A Comparison of Online Asynchronous Discussion Technologies in Hybrid Algebra Classes

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This research study compares the use of two different online asynchronous discussion technologies in hybrid algebra classes at an urban community college. One of the technologies is the discussion board, which utilizes text commenting, and the other technology is VoiceThread, which allows users to interact with audiovisual commenting. Students posted solutions to problems using one of these discussion technologies to create collaborative pre- and post-exam reviews. The impact of different methods of communication on student participation, exam scores, and satisfaction was analyzed. Participation rates and exam scores did not differ significantly with the use of the two different discussion tools. Surveys administered at the end of the semester showed that students preferred using a text-based discussion environment. Students' level of agreement to questions about ease of using the mentioned technology, its aid in teaching them the material, and their willingness to use it again were significantly higher at the 0.05 level in the text discussion group (n = 48) than in the audiovisual discussion group (n = 39). Advantages and disadvantages of using both technologies are discussed, and recommendations for improvement are shared.

Keywords: online learning, asynchronous online discussion, mathematics education, discussion board, VoiceThread

Online and hybrid mathematics courses have been a choice for students in higher education since the 1990s, when the use of computers and the internet became more widespread (Kentnor, 2015). This led educators to question whether students benefited from these courses as much as they did from traditional, face-to-face courses. Since then, numerous studies have been performed comparing student success between face-to-face and online/hybrid math courses (Aragon & Johnson, 2008; Ashby et al., 2011; Borba et al., 2016; Maggie P. Fay, 2017; Sauers & Walker, 2004).

As students and faculty enjoyed the advantages of online/hybrid courses such as flexibility in schedules and less time spent commuting, college administrators also saw advantages including classroom availabil-

ity, decreased overhead, and increased enrolment. This resulted in substantial increases in the number of online/hybrid course offerings (Kentnor, 2015). On the other hand, online/hybrid courses pose challenges as students need to be more independent and self-disciplined learners. This necessitated the need for educators to explore pedagogies and technologies which would help them in engaging students and improving their knowledge on the subject matter (Borba et al., 2016; Dean & Goodson-Espy, 2019; Hajra & Das, 2008; Howard & Beyers, 2020; Sliva, 2002; Smith & Suzuki, 2015).

When the COVID-19 pandemic forced colleges to switch to remote instruction, the online/hybrid teaching of mathematics was no longer a choice for faculty and students, but a mandatory modality. Challenges for educators and students with this rapid transition have been discussed widely (Carius, 2020; Khirwadkar et al., 2020; Mulenga & Marbán, 2020; Sabaruddin et al., 2020). Even though normalcy is gradually being restored and in-person classes are now possible, online/hybrid courses are expected to be in more demand than before. Therefore, maintaining the quality and effectiveness of these courses with little or no face-to-face meetings has become of utmost importance.

Many scholars had interest in learning how to use technology in ways that can best support students and faculty in the delivery of online courses even before the pandemic (Borba et al., 2016; Dean & Goodson-Espy, 2019; Hajra & Das, 2008; Sliva, 2002). As online and hybrid courses are becoming the prominent delivery format for the foreseeable future on many college and university campuses, it is more important than ever to seek optimal methods of using technology. Our study is aimed at finding answers to the question "what type of collaborative assignments delivered in which platforms would help students better in engaging them with the course and teaching them the material?" More specifically, we would like to determine whether the use of text-based versus voice-based asynchronous discussions yield any difference in student participation, success, and satisfaction in hybrid algebra classes at an urban community college.

