation section that used computer-mediated communication (CMC) in a synchronous online learning environment, mediated using web conferencing (WC) software. The goal was to promote student-centered learning and encourage active student involvement and cohesion.

It is widely accepted in the distance education literature that WC software can be used to immediately provide feedback in real time and build a sense of social cohesion among students (Hrastinski, 2008; Oztok, Zingaro, Brett, & Hewitt, 2013). Unlike older forms of synchronous communication in distance education, including VTC, WC technologies can support simultaneous communication over several different channels, or media. These media include instant messaging (IM), polls, audio and video, as well as a shared whiteboard that participants may contribute to anonymously and that enables students to import, collaboratively share, and annotate various types of documents. Some WC tools allow breakout rooms where students can engage in synchronous group work. The benefits and challenges of facilitating group work in synchronous online environments has not yet been extensively studied, but in asynchronous environments recent case studies have found that small group work activities can develop teamwork skills, trust, and cognitive processes among learners (Biasutti, 2011; Tseng & Yeh, 2013).

Students and instructors communicating over multiple channels creates unique challenges in facilitating learning in ways that promote student-centered learning and social cohesion without unnecessarily introducing cognitive overload, technical issues, and off-topic conversation (Cornelius, 2014; Cornelius & Gordon, 2013; Kear, Chetwynd, Williams, & Donelan, 2012; Martin, Parker, & Deale, 2012; Olson & McCracken, 2015). The process of managing multiple channels has been described as overwhelming and stressful to facilitators of WC learning environments (Cornelius, 2014; Kear et al., 2012; Peacock et al., 2012).

To address these challenges, it has been recommended that communication be limited to only those media that are needed (Cornelius & Gordon, 2013; Martin et al., 2012). Martin et al. (2012) list teaching strategies for instructors who are new to the WC environment. They suggest that the instructor "do not give eboard access unless they need it" and that the "private chat option can be disabled if you do not see the need for it … students prefer to use the private chat option to talk to their classmates/teammates" (p. 249).

It is not yet clear which communication channels are best suited for a given learning activity in the WC environment. Some argue that audio and video channels are particularly helpful for fostering social presence (Kear et al., 2012, p. 962; Peacock et al., 2012) and social bonding (Cornelius, 2014, p. 268). On the other hand, one study found that high school students prefer to use IM over other communication channels in the WC environment (Murphy, Rodríguez-Manzanares, & Barbour, 2011), and another argued that the WC facilitator "consider whether video or audio is really necessary", and to "choose how to use the media at your disposal to suit the situation" (Cornelius & Gordon, 2013, p. 280). Certain channels can also present more technical challenges than others. IM has been reported to be useful for those participants who are experiencing technical issues with other channels and provides a medium that supports socialization and elaboration (Carrington, Kim, & Strooper, 2010; Cornelius, 2014, p. 267). There is much to be learned in terms of identifying the learning activities, teaching practices, and communication channels that best guide learners towards a given set of learning goals.

The present study explores the following questions regarding the experiences of the high school students in the DCP.

- Is there a difference between the grades obtained by students participating in a WC delivery format, relative to their peers who participate in a delivery format administered over VTC?
- Do different learning activities and the affordance of different communication media affect student involvement, student satisfaction, and social cohesion during synchronous online learning sessions mediated with WC software?
- How do high school students use technologies to communicate with other participants in a synchronous learning environment mediated over WC software?

The first research question aims to explore whether the final grades obtained by students in the WC format are different from those of their peers who are enrolled in the same program and instead rely on VTC technology. The last two questions aim to characterize the learning activities and communication channels that students benefit from and how they may be better supported in future iterations of this distance education program.

Methods

Participants and context

The sample for this study consisted of twenty advanced high school students who, in the 2013/14 academic year, were enrolled in two consecutive multi-section mathematics courses offered through the Georgia Tech DCP (Morley, Usselman, Clark, & Baker, 2009). The first course focused primarily on Linear Algebra, the second on Multi-Variable Calculus. These courses are simultaneously offered to undergraduate students attending Georgia Tech and to high school students who were distributed throughout Georgia.

