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Let All Voices Be Heard: Creating an Engaging and Inclusive Asynchronous QR Classroom

Ruby A. Daniels
Texas A&M University - San Antonio, drrubydaniels@gmail.com
Kathryn Appenzeller Knowles
Texas A&M University - San Antonio, kappenzeller@austin.utexas.edu

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Abstract

With the shift to remote teaching, many instructors used Zoom for synchronous work. However, this presented issues (fatigue, turning cameras off, inequitable technical hurdles) that motivated quantitative reasoning (QR) instructors to look for asynchronous alternatives. A common technique has been text-based online discussions, which can be difficult for students to find engaging. This mixed method study (*N* = 41) describes an inclusive video alternative, specifically for teaching QR and quantitative fluency skills, which was piloted in two asynchronous sections and one hybrid section of the same course. Students posted their video responses, watched their classmates' videos, and wrote short lessons-learned papers. After measuring how many students addressed a set of QR questions and the length of video and written submissions, two coders independently rated the quality of students' written reflections as well as the reasonableness of their oral arguments. Fewer than half of the students addressed most QR questions, about a third presented arguments with medium to high reasonableness, and approximately 40% of students reflected substantively, with no significant differences found by class format. Students in the hybrid section had medium reasonableness of QR arguments, which differed significantly from online students whose arguments had low reasonableness. The length of videos and written submissions were significantly and positively correlated with the number of QR questions addressed. The findings suggest a QR activity with asynchronous videos, which allows students to see and hear each other, may be an effective pedagogical option to improve engagement and accessibility in online courses.

Keywords

asynchronous online, video engagement, accessibility, pedagogy, quantitative fluency

Cover Page Footnote

Dr. Ruby A. Daniels is an Instructional Assistant Professor at Texas A&M – San Antonio. With a background in marketing, communication, and research, she teaches various courses in the College of Business.

Dr. Kathryn Appenzeller Knowles is the Director of Quantitative Reasoning at Texas A&M – San Antonio. She creates quantitative reasoning programming, using her background in mathematics education. Her research interests include interdisciplinary contexts and subjects in pedagogy and curriculum design.

Introduction

Quantitative fluency is defined as "the ability to speak naturally, conversationally, and extemporaneously about quantitative evidence" (Schwab-McCoy 2019, 78). Most educators agree the process of becoming quantitatively fluent is time intensive, cognitively challenging, and extremely important (Cucchiarini et al. 2002; Efthimiou et al. 2012; Elrod 2014; Cartwright 2018; Easwar 2019; Schwab-McCoy 2019; Craig 2021; Erickson et al. 2021). Proficiency cannot be developed in a single course. Rather, quantitative fluency requires diligent application of quantitative reasoning (QR) skills over time in diverse situations. Schwab-McCoy (2019) suggest quantitative fluency is a continuous and iterative cycle. To demonstrate quantitative fluency, students first must have basic mathematical competencies. Later, when reading, writing, and speaking, they learn to apply their understanding of quantitative concepts to real-world problems. Schwab-McCoy (2019) states, "Students should be able to use quantitative evidence in regular conversation and explain such evidence verbally to their colleagues and peers" (78).

Unlike traditional classes assessed with multiple choice quizzes/exams, QR courses often incorporate case-based class discussion (Baird et al. 2019; Boersma et al. 2019; Dorée and Balbach 2019; Fung 2019; Gaze 2019; Bergstrom and West 2021). Such interactive activities allow students to (1) conversationally demonstrate their QR skills and (2) organically consider alternative perspectives from their peers and instructor. Live face-to-face (F2F) discussions illustrate the fluid and interactive nature of the quantitative fluency cycle (Schwab-McCoy 2019). The discussion process is not linear, where reading must precede writing or speaking. Instead, students might first speak during a class discussion; then later read, reflect, and/or write about lessons learned from the activity.

When the COVID-19 pandemic occurred in early 2020 and governments mandated stay-at-home orders, colleges and universities were forced to shift from predominantly in-person classes to online course delivery. The rapid transition to online teaching presented significant issues for educators with courses that previously relied on live, in-person discussion. In addition to having to learn new technology and modify their curriculum, traditional F2F instructors encountered unique challenges related to online learning (Gallagher and Palmer 2020; Gardner 2020; Laborissiere et al. 2020; Bashir et al. 2021; Ramlo 2021). No longer able to see and hear students during an in-person class, instructors were unable to pose reflective questions, spontaneously assess student understanding, and/or adapt in real time when students seemed confused. To adapt during the COVID crisis, educators shifted to either synchronous or asynchronous online classes.

Synchronous Online Courses

Some instructors transitioned to synchronous online discussions hosted in platforms like Zoom, WebEx, and Adobe Connect. While such technology supports oral discussion in real time, synchronous meetings present other challenges. For instance, when accessing class remotely, some students (especially those in rural areas) encounter difficulty maintaining a stable internet connection for lengthy online meetings (Lai and Widmar 2020; Levin 2020; Ratledge et al. 2020; Wright 2021). Others, who struggle to balance attending school with child and healthcare issues during COVID (Garcia and Weiss 2020), are unable to attend live synchronous sessions and/or tend to be distracted as they multitask during class. In a study of online students who attended synchronously through Zoom during the pandemic, Serhan (2020) found 61% disagreed that Zoom improved their learning, with about 42% of college students reporting significant distractions during class, such as interruptions from family members and the telephone (Gillick and Magoulias 2020).

Shortly after the shift to online learning, Zoom fatigue (Morris 2020; Sklar 2020; Bailenson 2021; Fauville et al. 2021;) started taking a toll on both students and instructors. Aguilera-Hermida (2020) found pandemic students reported a significant drop in motivation and cognitive engagement in online classes. Compounding the problem, many students were reluctant to turn on their web cameras (Serhan 2020). "When students keep their webcams off during synchronous online classes, instructors no longer receive nor have the opportunity to respond to students' body language, facial expressions, and general tone or vibe of the Zoom classroom" (Lemelin 2021, 5). Not surprisingly, instructors frequently reported frustration when teaching to "unseen and unheard students" (Lemelin 2021, 5). When synchronous learners are unwilling to engage in an oral conversation, the development of quantitative fluency skills is hindered.

