A Pandemic Crash Course: Learning to Teach Equitably in Synchronous Online Classes

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ABSTRACT

This article describes an equity-focused professional learning community that used the EQUIP observation protocol to provide data analytics to instructors. The learning community met during Spring 2020, and due to the global coronavirus pandemic, it moved online midsemester. This article describes patterns of student participation and how they were impacted in moving online. We found that student participation dropped significantly in moving online, but instructors were able to implement new teaching strategies to increase participation. We document seven concrete strategies that instructors used to promote equitable participation in their online classes and that can be incorporated by biology educators into their online teaching. The strategies were: 1) re-establishing norms, 2) using student names, 3) using breakout rooms, 4) leveraging chat-based participation, 5) using polling software, 6) creating an inclusive curriculum, and 7) cutting content to maintain rigor. In addition, we describe the faculty learning process and how EQUIP data and the learning community environment supported instructors to change their practices.

INTRODUCTION

During Spring 2020, a novel coronavirus (SARS-CoV-2) forced many university campuses to move all instruction online. This required instructors to move their classes online with minimal to no transition time. Exacerbating this formidable challenge, instructors faced personal uncertainty and chaos around them. This article describes a professional learning community that met during these unique circumstances. The community was originally convened to promote equitable student participation in face-to-face classes and moved online midsemester, shifting its focus. As such, the study of this learning community provides a unique opportunity to compare and observe changes in student participation both in face-to-face settings and then later online through synchronous meetings. This article addresses both the nature of student participation and the teaching strategies instructors used to support that participation.

While the learning community crossed disciplinary boundaries, in this article, we explicitly discuss how the lessons learned from the community can apply to biology education (broadly construed as biology and related intersections with fields such as mathematics and engineering). We accomplish this goal by providing a brief reflection on the learning experiences of faculty in these fields, connecting their learning process to their changes in teaching practices.

BACKGROUND

Participation and Equitable Instruction

Research connects participation (typically verbal talk) to learning (e.g., Banes *et al.*, 2019). Given this connection, students' participation in classroom discourse is an

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active area of research in biology education (Perez *et al.*, 2010; Smith *et al.*, 2011; Leupen *et al.*, 2020). Classroom discourse is important for two primary reasons. First, explaining their ideas helps students deepen their own understanding (Chi *et al.*, 1994; Trujillo *et al.*, 2016). Second, participation supports identity development (Boaler and Greeno, 2000). When students have an opportunity to participate and see others who they identify with participate, they develop a greater sense of belonging within the discipline (Lewis *et al.*, 2016; Le *et al.*, 2019).

Given the above, this article focuses on *participatory equity*, defined as a fair distribution of participation and opportunities to participate within the learning and teaching process (Shah and Lewis, 2019). To be clear, participatory equity is only one aspect of equity and cannot supplant students' subjective experiences of equity. These experiences are shaped by a variety of factors, including the curriculum, trust for the teacher, and having a safe learning environment (e.g., free of microaggressions, racism, and other forms of oppression). Even well-intentioned teachers may unintentionally create marginalizing classroom environments (Cooper and Brownell, 2016; Ernest *et al.*, 2019).

Classroom environments that focus on student participation are typically called *active-learning* classrooms. Such environments tend to support greater student learning in the aggregate (Freeman *et al.*, 2014). However, a growing body of research also shows that active-learning environments may disproportionately benefit students who are already advantaged in science, technology, engineering, and mathematics (STEM; Bando *et al.*, 2019; Ernest *et al.*, 2019; Setren *et al.*, 2019). These participatory inequities typically correspond to minoritized identities in STEM, say based on gender or race (e.g., Eddy *et al.*, 2015; Ernest *et al.*, 2019; McAfee, 2014). Thus, even though active learning may support student learning in the aggregate, as a matter of equity, it is imperative to create learning environments that do not disproportionately benefit already advantaged students. Fostering participatory equity is both a matter of influencing *who* gets to participate and *how* they get to participate.

To support equitable participation, we used the classroom observation tool EQUIP (Reinholz and Shah, 2018). EQUIP is available as a free Web app, that automatically generates data analytics to support instructor reflection (www.equip.ninja). EQUIP provides insight into patterns of classroom participation for both individual students and social marker groups (e.g., race, gender, dis/ability). Unlike other observation tools that focus on classroom participation writ large, the ability to disaggregate participation makes EQUIP an efficient tool for promoting classroom equity. In prior studies, EQUIP has been used in conjunction with a professional learning community to support iterative reflection on data analytics and incremental, sustained changes to teaching practices (Herbel-Eisenmann and Shah, 2019; Reinholz *et al.*, 2020).

The unit of analysis in EQUIP is a sequence. A sequence consists of talk-based participation for a given student that is uninterrupted by another student. A sequence may include multiple rounds of talk between a student and the instructor, but no other students. This definition of sequence makes it possible to assign all units of coding to particular students. Coding takes place along a number of discourse dimensions, which are fully customizable. In general, dimensions such as the length and type of student talk, teacher questions, and teacher responses to questions were commonly used in prior studies (Reinholz and Shah, 2018; Reinholz *et al.*, 2019; Reinholz *et al.*, 2020). Finally, EQUIP combines demographic information about the students (again customizable) with the coded data to generate data analytics. In this study, these analytics were used for professional development.