DCP courses offer synchronous 50-minute sessions five mornings per week. Students view live lectures that are facilitated by an instructor for three of these mornings, and during the other mornings students are divided into sections of roughly 50 to 60 high school students and connect to recitation sessions. In these sessions, teaching assistants (TAs) solve problems on concepts that students have encountered in lectures and assignments. TAs who facilitate these sessions are either graduate or undergraduate students and have completed a mandatory training course that deals with university teaching policies, as well as teaching strategies that promote active learning. TAs are also offered a training session on how to communicate using VTC technologies, and university staff are physically present during all of their recitations to provide technical support. All TAs are responsible for identifying and facilitating learning activities for their sessions that are aligned with course objectives and assessments.

High school students have connected to lectures and recitations through VTC since the DCP began in 2005. An additional format that relies on WC software was offered in the 2012/13 academic year for a small group of high school distance students (Mayer & Hendricks, 2014). Its primary purpose was to offer a delivery model that might promote engagement and increase community among those who were the only student in their school participating in the DCP, and possibly increase enrollment from schools that could not otherwise participate in this program due to financial barriers introduced by the use of VTC equipment.

For the first six months of the 2013/14 academic year, the WC recitation section was facilitated using Wimba Classroom, and for the last three months (for reasons that will be described later in this report) recitations were facilitated in 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. Students communicated through a number of methods during recitations, including instant messaging (IM) that was viewable to the group as a whole, private messaging, microphones, and the whiteboard editable either through the tablets or using a computer mouse. The WC tools also accommodated group work activities through the use of breakout rooms. Students in group work activities were given a set of problems from past quizzes that they would work on in groups of three to five students for ten to fifteen minutes, after which they were discussed as a group.

All twenty participants in this study were enrolled in the WC section. When applying to the DCP, all students were asked to indicate their academic year, gender and ethnicity, but not asked for their birthdate or age. Among the twenty participants, 19 identified as high school seniors, 1 as a high school junior; 16 identified as male, 4 as female; Ethnically/racially, 11 students identified as White, 5 as Asian, 3 as having two or more racial/ethnic identities, and 1 as Latino/a.

High school students admitted to the DCP are required to meet a high level of performance in mathematics. Minimum enrollment requirements include a math GPA of at least 3.5, completion of the Advanced Placement Calculus AB or BC course earning a 4 or higher on the AB Calculus exam or a 3 or higher on the BC exam, and a score of at least 600 on the Math SAT. Meeting these minimum requirements does not guarantee acceptance due to the competitiveness of the program (Eligibility Guidelines, n.d.).

Data collection methods

A mixed methods approach was utilized to answer the posed research questions. Using both quantitative and qualitative data allows for triangulation of the findings where possible, and for the weaknesses of certain methods to be balanced by the strengths of others, which improves the trustworthiness of findings (Rossi, Lipsey, & Freeman, 2003).

Research artifacts included student surveys, grades, logs of online activity, and online focus group discussions. In order to determine if differences existed in the academic performance between the students participating in the new WC section and their peers in the traditional VTC sections, average grades earned by students during the 2013/14 academic year were examined. In addition, average grades of undergraduate students participating in the campus-based face-to-face sections were also recorded, though the grades were expected to be lower due to the competitive admission requirements for the DCP.