Asynchronous Online Courses

Text-based discussions. Instead of conducting class synchronously, some online instructors developed asynchronous text-based discussion activities after the pandemic (Lowenthal and Moore 2020). Rather than requiring students to attend a live F2F session at a specific time, an asynchronous approach allows students to prepare a written response at their convenience; then post it in a learning platform, such as Blackboard or Canvas. After reading their classmates' thoughts, students respond to each other in a written discussion thread. Unfortunately, text-based discussions do not provide students with an opportunity to develop their quantitative fluency skills because no oral activity occurs. Additionally, written discussion threads often make students feel isolated (Lowenthal and Moore 2020). Multiple studies indicate the loss of a "human touch" (Dhawan 2020, 14) in online classes adversely affects student engagement. Post-pandemic research by Adnan and Anwar (2020) reports about 7 of 10 students found online learning during the COVID crisis less motivating than traditional in-person classes. Other studies indicated students felt online courses were stressful (Aguilera-Hermida 2020) and boring (Dhawan 2020). Because asynchronous text-based discussions inherently lack vocal inflection, facial expressions, and gestures, such activities are often perceived as impersonal and/or antisocial (Lowenthal and Moore 2020). Stodel et al. (2006) suggest text-only discussions make it challenging for online students to develop enjoyable and meaningful interactions.

Video-based discussions. Dissatisfaction with asynchronous text-based discussions as well as Zoom fatigue in synchronous online courses led to the development of video alternatives (e.g., Flipgrid, Kaltura, and VoiceThread). These platforms allow students to record and submit video responses to discussion questions, rather than relying on written posts. Unlike synchronous sessions that are hosted at a specific time, asynchronous video discussions permit online students to interact whenever it is convenient for them (Lowenthal and Moore 2020). These platforms allow students to share visually engaging video content that fosters personal connections with classmates (Lowenthal and Moore 2020; Keiper et al. 2021). Research indicates demand is growing for asynchronous video activities in online courses (Skylar 2009; Clark et al. 2015; Bartlett 2018; Lowenthal and Moore 2020; Keiper et al. 2021). When Johnson and Skarphol (2018) had students complete pre and post surveys in a class that used Flipgrid, they found student engagement increased. Lowenthal and Moore (2020) similarly reported 61% of college students preferred Flipgrid video activities over text-based discussions. One student shared Flipgrid was "the closest that I have ever felt like I was having a face-to-face conversation with another person in an online asynchronous setting" (Lowenthal and Moore 2020, 32).

Gap in the Literature

To date, no studies have investigated the use of asynchronous QR video activities in Flipgrid. While most colleges and universities are returning to traditional on-campus classes, enrollment in online courses is likely to continue (Gallagher and Palmer 2020). Many nontraditional students, who are working adults with families, now prefer online education (Li and Lalani 2020; Superville 2020; Fleming 2021; Hess 2021; McKenzie 2021). About 43% of full-time as well as 81% of part-time undergraduate college students work while taking classes (Perna and Odel 2020). According to the Institute for Women's Policy Research (2022), 26% of undergraduate students (about 4.8 million) are raising at least one child while working on their degree.

Because asynchronous approaches do not require students to immediately respond, such approaches work well for activities that require reflection about cognitively complex issues (Hrastinski 2008; Ogbonna et al. 2019; Fabriz et al. 2021). Unlike an in-person or synchronous class where students may feel "put on the spot" to answer a challenging QR question, asynchronous classes create a safe space for students to reflect, prepare, and practice before answering. Flipgrid provides a new pedagogical strategy that allows students to record (and re-record) their oral responses to QR questions in the privacy of their homes as many times as they like before posting for others to see and hear. In alignment with American Disabilities Act guidelines, Flipgrid automatically transcribes videos for hearing-impaired students (Choney 2018) and employs screen reader technology for visually impaired students (Flipgrid 2022). The closed captioning capabilities of Flipgrid also benefit English language learners as well as students with auditory processing difficulties, autism, attention deficit hyperactivity disorder (ADHD), dyslexia, and Down syndrome (Rev 2017). Asynchronous approaches also accommodate immunocompromised students who are unable to safely attend in-person classes.

As an increasing number of educators suggest online learning is no longer an option but a necessity (Dhawan 2020), researchers are urging educational institutions to accommodate the diverse learning needs of students beyond traditional classroom walls (Serhan 2020; Toquero 2020), so every student's voice is heard. While preliminary research about asynchronous video activities is encouraging, more research is needed (Lowenthal and Moore 2020). In a post-pandemic learning environment, QR educators need greater understanding of asynchronous ways to accommodate student needs and keep learners engaged, especially when teaching challenging concepts related to quantitative fluency.

Purpose and Research Questions

The purpose of the mixed method study was to explore college students' participation in an asynchronous video activity that required them to practice quantitative fluency. In particular, the study investigated how students used QR in their analysis as well as their engagement with the activity and reasonableness of their QR arguments.

RQ 1: After participating in an asynchronous video activity, in what ways did college students orally support conclusions with quantitative reasoning?
RQ 2: How engaged were college students who participated in an oral asynchronous video activity that required quantitative fluency?
RQ 3: How reasonable were college students' QR arguments when participating in an oral asynchronous video activity?
RQ 4: What significant correlations (if any) were found between engagement, QR reasonableness, and written reflection when students participated in an oral asynchronous video activity?

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Methodology

Teaching Intervention

Quantitative reasoning is a habit of mind when approaching numerical data, a comfort to critique quantitative information within a context, and ability to create sophisticated arguments (Karaali et al. 2016; National Numeracy Network n.d.). Students use critical thinking skills to investigate proposed claims with quantitative data to form arguments. While many college students believe the process of analyzing quantitative claims is complicated and time intensive, Lutsky (2008) suggests QR habits are "primarily simple and non-technical" (60). To illustrate, he proposes 10 QR "Questions at the Ready" that could be used to analyze quantitative claims in a myriad of contexts. The current study's teaching intervention developed a similar set of questions to help students easily evaluate the merit of quantitative research claims. In hopes of maximizing student engagement while also emphasizing the simplicity of the process, the questions were presented as a "Sniff Test." As shown in Table 1, the 7 questions in the Sniff Test align with 9 of Lutsky's (2008) 10 QR "Questions at the Ready."

An important part of critiquing information is attending to contextual elements, making a decision, and taking a position that can be defended with logically reasoned arguments. Lutsky (2008) articulates this connection between quantitative information and argumentation by explaining the ways in which "quantitative information may be used to help articulate or clarify an argument, frame or draw attention to an argument, make a descriptive argument, or support, qualify, or evaluate an argument" (63). In the case of the current study, students used a Sniff Test to identify potentially relevant elements to support their arguments about whether a company's claims should be believed.