The result of integrating technology into mathematics instruction has been found overall positive and showed that students could benefit from hybrid learning environments. Studies done specifically in hybrid algebra classes confirmed this positive effect in high schools (Smith & Suzuki, 2015), as well as studies done in hybrid developmental math courses at community colleges (Maggie P. Fay, 2017). Although most of the research comparing traditional, face-to-face courses to online/hybrid courses have

not revealed significant differences in success rates (Sauers & Walker, 2004; Scheetz & Gunter, 2004), the results differ depending on the courses taught and the student body. In a study of developmental algebra courses at a community college, grades and completion rates were lower for students in online/hybrid classes compared to students in face-to-face classes (Ashby et al., 2011). This invites instructors to design their online courses carefully, tailoring them appropriately to fit their student body and the course level that they teach, especially at community colleges where the student body includes nontraditional students with family or work obligations.

The participants in our study are students at a large urban community college who are enrolled in College Algebra, a gateway mathematics course for many majors. The student body is diverse in terms of ethnicity and full-time/part-time status (The Office of Institutional Research and Assessment, 2021). Low retention rates, common at community colleges (Craig & Ward, 2008), are also observed in the course that is under study. Given the dependence of success and retention rates on student bodies, we turn our attention to trends observed at community colleges.

Studies of factors that affect success and retention in online courses show that social presence can be a significant predictor of outcomes. In a research study done at a community college, Liu et al. (2009) discovered that community college students exist in a broad social context which can profoundly affect success in online learning. Their conclusions included a recommendation to develop integrated social and learning communities for improved retention and grades. Another community college research study on the factors that influence the completion rates of online courses revealed that 28% of the students who did not complete the course related their noncompletion with the course design and 9% to the fact that online learning did not fit their learning style preference. This suggests that instructors should design their courses to facilitate quality teaching and learning with innovative ways to improve course completion rates (Aragon & Johnson, 2008).

In this study, we explore two different online discussion technologies that can be used to potentially improve student interaction and success rates. We compare the use of text-based discussion boards with VoiceThread, a multimedia tool that incorporates voice and video commenting with image and text. We review the existing studies on these technologies below.

Literature Review

Text-based discussion boards have been used for a long time in the online teaching of mathematics, and research on online discussions in higher education settings has developed since the 1990s (Zhou, 2015). Jacob and Sam reported positive feedback from students in a first-year mathematics class who collaborated on discussion boards for finding solutions to problems (Jacob & Sam, 2008). Hong and Jacob also reported benefits on critical thinking with the use of discussion forums in a first mathematics course for engineering students (Hong & Jacob, 2012). One of several studies done on mathematics education students reported that discussion boards helped build a learning community based on students' comments (Sliva, 2002). Hajra et al. used three collaborative techniques: collaborative activity, online discussion, and group quiz for a differential equation class (Hajra & Das, 2008). Their findings indicated that students perceived online discussion as more beneficial than other forms of collaborative techniques.

VoiceThread has been utilized by many instructors, in many subject areas, and at several levels. The existence of a variety of communication possibilities with VoiceThread has been claimed to help "accommodate learners with different learning styles" (Gao & Zhang, 2012). VoiceThread was reported to help build a community of practice and make language learning easier (Bran, 2009). In a study of university students, McCormack found that the use of VoiceThread increased engagement, motivation, and higher-order thinking (McCormack, 2010). In a recent study in an online graduate program, VoiceThread was found to aid in creating an online community, and students reported feeling more connected with their classmates and their instructor (Delmas, 2017). In another recent study, VoiceThread was used in two graduate-level mathematics courses, and it was found to be helpful in facilitating communication about mathematical concepts (Dean & Goodson-Espy, 2019).

Our search of the literature revealed several studies that compared voice-based discussion boards with text-based discussions. One recent study compared student grades in a radiographic exposures course and did not show any significant difference (Weigel, 2019). In another study (Hew & Cheung, 2012), undergraduate students used voice- or text-based commenting in a course that explored educational technologies. The participation rates did not show any significant difference. Students were also asked their opinion on the challenges and the advantages of using voice-based discussion. Two of the advantages of voice-based discussion they reported were that it enables students to understand one another's

messages better and helps to foster a sense of online community. They did not report the responses of the students to the question, which asked about the challenges with using voice discussion. Their study also did not report the responses to either of the above-mentioned questions from students in the text-discussion group. We include in our study positive and negative comments from each experiment group to the corresponding technology. Another study that compared the two technologies in a large undergraduate communications course showed that students preferred text comments over voice comments (Marriott & Hiscock, 2002).