To characterize the learning environment in the WC section, a modified version of the College and University Classroom Environment Inventory (CUCEI) (Fraser & Treagust, 1986) was administered to participating students. The CUCEI is a validated survey instrument that was developed to measure seven dimensions of actual and preferred classroom environments among students taking undergraduate and post-graduate courses. Three of the constructs that captured student perception of the actual environment were selected for the current study: (1) Involvement (the extent to which students participate actively and attentively in class discussions and activities), (2) Student Cohesiveness (the extent to which students know, help, and are friendly towards each other), and (3) Satisfaction (the extent of enjoyment of classes). Each construct has seven items, and Fraser and Treagust (1986) found the Cronbach’s alpha coefficients for these constructs in their study to be 0.70, 0.90, and 0.88, respectively. The original items were modified in the present study to reflect the current research context by replacing references to “class” with “recitation” and by replacing “instructor” with “teaching assistant.” The original four-point Likert-type response scale was maintained, which ranged from “strongly disagree” to “strongly agree.” In addition, two open-ended question, “how could recitations be improved” and “if there’s anything else you'd like us to know about the course, please write it here,” were included following the rating items to provide a better understanding of students’ perspectives of the recitation section. This survey was administered in August 2013 and in April 2014.

A "Technology Survey" was administered in September 2013 and April 2014, which focused on how students used technology during their recitations. The appendix contains the entire survey. Both the modified CUCEI and the Technology Survey were administered online.

The WC tools that were used in this study allowed students to interact with each other and with the TA via IM, a shared whiteboard, and microphones. Figure 1 shows a screen capture of a moment during a whole group discussion, facilitated by Wimba Classroom. 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. Due to technical limitations of Wimba Classroom, students were not allowed to use web cameras.

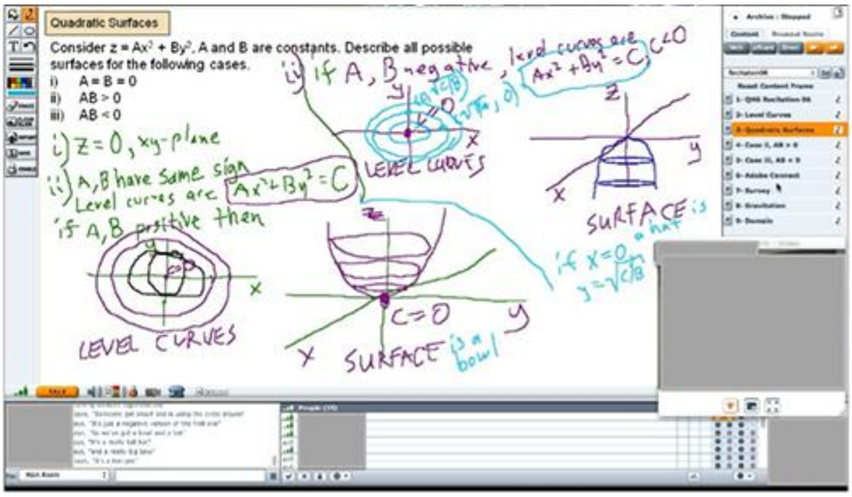

Figure 1. A screen capture of a moment during a whole group discussion facilitated with Wimba Classroom

Wimba Classroom and Adobe Connect allow students to use IM to send messages that all participants can read. Data for the current study included IM transcripts of 45 of the 49 recitations held during the 2013/14 academic year, as well as transcripts for all seven group-work activities that were conducted in Adobe Connect. Private messages sent between students cannot be recorded in either of these WC tools. Both Wimba Classroom and Adobe Connect archive the times that participants log in and out: this log report was used, along with the recitation transcripts, to calculate the rate at which students wrote comments during recitations (Martin et al., 2012; Lobel, Swedburg, & Neubauer, 2002; Oztok et al., 2013). Table 1 shows an example of the transcript data - the first 14 comments from the beginning of an exchange between four students in a group work activity.