In Table 1, the dots indicate overlap between the questions in the Sniff Test and Lutsky's (2008) QR "Questions at the Ready." For example, Lutsky's question "Who or what was in the sample?" encourages students to think about what is being studied, while the Sniff Test question asks, "Who or what was studied?" Similarly, the Sniff Test question "Did the researcher have an agenda?" and Lutsky's broad question "Are the findings those of a single study or source or of multiple studies or sources?" both explore the reliability of a source. Details about sponsorship, being peer-reviewed, or reliability further encourage students to consider motivations or agendas. As shown in Table 1, multiple Sniff Test questions aligned with Lutsky's QR "Questions at the Ready." It should be noted that the mapping in Table 1 is intended to illustrate how the Sniff Test questions, like Lutsky's QR "Questions at the Ready," broadly facilitate quantitative reasoning, not to argue for a one-to-one or mutually exclusive mapping. Although some may characterize Lutsky's (2008) questions as simplistic or rote, basic questions help new QR students, who may feel anxious or intimidated by quantitative concepts, attend to

Table 1
Comparison of Lutsky's (2008) QR "Questions at the Ready" and the Intervention's "Sniff Test"

QR "Questions at the Ready" (Lutsky 2008, 67–68)	**Research "Sniff Test" Questions**						
	When did data collection occur?	Where did data collection occur?	Who or what was in the sample?	How many were in the sample?	How was the sample selected?	How was the information collected?	Did the researcher have an agenda?
What do the numbers show?	●	●	●				●
How typical is that?				●	●		
Compared to what?	●	●					
Are findings that of a single study or source or of multiple studies or sources?							●
How were the main characteristics measured?						●	
Who or what was studied?			●				
Is the outcome of a study anything more than noise or chance?				●	●		
How large is the result of the study?							
What was the design of the study?				●	●	●	
What else might be influencing the findings?							●

important contextual aspects of claims. Lutsky indicated the QR "Questions at the Ready" are not an exhaustive or comprehensive list, but a way to frame questions in a general way and encourage students to build a habit of mind that fosters quantitative reasoning.

Figure 1. Infographic overview and timeline for the Sniff Test intervention

Figure 1 illustrates the study's two conditions (recorded and live) as well as a timeline for the Sniff Test activities. In fall 2021, the QR intervention was presented in three sections of an introductory marketing course. During a unit about the importance of objectively evaluating product research, the instructor provided a lecture that explained how a Sniff Test could be used to analyze quantitative claims. Two of the sections were 100% asynchronous; students watched a recorded lecture with a recorded practice activity about an eye cream (see Fig. 1). A third section was hybrid, with an in-person lecture and a live practice activity about the same product. During the lecture, students were given a worksheet with the Sniff Test questions (see Fig. 2) as well as three sources of information about a product that claimed to reduce facial wrinkles and undereye bags. After reviewing the evidence, students were instructed to practice (either asynchronously online or live in class) using the Sniff Test by filling in the worksheet and evaluating whether consumers should believe the company's claims.

Sniff Test

Topic:

Sniff Test	Source 1	Source 2	Source 3
WHEN did data collection occur?			
WHERE did data collection occur?			
WHO or WHAT was in the sample?			
HOW MANY were in the sample?			
HOW was the sample selected?			
HOW was the info collected?			
Did the researcher have an AGENDA?			

Notes:

Figure 2. Sniff Test worksheet

After reflecting about the practice activity in the lecture, students were instructed to independently conduct a second Sniff Test about a hemp oil product that claimed to improve sleep and reduce anxiety/pain. Like the lecture's practice Sniff Test activity, students were told to think critically about three sources of information (Step 1) then record a video response (Step 2) to the prompt: *Should the company's claims be believed? Why or why not?* (see Fig. 1). After sharing their video response on Flipgrid, students watched at least five responses posted by their classmates (Step 3). They then wrote about lessons learned (Step 4) from the asynchronous video activity. All intervention-related assignments were submitted online.

Sample

Participants were college students (*N* = 105) enrolled in three sections of an introductory marketing course at a Hispanic-Serving Institution (HSI) located in south Texas. Approximately 77% of the university's students are Hispanic, with 73% representing first-generation college students. About 70% are eligible for Pell grants, which are typically awarded to undergraduate students with exceptional financial need. Approximately 47% of students (*N* = 49) consented to have their assignments included in the study. Most of these students were enrolled in online sections of the course (*n* = 26, 53%), with the remainder participating in a hybrid version of the same class (*n* = 23, 47%). Women comprised about 60% (*n* = 29) of the sample, with men representing approximately 40% (*n* = 20). All sections of the course were taught by the same instructor and used identical lecture and practice activity materials. The only difference was the hybrid lecture was delivered live and in-person, while students in the asynchronous online sections watched a recording of the same lecture and practice activity.

Data Collection

In compliance with IRB guidelines, 49 students signed a standard informed consent form prior to data collection. Two deliverables were required to complete the Sniff Test assignment: an asynchronous video presentation and a written reflection. Most who consented (*n* = 39) also agreed to having their video responses used for purposes related to research and education.

Video presentation. After reviewing each of the sources about the product, students recorded and posted a short video response with conclusions based on their Sniff Tests. To provide students with a convenient way to record and share their videos, the instructor provided a link to a free asynchronous discussion platform (Flipgrid 2021). The platform allowed students to use an internet-connected device with a web camera (smart phone, tablet, laptop, etc.) to videotape a response that was up to 90 seconds long. At the conclusion of data collection, the students' video responses were downloaded and de-identified in compliance with IRB guidelines.

Written reflection. After watching at least five of their classmates' videos, students were instructed to write and submit a confidential reflection about what they learned from the asynchronous video activity. They were encouraged to reflect about: "How did the asynchronous video activity help you to understand and interpret market research? How did watching your classmates' videos affect your understanding?" Students were free to write as much or as little as they liked; no word count requirements were provided. After the students submitted their written reflections, the instructor downloaded and de-identified copies of the assignments.

Instrumentation

Table 2 details how students' QR-related comments, engagement, and reasonableness of QR arguments were coded. Because students' video responses and written reflections were open-ended, two coders independently rated students' assignments.

QR support for conclusions. The eight QR-related categories in Table 2 were based on the seven questions in the Sniff Test, as well as a final topic (misused results) that emerged organically in students' videos. Each video was dichotomously coded to indicate whether the student mentioned any of the specific QR-related comments. For instance, if a participant mentioned bias in the source, the *agenda* variable was coded 1. Likewise, if the same student described the geographic location of the data collection, the *where* variable was also coded 1.