The different findings on the text- and voice-based discussions in different settings motivated us to explore these technologies further to determine whether there is a significant difference in student satisfaction, participation, and success with the use of these technologies in hybrid algebra classes in a community college setting.

Research Questions

In our study, we compare traditional text-based discussion boards with VoiceThread, which allows voice or video commenting in the online portion of hybrid algebra classes, and explore whether the different methods of communication available in the two technologies studied will lead to differences in student satisfaction, participation, and exam scores. Our research question is: Does the use of text-based versus voice-based asynchronous discussions yield any difference in student participation, success, and satisfaction in hybrid algebra classes?

Based on this research question, the following hypotheses will be examined:

Hypothesis 1: Assignment participation rates of students who use text-based discussions versus voice-based discussions will differ significantly.

Hypothesis 2: Exam scores of students who use text-based discussions versus voice-based discussions will differ significantly.

Hypothesis 3: Student satisfaction with the use of text-based discussions versus voice-based discussions will differ significantly.

Materials and Methods

Participants

The participants were students enrolled in the hybrid algebra classes at an urban community college who gave voluntary consent to participate in the study. In hybrid classes, a percentage of face-to-face lecture time is re-

placed by online asynchronous activities. The classes in this study met in person 40%–50% of the time that a traditional face-to-face section would meet. The study was implemented in fall 2019, in four sections of hybrid algebra classes taught by the two participating investigators (PI) and in spring 2020, in seven sections of hybrid algebra classes taught by three instructors (including PIs). Each instructor used text-commenting in one of their classes and voice-commenting in their other class in each semester (one instructor used text-commenting in two sections in spring 2020). The instructors randomly chose to assign the technologies with each of their classes. The sample sizes were $n = 48$ for the text-commenting group and $n = 39$ for the voice-commenting group. This research setting allowed the PIs to make comparisons between the two groups which used different discussion technologies. However, PIs avoided having sections in which neither of the technologies were used since this would conflict with work ethics as not all students would have been provided equal opportunities for learning.

Procedure and Data Collection

To test the first and second hypotheses, participation rates in discussion assignments and scores for each module exam were compared between the two groups using independent-samples *t*-tests. To test the third hypothesis, student satisfaction surveys were administered. After reviewing the existing surveys in the literature such as the Mathematics and Technology Attitudes Scale (Pierce et al., 2007) and Community of Inquiry survey (Richardson et al., 2017), PIs developed their own survey which consisted of seven Likert scale questions and one open-ended question. Validity of the survey has been verified by checking the inter-item correlations and Cronbach's alphas.

Learning Materials

Course topics were divided into four modules, with an in-class module exam given after each. Each section was given either a discussion board (DB; text-based discussions) or a VoiceThread (VT; voice-based discussions) assignment before and after each module exam. The learning management system used for all the sections was Blackboard.

Students were first introduced with the discussion technology through an optional "ice-breaker assignment" where students and the instructor introduced themselves to each other. Demonstrations on how to use the discussion technologies were shown during face-to-face classroom sessions, and the students were provided detailed instructions with screenshots on how to use the discussion technologies.

A pre-exam review assignment (text- or voice-based) was posted on Blackboard before each module exam and included review questions that were designed to prepare students for the exam on that module. After each module exam, a post-exam review assignment was posted on Blackboard and included the questions from that module exam.