Table 1. A conversation between four students held during a group work activity

Comment number	Student code	Time	Comment
1	11	8:35	Hello friends
2	9	8:35	Hello
3	5	8:35	hello there
4	19	8:35	Hi there!
5	11	8:35	So x is from 0 to 2,everything else is in terms of y and z
6	5	8:35	wow that was an awful x-axis
7	19	8:37	What line is that? z =2 - y?
8	19	8:38	What's the green line?
9	11	8:38	y+z = 2
10	9	8:38	z = 2-y
11	19	8:38	Okay, that's what I thought. Thanks guys.
12	11	8:39	So lets do dzdydx
13	11	8:39	x first cause it's the easiest
14	5	8:41	so we need 2 triple integrals?

The comments in Table 1 are provided to give the reader a sense of some of the interactions that are possible with group work in this synchronous online environment. A screen capture of the whiteboard that shows the end product of their concurrent group work is shown in Figure 2.

The final source of data for this study was a set of focus group discussions held during recitations for the purpose of gaining further insight into how students preferred to interact with their peers. These discussions were held at the end of the program (April 2014). During these sessions, students were only able to participate through the use of the IM tool that the WC software provided. Like survey participation, focus group participation was completely voluntary. The focus groups were semi-structured and included the following prompts.

- Students can write on the board at any time. In what ways, if any, did this help your learning in recitations?
- Is it important to get to know other students in recitation? Why/why not?
- Most students didn’t communicate with microphones very often. Why do you think this was the case?

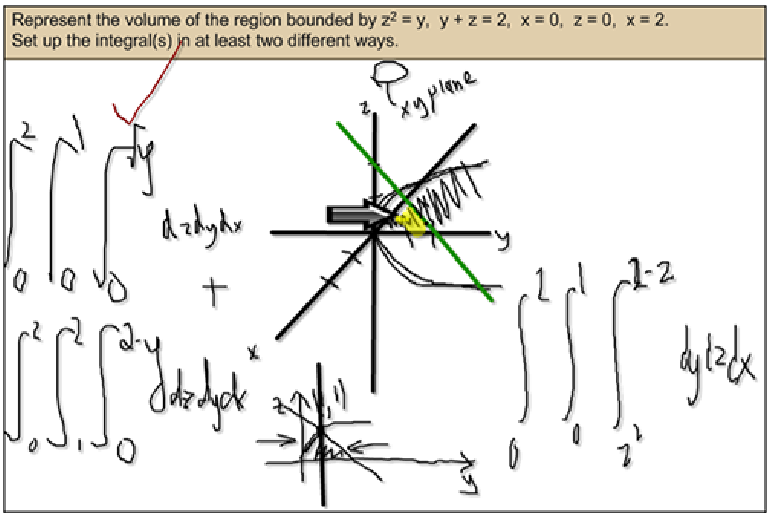

Figure 2. The end product of a group work activity produced by the students whose discussion is shown in Table 1

In order to minimize the impact on learning activities, brief focus groups were held with the same students in three consecutive recitation sections. In each focus group, one of the three prompts was presented along with any needed follow-up questions for clarification. 12 students were present for the first question, 11 students for the second, and 13 students for the third. Identified themes from the focus groups data were triangulated with survey results in order to verify and strengthen study conclusions. All qualitative data were analyzed for thematic content in which codes were first developed using open and axial coding, which were then organized and linked to form key categories (Miles & Huberman, 1994; Neuman, 2011, p. 512).

Results

Academic achievement data

Average grades for high school students participating in the WC recitation section, in the Distance Calculus VTC sections, and undergraduates in the on-campus face-to-face sections are presented in Table 2.

Table 2. Average final grades obtained by students in the WC, VTC, and on-campus sections

	Fall 2013		Spring 2014	
Delivery format	*N*	Average (*SD*)	*N*	Average (*SD*)
Distance learning, WC	20	95% (0.05)	17	96% (0.04)
Distance learning, VTC	307	95% (0.07)	293	91% (0.07)
Face-to-face	212	88% (0.11)	207	84% (0.12)

In both semesters, differences in final grades obtained by students in the WC section were not statistically significant from those in the VTC section, suggesting that students participating in these two formats performed at academically similar levels. Final grades obtained by the on-campus students (the face-to-face delivery model) are included for comparative purposes and show lower average grades than those among students in the DCP. This finding is expected given the stringent admission criteria in mathematics for those in this program, and the fact that participating students all needed to have successfully completed Advanced Placement Calculus before their senior year in high school (Eligibility Guidelines, n.d.). DCP students are drawn from a pool that contains only the most academically advanced students in the state.