Engagement. Researchers suggest student engagement has behavioral, cognitive, and emotional dimensions (Lester 2013; Henrie et al. 2015). Behavioral engagement focuses on activities that can be directly observed by humans or tracked by technology (Liu et al. 2018), such as attendance, participation, assignment completion, assignment length, number of posts, time spent with on-task behaviors, etc. In a comprehensive literature review of student engagement research, Henrie et al. (2015) found 77% of studies operationalized student engagement with behavioral measures. In contrast, cognitive measures of student engagement are not externally visible (Liu et al. 2018). Instead, they are operationalized with qualitative indicators, such as student elaboration, explanation, interpretation, and reflection (Henrie et al. 2015). According to Henrie et al. (2015), about 60% of studies used multiple measures of student engagement.

In the current study student engagement was operationalized with behavioral and cognitive measures (Henrie et al. 2015). Behavioral engagement was measured with video length and word count to assess time spent with on-task behaviors. Two variables measured cognitive engagement. As shown in Table 2, an overall cognitive video elaboration and explanation (Henrie et al. 2015) score was computed for each student by summing the frequency of all eight QR-related comments (range from 0 to 8). Students' written comments were also coded to measure levels of cognitive reflection (0 = no reflective comments, 1 = low reflection, 2 = medium reflection, 3 = high reflection) about the asynchronous video activity. Comments that merely described the product, focused on statements made by classmates, and/or strayed from the prompt were coded 0 to indicate no reflection was provided by the student.

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Table 2
Sniff Test Variables, Descriptions, Examples, and Coding

QR Related Comments	Description	Example	Coding
When	Identified a general time when the information was published or created	The study was published in 2018. The reviews spanned from 2018 to 2021.	0 = Not mentioned 1 = Mentioned
Where	Mentioned the geographic location of the data collection	Data collection occurred in the United States.	
Who	Described who or what provided the information	Consumers People using the product People who left online reviews	
Sample size	Identified how many were included in the source's sample	There were about 3,000 reviews. The study had a sample size of 3,254.	
Sample selection	Explained how the sample was chosen	It was a self-selected sample.	
Data collection	Described how the information was collected from the sample	It was an online survey. They used open-ended questions.	
Agenda	Provided context about the objectivity and/or bias of the information	There was bias. They were trying to sell something. Some reviews were deleted.	
Misused results	Questioned the validity of the results	The product contains hemp oil—not CBD.	
Engagement	**Description**	**Example/Explanation**	**Coding**
Behavioral	Video length (seconds)		Continuous (0 to 90)
	Written reflection (word count)		Continuous
Cognitive	Video explanation	When + where + who + sample size + sample selection + data collection + agenda + misuse of results	Computed (0 to 8)
	Written reflection	I missed some important information. Next time I'll be more skeptical when reading online reviews.	0 = No reflection 1 = Low 2 = Medium 3 = High
Engagement	**Description**		**Coding**
Reasonableness of QR arguments	Assessed the appropriateness of the student's QR arguments		0 = No QR arguments 1 = Low 2 = Medium 3 = High

Reasonableness of QR arguments. As shown in Table 2, students' QR arguments were also assessed for reasonableness (0 = included no QR arguments, 1 = low reasonableness, 2 = medium reasonableness, 3 = high reasonableness). When students merely provided answers to each of the eight Sniff Test questions, without any interpretation or conclusions, the video was coded 0 because there were no QR arguments. Responses based on assertion, opinion, or superficial analysis of only one piece of evidence were coded as displaying low QR reasonableness. Students who considered multiple sources and/or included detailed analysis about one piece of evidence received an evaluation of medium QR reasonableness. High ratings were assigned to videos that made connections between multiple sources and/or applied the underlying concepts to a different context.

Gender. Control variables are included in statistical analysis to hold constant any effect on the dependent variable (DV) by a variable that is not of interest to the study's research question. Gender is often included as a control variable in social science research because of gender-normative bias in a wide range of social interactions. That bias, whether directed toward the self or others, may lead to unanticipated spurious or confounded relationships between independent variables (IV) and the DV. For example, bias regarding the generalized math efficacy of males versus females may lead individuals to perceive themselves as higher or lower in math skill, which could influence relevant attitudes or behaviors.

Aside from being a normally controlled variable, there is a history of research concerning gender differences regarding mathematics, such as problem solving (Hyde et al. 1990; Lubienski et al. 2021), course-taking (Card and Payne 2021), and performance on standardized tests (Gallagher 1990; Gallagher and Lisi 1994). A critique of past work around gender gaps and mathematics is the relationship of student-specific characteristics, other than gender, and mathematics achievement (Cheema and Galluzzo 2013). Researchers found socioeconomic status and race are important predicators related to questions being investigated. When controlling for other variables, such as anxiety and math-specific self-efficacy, gender differences may disappear.

Although empirical research may be mixed, females are underrepresented in the number of degrees awarded in mathematically intense Science, Technology, Engineering, and Mathematics (STEM) fields (Card and Payne 2021) as well as STEM occupations (Wang and Degol 2016). This underrepresentation could be linked to gender differences on high-stakes tests and the implications for STEM opportunities (Mejía-Rodriguez et al. 2021). Even with a disproportionate number of males scoring higher than females on high-stakes tests, the disproportionate number of males in the mathematically intense occupations is even more drastic. With gender being a normally controlled variable as well as mixed results in gender and mathematics-related contexts, exploring potential gender differences was considered relevant in the current study.

Results

Preliminary Analysis

Before addressing the study's research questions, a preliminary analysis was conducted. First, the data were cleaned to ensure participants' responses were accurately recorded. Next, the coding of participants' open-ended data was assessed to verify sufficient interrater reliability. Finally, we looked for differences in engagement and QR reasonableness by gender and class format in case the data needed to be disaggregated in the final analysis.

Interrater reliability. To ensure the open-ended data were coded reliably, two doctoral-trained coders, with backgrounds in mathematics and quantitative research methods, independently watched students' video responses and read their written reflections. After a preliminary review of the data, a codebook was developed to calibrate the rating process. When needed, information in the codebook was revised and clarified. For instance, the original codebook contained seven QR-related comments based on the Sniff Test categories. After watching the videos, both coders agreed an eighth category (misused results) was needed. Similarly, the coding of the QR reasonableness variable, which was originally based on a 3-point scale (1 = low reasonableness, 2 = medium reasonableness, 3 = high reasonableness), was modified to include 0 for videos that did not contain any QR arguments.