The assignments in both groups contained the same content, but the groups used either audio/video commenting (VT) or written, text-based commenting (DB). For both the pre- and post-exam reviews, students were assigned problems and were provided with hints. Students were required to work out their assigned problems, show steps, and explain their solutions. The students were also instructed to contribute to each other's solutions. The instructors monitored the interactions, provided positive feedback for correct work, and supplied hints and helpful comments when needed. Details on both assignments are given below.

The rubric outlining the scoring criteria for the review assignments were shared with the students. The rubric assigned higher point values to students who post more collaborative and substantive comments.

Pre-Exam Review Assignments

The pre-exam review assignments were posted at least one week before each module exam and the final exam. The four pre-module exam reviews were required. Each student was assigned one of the exam review problems to work out, post the solution, and provide an explanation of steps by the first deadline. The students were also asked to comment on at least one classmate's solution by finding missing or incorrect steps or offering alternative solutions. The students were given a second deadline to complete this part of the assignment. The students were offered extra credit for posting solutions to problems that were unsolved by the first deadline and for posting comments to more than one classmate's solutions.

The assignments consisted of instructions, followed by a table that included the list of students and the problem that each of them was assigned. Students then were provided step-by-step technical instructions for the discussion technology that they were expected to use. Lastly, the assignment included the review problems, together with hints or references to the textbook.

Post-Exam Review Assignments

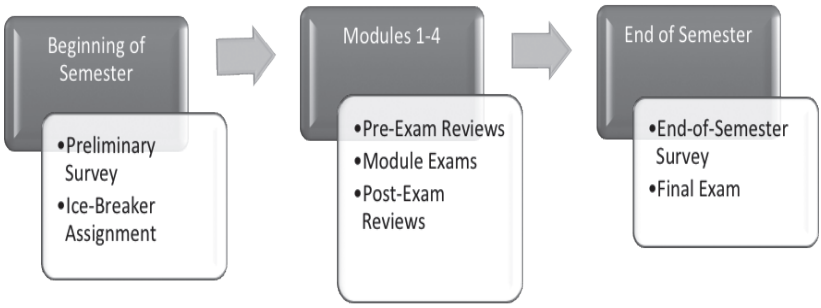
The post-exam review assignments were posted immediately after each module exam, and students were given a week to complete them. These

assignments were optional. The exam questions were posted on the course site, and the students were asked to choose a problem, work out its solution, and post to the discussion tool that is being used by their class. The post-exam review assignment instructions were similar to the pre-exam review assignment except that the students were not assigned problems and were allowed to post to any one problem on a first-come, first-served basis. The students were also asked to comment on what steps they did right or wrong in the exam. The step-by-step technical instructions on how to post with the discussion technology used in the class were again included in these assignments.

Assessment

The students were given exams after each module was covered. The final exam was cumulative. Apart from the module exams and the final exam, the assessment tools that were developed and used by the PIs to implement the experiment and test the hypotheses were student surveys. These are explained below. The flowchart that shows the research design is given in Figure 1.

Figure 1. *Flowchart of the Research Design*



Student Surveys

At the beginning of the semester, a one-question survey was administered to students in both groups, asking about their previous experience and familiarity with the online discussion technologies. At the end of the semester, an online survey was administered to students.

The end-of-semester survey aimed to assess students' attitudes about the text- or voice-based discussion technology used for the review assignments, students' perceptions of the ease of use of these technologies, and their satisfaction. The survey included seven five-point Likert scale questions. The answer choices ranged from *strongly disagree* to *strongly agree* with the score of each choice ranging from 1 to 5. Three of the survey

questions (1, 3, and 4) directly aimed to assess the students' satisfaction on the asynchronous discussion technologies. The other four questions aimed to assess the study habits of students (2 and 6) and their satisfaction with the online homework component of the course (5 and 7). The online homework platform used in the two samples were the same. These questions (2, 5, 6, and 7) were included to check if any differences between the samples in responses to questions on discussion technologies might be due to differences in the samples' characteristics. The last question was an open-ended question in which students were asked to provide further feedback. The survey questions are listed in Table 1.