Student involvement, satisfaction, and cohesion

The modified items from the CUCEI were administered to the 20 students participating in the WC recitation section. Responses were converted to numerical values (strongly disagree = 1, disagree = 2, agree = 3, strongly agree = 4). Measures of internal consistency for each of the three constructs, Cohesiveness, Involvement, and Satisfaction, were calculated using Cronbach's alpha and were found to be adequate (Kline, 2005) at 0.69, 0.77, and 0.71, respectively.

Items within each construct were averaged and then a grand average calculated across all participants. As noted previously, the instrument was administered at the beginning and end of the 2013/14 school year. Of the 20 members of the recitation section, 10 students (50%) provided responses at both time points. Table 3 presents the average ratings per construct for these students.

Table 3. Modified CUCEI results, August 2013 and April 2014 data ($N = 10$)

Construct	August 2013 (*SD*)	April 2014 (*SD*)
Cohesiveness	2.08 (0.32)	2.52 (0.40)
Involvement	3.20 (0.28)	3.28 (0.37)
Satisfaction	3.26 (0.41)	3.44 (0.43)

Satisfaction and Involvement scores were above the midpoint of 2.5 (3.26 and 3.20, respectively) at the August 2013 administration. The Cohesiveness construct was below the midpoint, with an average of 2.08 overall (near "disagree" = 2). At the conclusion of the two semesters, each of the three constructs showed an increase. Considering the matched students, the largest changes occurred in the measure of Cohesiveness (increase of 0.44), which was the only construct among the three found to have a significant increase between the August 2013 and April 2014 data ($t(9) = 4.99$, $p < .01$).

Students had high levels of Satisfaction and Involvement early in the school year and these constructs increased non-significantly by the end of the program. Students began the school year with low levels of Cohesiveness, as would be expected because they did not previously know one another, but their cohesion increased by the conclusion of the year. Because non-significant results may be due to lack of statistical power due to the small sample size, a post hoc power analysis was conducted using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) with power set to 0.80 and alpha = 0.05. Given the effect size for Satisfaction of 0.43 and for Involvement of 0.24, the analyses indicated that sample sizes would need to increase to 47 and 136, respectively, in order to detect group mean differences.

In order to better understand these results, responses to open-ended questions in the surveys, and focus group data were examined. With respect to social cohesion, a focus group session held at the end of the program explored the benefits of getting to know other students. Three students (among eleven present) described how getting to know other students had a positive impact on their learning through increasing their level of satisfaction with their recitations. One of those three students wrote "*It makes me look forward to recitations even more*." Four students in the August CUCEI survey indicated that group work was an activity that helped them develop cohesion. But other students wrote that they did not feel that cohesion was necessary. One student wrote in the April CUCEI survey, "*I don't really think it's necessary to get to know each other, but I think that working together is important and the discussions of content really help that.*" These data are consistent with the focus group discussion data on social cohesion, where three students (among eleven students present) described how getting to know each other was not essential, but working together to understand course content was beneficial to their learning. In other words, students viewed group work as an activity that promoted social cohesion and satisfaction, but the ability to help each other learn course material was the vital aspect for learning, not the development cohesion among group members.

With respect to student involvement, the anonymous nature of the shared whiteboard was also discussed. Four students (among twelve present) described how the anonymity of the whiteboard helped them be more involved during recitation activities, and four students expressed how it helped them learn from each other. Two of the comments from this discussion included "*it helped because you can learn from yours and others mistakes while also being anonymous about it*" and "*Anon makes it easier for you to put an answer and contribute to the class*."