After the open-ended data were collected and coded, Cohen's kappa assessed the extent to which the two raters assigned the same score to a student's response (Sun 2011; McHugh 2012; Henrie et al. 2015). Like a correlation, a kappa statistic ranges from -1 to +1 (McHugh 2012). According to McHugh (2012), kappa scores of 0.59 or lower indicate weak to no agreement between raters. Scores from 0.60 to 0.79 indicate moderate agreement, while scores of 0.80 to 0.90 show strong agreement. Kappa scores above 0.90 reflect almost perfect agreement. As shown in Table 3, the kappas for 7 of the 8 Sniff Test comments showed strong to near perfect agreement. All the QR-related comments, including the "who" category, exceeded McHugh's (2012) minimum threshold of 0.60. The kappa scores indicated coding of 7 of the 8 Sniff Test comments showed strong to near perfect agreement. Similarly, moderate to strong agreement was detected for the coding of the cognitive written reflection and QR reasonableness variables (see Table 4). These results suggest the coding of students' open-ended data was reliable and suitable for additional descriptive and inferential analysis.

Table 3
Interrater Reliability for QR-Related Comments

QR-Related Comments	κ	*p*
When	1.00	0.00
Where	1.00	0.00
Who	0.73	0.00
Sample size	0.95	0.00
Sample selection	0.86	0.00
Data collection	0.80	0.00
Agenda	0.90	0.00
Misused results	0.85	0.00

Table 4
Interrater Reliability for Cognitive Written Reflection and QR Reasonableness

Other Coded Variables	κ	*p*
Cognitive–Written reflection	0.82	0.00
Reasonableness of QR arguments	0.79	0.00

Group comparisons. Analysis of variance (ANOVA) divided the study's categorial variables of gender (male/female) and class format (online/hybrid) into groups, then compared differences in group mean scores for video length, word count, video explanations, written reflections, and QR reasonableness. No significant differences were detected in the responses based on gender. Male and female students' video length ($F(1, 39) = 3.33$, $p = 0.08$), word count ($F(1, 38) = 0.00$, $p = 0.98$), and video explanations ($F(1, 39) = 0.00$, $p = 1.00$) were statistically similar. Likewise, male and female students had similar responses for written reflection (X^2 (3, $N = 41$) = 2.42, $df = 3$, $p = 0.49$) and QR reasonableness (X^2 (3, $N = 41$) = 0.88, $df = 3$, $p = 0.83$).

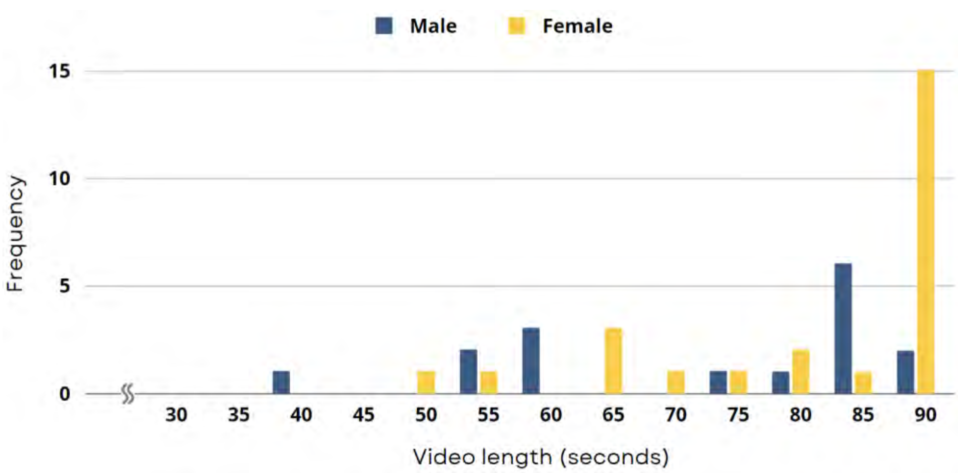

Figure 3. Comparison of video length by gender

Since gender differences in video length neared significance, post hoc descriptive analysis was conducted. The best measure of central tendency for women's video length was the median (86 seconds) because the data were skewed to the right (*skewness* = -1.22). While the length of women's videos ranged from 49 to 90 seconds, a large proportion of women recorded videos that were about 90 seconds long (see Fig. 3). Because men's video length was normally distributed (*skewness* = -0.80), the mean was the best measure of central tendency ($M = 71.50$ seconds; $SD = 16.11$). The length of men's videos varied from 36 to 89 seconds.

Students in online and hybrid sections had statistically similar video length ($F(1, 39) = 3.20$, $p = 0.08$), word count ($F(1, 38) = 1.21$, $p = 0.28$), and video explanations ($F(1, 39) = 0.15$, $p = 0.70$). Students in both class formats also had similar written reflections (X^2 (3, $N = 41$) = 0.69, $df = 3$, $p = 0.88$). Additional descriptive analysis explored the nearly significant difference in video length by class format. The mean video length for online sections (*skewness* = -0.84) was 73.21, with a standard deviation of 14.77 and a range between 36 and 90 seconds. The length of videos in the hybrid sections was skewed to the right (*skewness* =

-1.69) with a median of 87 seconds and a range between 49 and 90 seconds. As shown in Figure 4, a high proportion of hybrid students recorded videos that were nearly 90 seconds long.

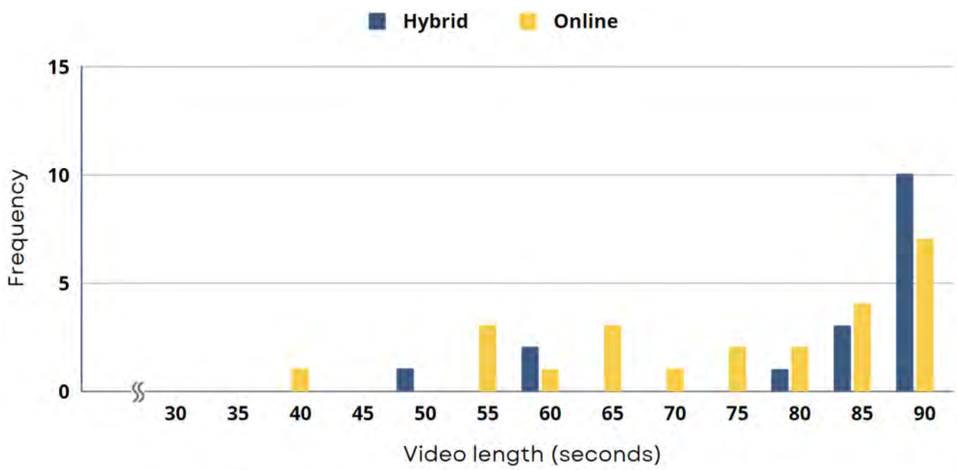

Figure 4. Comparison of video length by class format

A chi-squared test compared the observed and expected results of QR reasonableness by class format. The reasonableness of QR arguments differed significantly in online and hybrid sections of the course (X^2 (3, N = 41) = 8.50, df = 3, p = 0.04). Students in the hybrid section had more reasonable QR arguments than students in the online sections. Participants in online sections had a median score of 1 (low), while students in the hybrid section had a median score of 2 (medium). As shown in Figure 5, 53% of hybrid students (n = 9) displayed medium to high QR reasonableness, compared to only 21% of online students (n = 5).