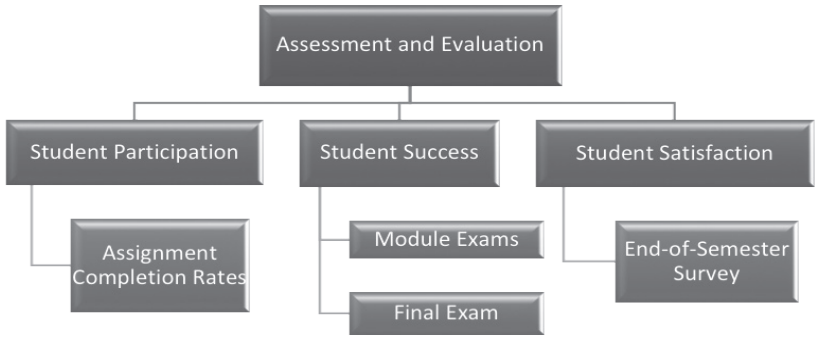
Table 1. *Questions in the End-of-Semester Survey*

Question	Statement
Q1	DB/VT review assignments helped me learn the material.
Q2	I completed DB/VT assignments on time.
Q3	It was easy to view and add comments on DB/VT.
Q4	I would like to use DB/VT if I take math classes in the future.
Q5	Assignments through online homework platforms helped me learn the material.
Q6	I completed my assignments through online homework platforms on time.
Q7	I would like to use online homework platforms if I take math classes in the future.
Q8	Do you have any suggestions to improve the online or in-class portion of this course or any other comments concerning DB/VT or any other component of the course?

Results

The assessment and evaluation design is summarized in the flowchart shown in Figure 2, and the steps taken to evaluate each of the three specific hypotheses are explained below.

Figure 2. *Assessment and Evaluation Design*

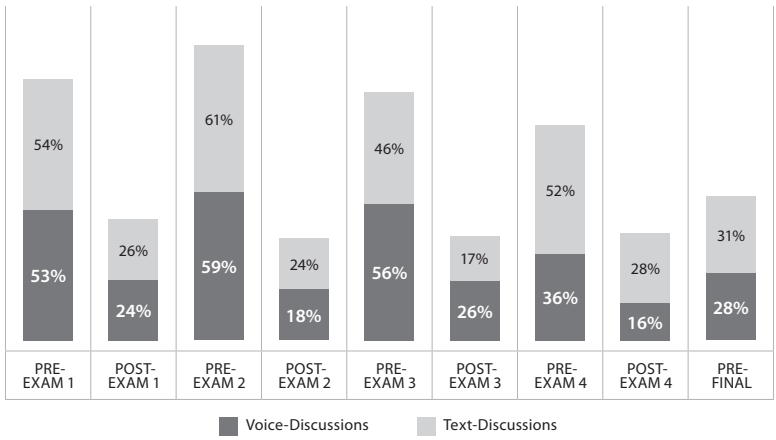


Hypothesis 1: Student Participation

The participation rates of students in text-based versus voice-based review assignments did not show any significant differences. We concluded that the participation rates did not depend on the platform used. The rates are shown in Figure 3.

The participation rates of students in either the text- or voice-discussion groups heavily depended on whether the assignment was required or optional. The pre-exam review assignments were required, while the post-exam and pre-final review assignments were optional. This resulted in the participation rates for pre-exam reviews being significantly higher than the rates for post-exam reviews. The participation rates for pre-exam assignments in either of the two discussion platforms did not show either an increasing or a decreasing trend with time. Similarly, the participation rates for post-exam reviews stayed almost constant in time.

Figure 3. *Participation Rates for Pre- and Post-Exams and Pre-Final Review Assignments Shown in Chronological Order for Text-Based Versus Voice-Based Discussion Technologies*



Hypothesis 2: Student Success

We compared the scores of the module exams and final exam between the two groups to test our hypothesis on student success. All exam scores were out of one hundred. Neither of the assessments showed a significant difference between the two groups. The sample sizes, average scores, and standard deviations are summarized in Table 2. We concluded that exam scores, hence student success, did not depend on the platform used for the exam reviews.