Finally, with respect to student satisfaction, when asked on the first CUCEI in August "How could recitations be improved" five out of eighteen students described that they would like to see improvements to the WC software. One such comment made in this survey included: "*Wimba classroom seems to be a great learning tool, but also has many bugs.*" None of the students had positive comments related to Wimba in any of the surveys, and none of the comments in any of the surveys that related to Adobe Connect were negative. In an open-ended question that asked learners to describe technical issues in more detail, students described in the Technology Survey how issues they experienced limited their involvement in recitation activities. One example included "*One day, it took me about 20-30 minutes to get Wimba to load (and by that time, a considerable part of recitation was over)*." These comments suggest that technical issues impacted student involvement and satisfaction with recitation sections, and the switch from Wimba Classroom to Adobe Connect may have affected student satisfaction ratings.

Technology use

To characterize how students were involved in recitations via IM, the number of comments and words typed by students during recitations were determined. IM comments made during group work activities in Wimba Classroom could not be recorded, so group work data are only available from the seven activities held using Adobe Connect. The average number of comments that students wrote in whole group discussion per hour was calculated for each of the 45 recitations, and then the grand average across all 45 discussions is presented. Identical calculations were made for the group work activities (Table 4).

Table 4. IM transcript summary

	Whole group discussion	Group work activities
Total number of comments	5308	898
Number of sessions recorded	45	7
Average number of comments made per hour	158 (*SD* = 60)	509 (*SD* = 63)
Average words per comment	5.72 (*SD* = 5.61)	5.72 (*SD* = 5.20)

The overall comment rate was higher during group work activities than in whole group discussion ($t(6) = 1.65$, $p < .01$). The content of these comments was not examined: further research is needed before additional conclusions can be drawn from these findings. But the data in Table 4 are relevant to the research question regarding whether different learning activities affect student involvement.

A focus group discussion was facilitated at the end of the Spring 2014 semester that focused on communication during recitations with microphones. Of the thirteen participants in this discussion, five students described how having access to the whiteboard and IM was sufficient for communication during recitations. Two students did not use microphones due to the presence of others in their local physical environments that they could not disturb. Another two students described how they found microphones useful during group work.

Table 5 presents data collected from the technology survey. Responses were converted to numerical values (never = 1, rarely = 2, sometimes = 3, often = 4, always = 5) and averaged to produce the results below.

Table 5. Technology issues encountered by students

Technology problem	September 2013 (*N* = 13)	April 2014 (*N* = 13)
Difficulty logging into Wimba/Adobe Connect.	2.0	1.2
Difficulty with my Internet connection.	2.2	2.5
Difficulty using text chat.	1.5	1.2
Difficulty writing on the whiteboard.	2.2	1.7
Difficulty using the Wacom tablet.	1.6	2.0

Note. Never = 1, Rarely = 2, Sometimes = 3, Often = 4, Always = 5.

Over the course of the year, the most common source of technical issues that students experienced was related to their Internet connections. Three students reported that they often experienced problems with their Internet connection in the April 2014 survey. These findings are relevant to the question of whether students could benefit from having access to web cameras, which require high connection speeds (Carrington, Kim, & Strooper, 2010). Table 5 also suggests that students had fewer difficulties logging into their WC software at the end of the year than at the beginning, and that they had more issues at the start of the year with writing on the board. Both of these findings may help explain why Satisfaction scores increased. Finally, in both September and April, students reported fewer difficulties with using text chat than with anything else, which may help explain why some students expressed during the focus group discussions that communicating via the whiteboard and IM was sufficient.

Discussion

Grade data

Differences in average final grades obtained by the high school students in the VTC and WC sections were not statistically significant. These results are encouraging: they suggest that it is possible for students to be successful in the WC delivery model that was introduced in 2012 to be a low cost alternative to the VTC model (Mayer & Hendricks, 2014). Further iterations of this delivery model with different TA's are needed to determine whether the WC format consistently produces equivalent or higher final grades than the VTC delivery format.