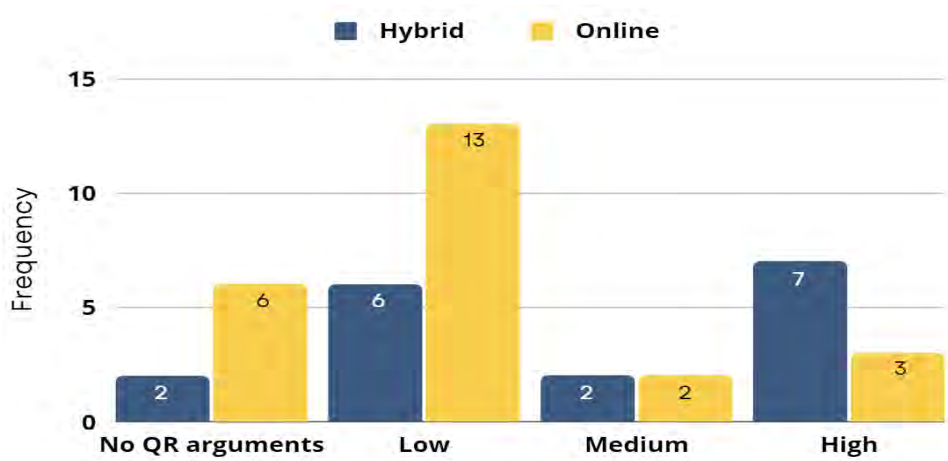

Figure 5. Comparison of QR reasonableness by class format

Frequencies and Descriptives

QR support for conclusions. The first research question (RQ 1) asked about ways college students supported conclusions with QR after participating in an asynchronous video activity. A compilation of student video responses can be viewed in Figure 6.

Figure 6. Compilation of students' QR video responses (Daniels 2021)

Figure 7 plots the frequency of QR-related comments students made to support conclusions. Most study participants (80%, *n* = 33) described who provided information (e.g., consumers or people who left online reviews), with 49% (*n* = 20) commenting about how the data were collected (e.g., survey or open-ended questions). Forty-nine percent (*n* = 20) of students expressed concerns the information could be biased. Other QR-related comments addressed the source's sample size (37%, *n* = 15), misuse of results (34%, *n* = 14), time of data collection (27%, *n* = 11), sample selection (22%, *n* = 9), and geographic location (2%, *n* = 1).

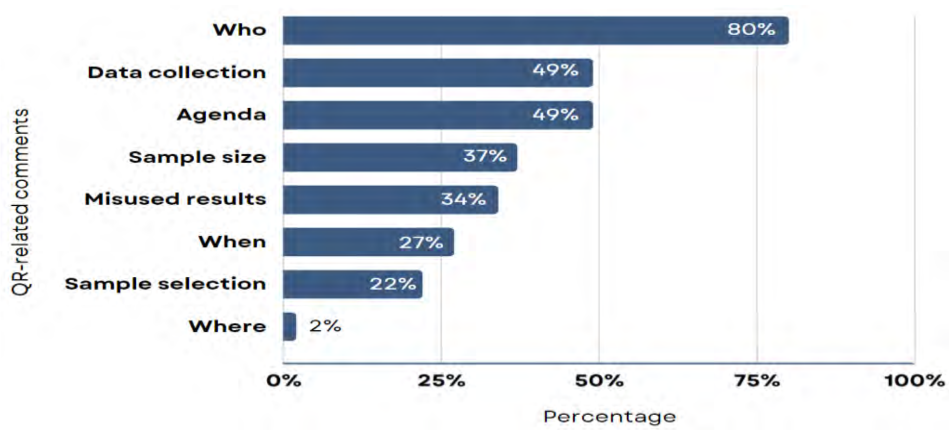

Figure 7. Percentage frequency of QR-related comments mentioned in all videos

Because the preliminary group comparisons detected a nearly significant gender difference, post hoc analysis compared how frequently men and women made specific QR-related comments. While the percentage of men and women who made specific comments varied, no statistically significant differences were detected. Regardless of a participant's gender, the percentage frequency of specific QR-related comments was approximately the same (see Fig. 8).

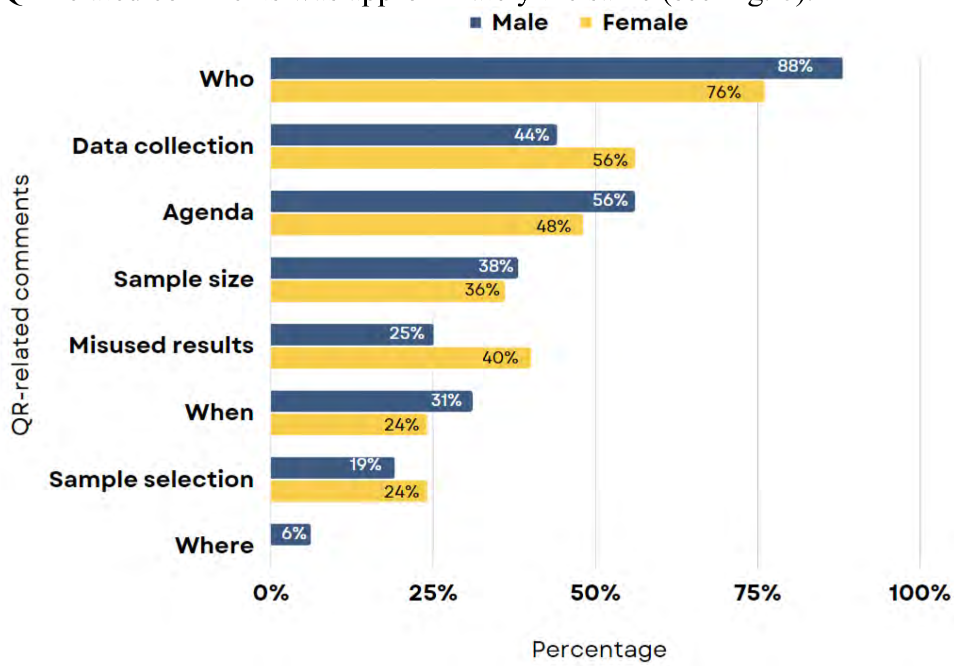

Figure 8. Percentage frequency of QR-related comments by gender

Engagement. The second RQ examined how engaged college students were when participating in an asynchronous QR video activity. Behavioral engagement was measured by two indicators: video length and word count. Flipgrid was configured to allow students to record up to 90 seconds in their videos. Ranging from 36 to 90 seconds, the average video length was 76.54 seconds (*SD* = 14.54 seconds). The length of students' written reflections ranged from 56 to 255 words, with an average of 121.75 (*SD* = 46.17).