Table 2. *Mean and Standard Deviations for the Exam Scores for Each Group*

Assessment	Group	*n*	Mean	Standard deviation
Exam 1	Text	45	59	26.7
	Voice	30	64	22.5
Exam 2	Text	39	88	13.5
	Voice	29	89	9.8
Exam 3	Text	39	80	18.0
	Voice	25	82	18.3
Exam 4	Text	38	86	12.7
	Voice	25	85	16.6
Final Exam	Text	41	86	10.7
	Voice	27	83	19.1

Hypothesis 3: Student Satisfaction

Questions 1, 3, and 4 were used to test the hypothesis that student satisfaction was significantly different in the text- and voice-discussion groups. The inter-item correlations for these questions showed moderate to strong correlation and the Cronbach's alpha for these questions was .881, which shows good reliability. Questions 2 and 6, which aimed to assess the study habits of students, were moderately correlated. Similarly, Questions 5 and 7, which aimed to assess the opinions on the online homework platforms, showed moderate correlation. The inter-item correlation between groups of questions that measured different constructs mostly showed no correlation. The correlation coefficients are given in Table 3. Intercorrelations being high for items within the same group and low for the items from different groups support the validity of our survey through both convergent and divergent validation.

Table 3. *Inter-Item Correlation for Survey Questions*

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Q1	1						
Q2	0.353	1.000					
Q3	0.638	0.600	1.000				
Q4	0.770	0.483	0.742	1.000			
Q5	0.265	0.192	0.167	0.308	1.000		
Q6	0.002	0.593	0.166	0.088	0.428	1.000	
Q7	0.165	0.260	0.155	0.321	0.698	0.533	1

We have performed independent-samples *t*-tests for the survey responses in the two groups. The mean of responses in the text-discussion

group to Questions 1, 3, and 4 were significantly higher than the mean of responses in the voice-discussion group at the 0.05 level. The mean of responses to the remaining questions, which assessed the study habits of students and their opinions on the online homework platform (same platform used in both samples), did not differ significantly between the text- and voice-discussion groups. This provided evidence that the significant difference between responses to questions on the discussion technology was not the result of the differences between the samples. We concluded that the students preferred using a text-based discussion technology over a voice-based discussion technology. The number of participants, mean, and standard deviations for each question in each sample, and the *p*-values are listed in Table 4.

Table 4. *Mean, Standard Deviations, and p-Values for Each Survey Question in the Text- and Voice-Discussion Groups*

Question	Group	*n*	Mean	Standard deviation	*p*-value
Q1	Text	48	4.10	0.82	0.0398
	Voice	39	3.64	1.14	
Q2	Text	37	3.86	0.96	0.2405
	Voice	30	3.53	1.23	
Q3	Text	48	4.42	0.70	0.0027
	Voice	39	3.72	1.22	
Q4	Text	47	4.02	1.06	0.0002
	Voice	39	2.97	1.31	
Q5	Text	42	4.24	0.92	0.5595
	Voice	32	4.38	1.02	
Q6	Text	31	4.06	0.91	0.4436
	Voice	24	4.25	0.83	
Q7	Text	41	4.22	1.02	0.6003
	Voice	32	4.34	0.96	

Students' responses about their timely completion of the assignments through the discussion technologies (Question 2) and their opinion on the ease of the technologies (Question 3) were moderately correlated. Students' responses about their completion of the assignments through discussion technologies (Question 2) and the online homework platform (Question 6) were also correlated. Similarly, students' opinions about the online homework platform's aid in teaching them the material (Question 5) and their willingness to use it again (Question 7) showed moderate to strong correlation. These results (except Question 3) did not differ between the text- and voice-discussion groups.