Involvement, cohesion, and satisfaction

Students in the WC section were given permission to write on the whiteboard anonymously at any time. During the focus group discussion on the use of the whiteboard, students expressed that the anonymous nature of this communication channel made it easier for them to be involved in recitation activities. While some educators have found that anonymous interactions in an online environment can lead to unnecessary distractions (Martin et al., 2012), others have found that anonymity in an asynchronous medium can create more authentic discussions and increase student participation (Bowen, Farmer, & Arsenault, 2012). Although to the best of the TA's knowledge, there were no instances of disruptive behavior, this could have to do with the small class size, the presence of the TA, or any number of other factors. Ultimately, the WC facilitator must be mindful of the maturity of their students when deciding the extent to which anonymous interaction should be incorporated into their sessions, and further research on the anonymous involvement is needed.

Focus group data collected in this study suggested that for some students, group work helped develop social cohesion. The small but statistically significant increase in social cohesion, as measured by the modified CUCEI, may be attributable to students getting to know each other throughout the year through group work.

The increase in satisfaction scores, as measured by the CUCEI, may have been due to the transition from Wimba Classroom to Adobe Connect. But the increase in satisfaction may have also been due to the increase in social cohesion that was observed: students described that getting to know their peers made recitations more enjoyable. Similar dynamics between student satisfaction, technical issues and social cohesion have been reported elsewhere (Kear et al., 2012; Laubach & Little, 2009; Kuo, Walker, Belland, Schroder, & Kuo, 2014). It should also be noted that for some students, the development of social cohesion was not perceived as essential. Further research on the extent to which its development is needed may require further research, particularly among advanced high school students in fully online courses.

How students used technology to communicate

Results presented in Table 4 gives us a clearer picture of how and when students used IM during recitation activities. That IM tends to be associated with fewer technical issues than other channels, and that students became more involved through IM during group work than in whole group discussion, are consistent with findings of recent studies (Bower & Hedburg, 2010, p. 475; Cornelius, 2014, p. 267). Average comment rates and lengths can be compared to those reported in the synchronous CMC literature (Lobel, Swedburg, & Neubauer, 2002; Martin et al., 2012; Oztok et al., 2013). Differences between comment rates and lengths found in this study and others could be attributed to several factors, including the nature of the activities the students were engaged in. Moreover, comment rates and comment counts cannot by themselves describe the quality of student interactions (Hrastinski, 2006, p. 140). A content analysis, such as that used by Hou and Wu (2011) or Bower and Hedburg (2010), would provide a deeper understanding of the nature of the discussion.

Study data identified challenges related to providing students access to microphones and web cameras. The video stream from web cameras requires additional Internet bandwidth, and three students in this study reported that they often experienced issues with the quality of their Internet connections. Five students wrote that they were able to communicate sufficiently with IM and the whiteboard, and two students were unable to connect in areas where they could use microphones. These findings are consistent with those reported on a recent case study that found that high school students preferred to communicate via text in WC environments (Murphy, Rodríguez-Manzanares, & Barbour, 2011, p. 590). Requiring that all students have access to web cameras and microphones necessarily increases costs for a program whose purpose is to provide a low-cost alternative to a more expensive delivery model. Combining these findings together, it does not seem likely that future students participating in the DCP WC delivery model will be expected to have access to web cameras and microphones.

Finally, students consistently expressed frustration with the technologies they were using across all of the surveys, so a decrease in technical issues may have led to an increase over time in student satisfaction scores as measured by the CUCEI. These findings are consistent with other case studies that suggest that learners using WC tools benefit from additional technical support (Cornelius, 2014; Martin et al., 2012; Olson & McCracken, 2015), and therefore have implications for the way that technical support and training could be improved in future offers of the WC format in the DCP.