Two indicators assessed cognitive engagement. A total video explanation score was computed by summing how many of the eight QR-related comment categories were mentioned by the student (see Table 2). For instance, a participant who commented about a source's sample size, data collection, and agenda received a total video explanation score of 3. The video explanation variable, with a potential range from 0 to 8, had median of 3 QR-related comments. Cognitive engagement for the written assignment was assessed on a 4-point scale (0 = no reflection, 1 = low reflection, 2 = medium reflection, and 3 = high reflection). While about 39%

(n = 16) of students' written assignments included medium to high cognitive reflection, 46% (n = 19) did not include any reflection (see Table 5).

Reasonableness of QR arguments. The third RQ measured the reasonableness of college students' QR arguments when participating in an asynchronous video activity. About half of the students' video responses (46%, n = 19) were coded as having low reasonableness, while 34% (n =14) of students demonstrated medium to high reasonableness. About 20% of students (n = 8) made no QR arguments (see Table 6).

Table 5
Levels of Cognitive Engagement in Student Written Reflections

Cognitive Written Reflection	Frequency	%
No reflection	19	46%
Low	6	15%
Medium	7	17%
High	9	22%
Total	41	100%

Table 6
Reasonableness of QR Arguments in Student Videos

Reasonableness of QR Arguments	Frequency	%
No QR arguments	8	20%
Low	19	46%
Medium	4	10%
High	10	24%
Total	41	100%

Correlations

The last RQ examined potential relationships between the study's engagement indicators and QR reasonableness. As indicated in Table 7, some measures of behavioral and cognitive engagement were significantly correlated. A positive relationship was detected between the length of a student's video response and the word count of his/her written reflection ($r(39) = 0.33$, $p = 0.04$). Students with longer videos tended to have longer written reflections. Similarly, video explanation scores significantly and positively correlated with video length ($r(39) = 0.38$, $p = 0.02$) as well as the word count of a student's written reflection ($r(39) = 0.34$, $p = 0.04$). Longer videos tended to include more QR-related comments than shorter ones. Likewise, students who used more QR-related comments in their video explanations, tended to have longer written reflection assignments.

Table 7
Correlations Between Video and Written Assignment Variables

Variables	Video			Written Assignment	
	Length	Explanation	QR reasonableness	Word Count	Reflection
Length	1.00				
Explanation	0.38*	1.00			
QR reasonableness	0.19	0.00	1.00		
Word count	0.33*	0.34*	-0.09	1.00	
Reflection	-0.16	0.02	-0.05	0.27	1.00

* $p < 0.05$

Discussion and Implications

The purpose of the study was to explore college students' participation in an asynchronous video activity that required them to practice quantitative fluency. The study introduced a new asynchronous pedagogical strategy that required students to (1) analyze three sources with quantitative evidence, (2) video record their conversationally spoken argument, (3) watch their classmates' responses, and then (4) write a lessons-learned reflection about the activity. Unlike prior research based on student perceptions of Flipgrid video discussions (Lowenthal and Moore 2020; Keiper et al. 2021), coders observed and coded video and written assignments to record the frequency of students' QR-related comments, engagement, and QR reasonableness.

Given the lecture spent equal time on each Sniff Test question and the worksheet outlined specific contextual aspects to explore, we were surprised at the frequency distribution of students' QR-related comments (see Fig. 7). To engage with QR and not merely report information, students had to make an argument using quantitative data. With a limited amount of time in Flipgrid to record their video responses, students selected the QR-related information they perceived was relevant to their orally communicated argument. For example, the product they analyzed made CBD-like claims even though it was clearly marked as hemp oil. Students who had prior knowledge about the difference between hemp oil and CBD may have been more likely to notice and include QR-related comments about the misuse of results in their argument. Aside from including QR-related comments that seemed most meaningful to them, students appeared to also include QR-related comments about more obvious information, like who or what was being studied.

Behavioral and cognitive indicators revealed moderate to high student engagement in the asynchronous QR video activity. In their video responses, most students used all or nearly all the time allowed for the assignment. While the word count of written reflections varied, most students chose to write responses that were about a half a page or longer. The frequency of students' specific QR-related comments also suggested moderate cognitive engagement with the video activity. Most students included three or more QR-related comments in their video responses.

About 4 out of 10 students included moderate to high cognitive reflection in their written assignments. One student shared, "I learned that we should read each source carefully, because people can make something sound good when it really isn't." Another student observed, "doing your own research (besides reading [online] reviews) can help you make a good judgment call on buying the right product. I was inspired to do more research myself when purchasing important items." A third student described how he used the QR process in a real-world situation after participating in the asynchronous video activity.

> I took my mother to purchase a new car and the numbers the finance manager laid out did not pass the Sniff Test. My mom was putting a substantial down payment on the car, it was 50% of the cost of the car. She was going to be financing $12,000 for 4 years. When the numbers came out (quoted at 4%), they asked for $382 a month. This was a huge red flag. I told the manager "These numbers don't pass the Sniff Test." After the conversation, her payment was reduced.

While these findings suggest an asynchronous video activity with a written reflection may engage some college students in meaningful dialogue about QR, 61% of students demonstrated no or low reflection in their written reflections.

The phrasing of the written assignment's prompt may have contributed to low levels of reflection by students. They were asked to describe how the asynchronous video activity helped them understand and interpret market research as well as how watching their classmates' videos affected their understanding. The prompt's phrasing may have needed clarification and elaboration. Instructors could provide a series of specific reflective questions for students to consider when preparing their written assignments:

- How did the Sniff Test process differ from the way you typically evaluate research?
- How did watching insight from your classmates affect your perceptions of the product?
- What was challenging about applying the Sniff Test?
- How might using a Sniff Test help you personally or professionally in the future?

Awareness that they were being observed for the study might have also contributed to low levels of student reflection. McCambridge et al.'s (2014) systematic review of studies about the Hawthorne effect found participation in research can and does influence behavior in some circumstances. However, the complexity and variety of research designs makes it difficult to understand the mechanism and effect size of the phenomena (Chiesa and Hobbs 2008; McCambridge et al. 2014). Before participating in the asynchronous video activity, students signed a consent form that explained the study. The open nature of the Flipgrid platform also made students aware that their classmates would observe their Sniff Test analysis. Fear of being judged or concerns about possibly offending other students may have resulted in some participants being reluctant to describe challenges they experienced completing the oral and written activities.