Qualitative Comments

The response of the students to the open-ended question also supports our conclusion about the preference of students on the discussion technology. The question asked if the students had "any suggestions to improve the online or in-class portion of the course or any other comments concerning the discussion technologies used or any other component of the course." In the text-based discussion group, there was one positive and one negative comment about the discussion technology used. However, in the group where audiovisual commenting was used, there were five comments about the discussion technology used, which were mostly negative. Students' main criticism was the technology was difficult to use. All the students' comments are given in Table 5.

Table 5. *Students' Answers to the Open-Ended Survey Question on the Discussion Technologies Used*

Discussion Technology	Student Comment
Text-based	The cooperative element of the discussion boards is a great idea I hope this is included in the future
	I think My Open Math videos under each question helped me a lot more than discussion board.
Voice-based	Voice thread was a very difficult website to follow, so using a simpler website might help improve learning the material.
	Don't use voice thread
	Improving the interface if possible. At least in my case, trying to access it mobile was virtually impossible.
	Did not enjoy voice thread, never worked for me, it's difficult to use.
	I just feel like voice thread isn't really needed but, having more zoom calls would be awesome

Discussion

The overall experience of students with collaborative exam review assignments in either of the two platforms can be considered positive since the majority of the students (71%) either strongly agreed or agreed with the statement that the review assignments (text- or voice-based) helped them learn the material. This suggests the use of this type of exam review assignment in future semesters. However, the responses to the student satisfaction survey revealed a significant difference between the text- and voice-discussion groups, with the former receiving more positive results. This suggests to us to continue using text-based discussion boards for

this type of assignment and possibly taking advantage of VoiceThread's auidovisual features in other types of assignments in future semesters.

Our initial expectation was that the use of a platform that allows audiovisual commenting would help increase the sense of community, better engage students, and, hence, be welcomed by students, as observed in other studies comparing these technologies (Bran, 2009; Delmas, 2017; Hew & Cheung, 2012; Koricich, 2013). However, our literature review did not reveal any studies comparing text and audiovisual commenting done in mathematics classes at community colleges. As already pointed out, outcomes of using a specific technology in a classroom depends heavily on the subject being taught, the level of the course, and the student body. These all differ from ours in the mentioned studies, which could explain the bifurcating results. This invites instructors to carefully explore the available methods and technologies and choose the ones that are most suitable for their classes.

Another factor that accounts for the varied student opinions in different studies is the way that a given technology is used. Mathieson has reported positive opinions from students, where they felt more "connected" with their instructor when audiovisual feedback was provided to students compared to text-only feedback (Mathieson, 2012). There are mainly two differences in their setting with ours which might account for the varied feedback. First, only the instructor (not students) used the mentioned technologies to provide feedback to students. Therefore, this study did not compare students' experiences with using the technology themselves. Second, in their study, the feedback that the students received from the instructor was private to the student, whereas in our case, the comments the students made and the feedback they received were public. This suggests that audiovisual components might have worked better for student-instructor interaction but not for student-student interaction. Even for this type of interaction (private feedback from instructor to student), the outcome has been reported to vary, potentially due to factors that have not been examined in the studies, such as age of students, or students being traditional or returning to school (Orlando, 2016).

We discuss here potential reasons underlying students' preference for text-based discussions over voice-based discussions. Based on the students' response to Question 3, "It was easy to view and add comments on the specified platform," and their comments to the open-ended question (Question 8), we understand that the main challenge with the use of VoiceThread was technical difficulties. For example, the students might have preferred accessing the discussion platform through their mobile devices,

but better internet connection is required and more glitches are expected when communicating with audiovisuals.