Study limitations

This study is exploratory and its findings are unlikely to be generalizable to all contexts for several reasons. Results are based on a small population of advanced high school students. Secondly, the observed group dynamics may lie in the particular direction and structure that the teaching assistant facilitated. The activities, curriculum, and the direct questions that the assistant asked would have undoubtedly affected the group's approach to interaction and resulted in communication patterns that would have been different with other facilitators. Thirdly, the dynamics observed in the WC model are constrained by the features afforded by particular tools that were used. As new systems and technologies become available, the situation may change. Furthermore, interactions on the whiteboard and via audio were not recorded and therefore not studied. Non-observable communication would likely have occurred during recitations between students through face-to-face interactions between students attending the same school and via private messaging. Finally, comparisons between grades obtained by students in different recitation sections are complicated because the sections had different TAs, learning activities, grade weightings, and used different technologies.

Conclusions

Study results confirm findings from case studies in the recent distance education literature. Supporting evidence includes that group work activities are a way for learners to develop social cohesion, and can have a positive impact on student satisfaction. These findings are consistent with a recent case study that reported that learner-learner and learner-instructor interactions were significant predictors of student satisfaction (Kuo et al., 2014). Given that not all instructors incorporate group work activities in WC environments (Cornelius, 2014), further research on the benefits and challenges of facilitating group work activities in these settings is needed.

Study findings also clarify the role of audio and video channels in WC environments. While some participants felt that audio and video would have been beneficial for developing social cohesion, barriers to their use were identified. All of the identified restrictions are specific to the context of this study, but some of them have been reported elsewhere (Carrington, Kim, & Strooper, 2010; Murphy et al., 2011, p. 589). Educators who are deciding whether or not to require learners to have audio and video capabilities for WC sessions must consider the tradeoffs between the social benefits these channels afford and, among other factors, the technical requirements that their learners must meet in order to utilize them.

Our results also suggest other directions for future research related to the anonymous nature of the whiteboard. Research is needed clarify how anonymous interaction impacts student involvement in the WC environment and on how disruptive behavior is managed. Also, given that some students in this study found that the development of social cohesion was not essential, further research in this area may be needed, particularly among advanced high school students in online courses.

The findings presented in this article, along with those in the WC literature, are part of an ongoing effort to clarify how to best foster a student-centered environment in synchronous online learning platforms. The technologies and teaching practices that facilitators use, and how they develop and moderate learning activities, are just some of the decisions that impact the role instructors and administrators are faced with. As the technologies they use inevitably evolve, so too will our understanding of their role in distance education with ongoing research in this field.

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Appendix: Technology Survey

Please indicate which of the following technical problems you have encountered during recitations since the beginning of this semester.

	Never	Rarely	Sometimes	Often	Always
Difficulty with my Internet connection					
Issues related to my computer hardware					
Difficulty moving in or out of a breakout room					
Difficulty writing on the white board					
Difficulty using text chat					
Difficulty using the Wacom tablet					
Difficulty with my computers operating system					
Difficulty logging into Wimba					
Difficulty hearing the TA					
Difficulty seeing the TA					
Difficulty updating Java					

Please indicate what you do when you encounter technical issues during recitations.

	Never	Rarely	Sometimes	Often	Always
I log in and out of Wimba					
I refresh my web browser					
I reboot my computer					
I contact Wimba technical support					
I get help from another student					
I get help from a teacher or staff at my school					
I get help from my teaching assistant					
I resolve the issue myself					

Please indicate how often you experience the following situations.

	Never	Rarely	Sometimes	Often	Always
I experience technical issues in recitations that make it difficult to participate in recitations.					
I experience technical issues in recitations that make it difficult to learn.					
I experience technical issues in recitations that make it difficult to understand what other students are saying.					

Please indicate how you connect to the Internet during recitations.

	Never	Rarely	Sometimes	Often	Always
I connect using a wireless connection					
I connect using a wired connection					
I connect from home					
I connect from school					