In addition to several students exhibiting no to low written reflection, some students drew unreasonable QR conclusions in their videos. For instance, after pointing out problems with the evidence, a few participants still said they believed the company's claims. Others concluded people should decide for themselves because "not everything is for everyone." As indicated in the description of the teaching intervention, the video activity occurred during a single week of a 16-week course. So, students did not have any other opportunities to apply QR or quantitative fluency later in the course. If similar QR video activities were used throughout the course, students could use instructors' oral or written feedback to improve their QR in future asynchronous video activities. Reinforcing QR concepts over time is important because “numeracy is not something mastered in a single course [and] can only be developed through repeated practice” (Lutsky 2008, 62).

Although students in both the online and hybrid sections were demographically similar, data analysis found students in the hybrid section of the course, which included a live, in-person version of the lecture, had significantly more reasonable QR arguments than students who watched a recorded version lecture. While both presentations by the instructor included the same practice activity, students in the online class were prompted to pause the recorded lecture so they could review three sources of quantitative evidence. After reading each source, students resumed the lecture and compared their thoughts to a recorded debriefing from the instructor. In contrast, during the hybrid class, the instructor stopped lecturing to allow about 10 minutes for students to privately review the sources. The instructor then facilitated a traditional class discussion about the strengths and weaknesses of each source. Because the recorded practice activity was not supervised by the instructor, online students may have skipped or hurried through the practice Sniff Test activity, resulting in reduced understanding of the QR concepts. Because this was an exploratory pilot study of the intervention, it is possible other variables, such as the size of the study’s sample, student attentiveness, distractions, and/or lack of live dialogue, may have contributed to differences in the QR reasonableness of online and hybrid students.

In situations when a hybrid approach may not be an option, asynchronous instructors may consider creating video lectures with embedded questions that require students to engage with the content by pausing the recording and applying QR asynchronously. Van Drom (2018) suggested videos with embedded questions promote active, rather than passive, watching of a recorded lecture. For instance, an instructor could insert an open-ended question in a video lecture that requires students to type a written response about each of the three sources provided in the practice Sniff Test activity. This process would (1) actively prompt students to think about each source and (2) prevent them from skipping the asynchronous activity. Research of video lectures with embedded questions found in-video questions helped create engaging and interactive content that assists in formative assessment (Cummins et al. 2016). Mirriahi et al. (2021) suggest in-video questions are particularly helpful when students lack prior knowledge of a topic, such as quantitative reasoning.

The lecture about the Sniff Test occurred during Week 6 of a 16-week semester. Students in the hybrid section of the course initially reacted to the video activity with some apprehension. In addition to being concerned about their ability to demonstrate quantitative reasoning, students were unfamiliar with Flipgrid, uncomfortable recording a video, and/or disliked making oral presentations. In contrast, online participants reacted more favorably to the video activity. Unlike the hybrid students who only used Flipgrid once, the online students began sharing Flipgrid videos about other course topics in the first week of class. After completing the Sniff Test video activity, several students in both the online and hybrid sections of the course described the process as simple, engaging, and helpful. One participant shared, “Listening to other videos truly gave me what I felt like was insider access to the minds of my classmates.” Others described how the activity made them feel more confident, reinforced their understanding, and/or inspired them to think more critically.

Limitations and Future Research

The findings of the exploratory study are subject to limitations. Conclusions were based on a self-selected convenience sample of 41 students enrolled in an introductory marketing class. Only students who consented to share copies of their video and written assignments were included in the analysis. A larger sample of randomly selected students from other QR courses may result in different findings. Because the study’s asynchronous video activity was hosted in Flipgrid, the results of interventions in other video platforms (e.g., Kaltura, VoiceThread) may vary. Additionally, the context of the study’s teaching intervention focused on one product and asked students to evaluate research from three sources. QR interventions that use a different context and/or include other sources may produce different results. Finally, the QR questions in the study are exploratory in nature and should not be used in situations that require a validated scale.

The settings of the Flipgrid video activity might also have influenced the results. Student videos were limited to 90 seconds. With additional time students may have included more analysis. Furthermore, the instructor moderation option of Flipgrid (Flipgrid 2020) was not activated in the study. As a result, some students may have watched their classmates’ videos before recording a response. Once an instructor’s Flipgrid activities are created, they can be easily duplicated in subsequent semesters. However, because it takes time to create Flipgrid threads each semester, the video activity may be laborious for large QR classes or courses with multiple sections and high enrollment.

While the study used behavioral and cognitive measures consistent with the literature, video length and word count may not fully capture student engagement. Students could spend a long time working on their videos and written reflections, yet produce a concise, sophisticated argument. The general phrasing of the written reflection prompt may have contributed to lesson-learned responses that contained little to no reflection. Instructors who try an asynchronous video activity in Flipgrid should provide a more detailed prompt to encourage deeper student reflection.

Future research should continue exploring the effectiveness of asynchronous QR video activities. In addition to studying other interventions, researchers should consider using larger, more diverse samples across various courses. As Fisher (2019) noted, “we need to temper our expectations for quantitative literacy classes. If literacy requires the commitment of many different social groups across many different dimensions of society, then one college course is not going to suddenly create a literate population” (11). Instructors who want to limit students’ ability to watch their classmates’ responses prior to posting should activate the platform’s moderation settings (Flipgrid 2020). Because video responses and written reflection data are open-ended, multiple raters should be used to verify the reliability of coding prior to any data analysis. Finally, while the current study only required students to post one video, future studies should consider analyzing alternative approaches that allow students to post video or written responses to each other in Flipgrid as well as testing the effectiveness of embedded questions in recorded lectures.

Conclusion

Many QR educators recognize robust dialogue about quantitative reasoning is an effective way to develop quantitative fluency skills (Baird et al. 2019; Boersma et al. 2019; Dorée and Balbach 2019; Fung 2019; Gaze 2019; Bergstrom and West 2021). Before the COVID-19 crisis, most QR courses fostered quantitative fluency with in-person case-based discussions. In the aftermath of the pandemic, many educators now facilitate QR courses online. While synchronous alternatives are available, live Zoom-like discussions present challenges, such as screen fatigue, student hesitance to activate their web cameras, and various technological hurdles. Alternatively, text-based online discussions tend to be perceived as impersonal because they lack vocal inflection, facial expressions, and gestures that make a more personal connection. The results of the current study, while preliminary and exploratory, indicate video-based platforms, like Flipgrid, merit further investigation because they provide QR educators with a new, highly accessible pedagogical strategy that allows every student to be seen and heard.

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