At the beginning of the semester, students were asked about their previous experience with the discussion technology that would be used during the semester. About 60% of the students ($n = 44$) in the text-discussion group answered that they had used a discussion board before. However, this number was significantly lower in the voice-discussion group. Only one student ($n = 33$) had used VoiceThread before. Students' unfamiliarity with using an audiovisual discussion technology may have had some impact on the relatively negative comments about this technology.

Another reason could be that some students' home settings might not be suitable for adding or viewing video or voice comments. Students with limited access to quiet, private study areas could have difficulty completing an assignment that requires such an environment. Other reasons could be that some students were shy or were math-anxious.

When the text-commenting option was enabled on VoiceThread (during fall 2019), some students only typed their comments, although the instructions made it clear that audiovisual comments were required. When the text-commenting option was disabled (during spring 2020), some students chose only to post the solution to their assigned problem as an image but never added voice comments explaining their solution. Although students were given a chance and were even required to interact with classmates and the instructor through audiovisual components, many students didn't take advantage of this feature.

The opposite of the above situation was also observed, and some students might have benefited more by the use of voice commenting since this gave them the chance to better express themselves. It happened that some students who preferred to stay quiet during the lectures posted very clear, detailed, engaging voice comments which utilized the annotation feature of the platform.

Having students respond to each other's posts has been a challenge in both of the platforms. Although the rubrics required adding substantive comments to each other's posts, some students did not post at all, and the comments of many were not substantive. The students were expected to find mistakes or missing steps or show alternative ways. Despite emphasizing this expectation multiple times, many students did not analyze or question the solution posted by a classmate. They simply responded with generic positive comments such as "Good job!" or "Great work!"

We find that, from the instructor's point of view, VoiceThread is a valuable tool due to the ease in explaining solutions to mathematical problems. It is not possible to write most mathematical notation on a text editor in an easily readable way. It is much easier to either explain it verbally by recording a voice/video comment while writing on the screen with the annotation feature of VoiceThread. Although setting up and grading assignments on VoiceThread is slightly more involved and time-consuming compared to the discussion board, the benefits would outweigh the difficulties.

The transition to online teaching due to COVID-19 occurred while this study was being performed. Students enrolled in this study may not have had any previous experience with online learning and the technologies used. This could have contributed to their reluctance to using a more sophisticated technology that allowed audiovisual commenting. Their willingness might have increased as online teaching has become more familiar. Further studies would reveal any changes in students' attitudes and preferences since online teaching has become more prevalent.

Due to the nature of the course and the student body involved in this study, the exam review assignments were designed to be frequent (nine assignments) during the semester. On the other hand, recording a voice/video comment takes more time than typing a comment. These two facts together could have added to the students' reluctance to using an audiovisual commenting technology for the assignments. A suggestion is to design online mathematics courses to have more frequent, easy-to-complete, low-stakes assignments that make use of text-commenting technologies and less frequent (once or twice), higher stakes assignments that make use of audiovisual commenting technologies. The more frequent, easier-to-complete, text-commenting assignments could help develop a community among students while the less frequent audiovisual commenting assignments could help students improve their use of mathematical language and presentation skills.

Limitations

The courses were taught as hybrid for the first six weeks of the spring 2020 semester and then transitioned to fully online instruction due to the COVID-19 pandemic. The first module exam was given in class, on campus; the rest of the module exams and final exam were administered online without proctoring. While the survey data from the fall 2019 semester was included in the analysis of the survey results, the exam scores analyzed were solely collected in spring 2020.

Conclusions

We compared the use of text-based commenting technology, discussion board, with VoiceThread, a technology which enables voice and video commenting, for asynchronous online discussions in hybrid algebra classes at an urban community college. Our analysis of the survey responses showed that students preferred text-based discussion technologies over the voice-based discussion technologies. The use of different technologies did not reveal any difference in participation in the assignments or in the exam scores. Our results add to the existing bifurcating opinions of students on voice-based discussion, expand the existing research in the field of entry-level college mathematics, and provide insight to instructors in choosing the optimal technologies and methods for their students.

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