Equitable Teaching in Online Environments

Online education typically takes place in one of two forms (Skylar, 2009): asynchronous teaching (e.g., recorded lectures, discussion boards, at-home assignments) or synchronous teaching (e.g., a videoconference call, live Twitter stream). Consistent with principles of universal design for learning (Rose, 2000), a combination of both asynchronous and synchronous teaching methods is ideal, because it provides learners with different entry and access points to learning (Offir *et al.*, 2008). One of the advantages to having synchronous discussions to supplement asynchronous activities is that they most closely mimic the interactive experience of a face-to-face classroom (Skylar, 2009). For the present study, we focus on participation in synchronous teaching online, as it is a primary site for public student participation.

To understand the unique affordances and constraints of teaching and learning in online environments, researchers have developed the community of inquiry framework (Garrison, 2007; Kozan and Richardson, 2014). The framework is grounded in a social constructivist view of learning and highlights three critical areas of focus for creating productive online learning environments: *social presence*, *cognitive presence*, and *teaching presence*. While no framework can capture all aspects of teaching, this framework focuses on areas of teaching that are particularly salient for an online context. We describe here each aspect of the framework and how it relates to challenges in teaching online.

Social presence refers to the degree of social connection within the online learning community. Social presence requires that students are able to build and maintain relationships, identify with the community, and engage in trustful communication (Kozan and Richardson, 2014). An important aspect of establishing social presence is through noncontent *instructor talk* that helps establish a particular type of learning environment (Seidel *et al.*, 2015; Harrison *et al.*, 2019). Such talk helps build relationships with students and also establishes the nature of the classroom context. Given the unique circumstances of online learning environments, instructor talk may be especially important, as additional attention to social presence is required to alleviate issues of isolation and alienation that may not be present in a face-to-face classroom (McInnerney and Roberts, 2004).

A student's home context becomes particularly relevant in online learning. Some students may balance conflicting priorities: sharing space with others, taking care of children or elderly family members, or lack of safe space to engage (Jegede and Kirkwood, 1994). Online teaching can also exacerbate gender inequity, as women tend to shoulder a disproportionate share of childcare and familial responsibilities (Germano, 2019). An online environment can also compromise racial equity by making it more difficult to build trust (Tu and McIsaac, 2002), which is especially important for supporting racially minoritized students in STEM (Ladson-Billings, 1995). Thus, one can

infer that it is the students who are already minoritized in STEM who might be the most disadvantaged by the social environment of moving instruction online. To promote equity, instructors need to understand students' individual circumstances and adjust their instruction accordingly. This may require additional effort, as the online environment makes it more difficult to have the informal one-on-one check-ins with students during class.

Cognitive presence relates to opportunities for exploration, reflection, and constructing meaning (Garrison, 2007). Cognitive presence can be supported when instructors build deep and meaningful learning opportunities for their students. For activities like discussions, problem solving, and individual reflection, it may be relatively easy to move classroom activities to an online format. Yet, for other activities, like a laboratory exploration, it may be extremely difficult to replicate an in-person learning experience. In such cases, it may be necessary to implement an alternative experience, such as a computer simulation (Whitworth *et al.*, 2018).

Cognitive presence may be inhibited by differential access to technology. Research highlights that students may have differential access to the technology (e.g., fast Internet, video cameras, computers) needed to participate (Ng, 2007). Yet such technology may be foundational to cognitive engagement. Slow Internet speed could inhibit students from engaging with discussions as they unfold. Students with dis/abilities are also disproportionately impacted, given potential barriers such as difficulty focusing on a computer screen for a long period of time, challenges managing executive functioning, or needing adaptive technologies to access a computer (Roberts *et al.*, 2011). Thus, even though a teacher may set up a cognitively rich and engaging task in theory, when it comes to implementation, the demand may be reduced or may be inaccessible for some students.

Teaching presence focuses primarily on the facilitation and implementation of learning opportunities. Teaching presence focuses on the ways that instructors make meaningful learning opportunities available to learners. This typically involves using a variety of different technologies to provide different avenues for participation. Promoting teaching presence online can be difficult when compared with a physical classroom space, because typical embodied actions (like moving one's physical location in the classroom to promote participation from that area of the class) are no longer possible.

The capacity to effectively facilitate depends on teachers' capacity to leverage technology for learning (Mishra and Koehler, 2006). Thus, teaching effectively online may require sustained professional learning (Rienties *et al.*, 2013). In the present study, with instructors who typically did not teach online, moving instruction online was a formidable challenge.

These three dimensions—social, cognitive, and teaching—are interrelated and must be considered together (Garrison, 2007). For instance, the lack of social presence can inhibit cognitive engagement and make it more difficult to facilitate discussions effectively (a component of teaching presence). Conversely, the presence of meaningful learning opportunities (cognitive presence) can help support community, by giving a meaningful, shared goal for students.

Largely absent from the community of inquiry framework, however, is an explicit focus on equity. As outlined earlier, a number of equity issues are associated with all dimensions of the framework. Unless instructors attend to these dimensions directly, they are likely to exacerbate inequity in their classrooms. Thus, the present study makes an important theoretical contribution to the work on communities of inquiry, as we more wholly conceptualize equity issues related to each component of the framework and how to address them.

With regard to equitable teaching strategies online, our approach focused on translating what is known about supporting equitable participation in face-to-face classrooms (e.g., Tanner, 2013; Seidel *et al.*, 2015; Harrison *et al.*, 2019) and adapting it to a synchronous online environment. We take this approach given the dearth of studies relevant to biology education that focus on equitable participation in synchronous online environments. Drawing on the community of inquiry framework and conceptions of equitable teaching, the article addresses the following research questions:

1. How did the nature of student participation change in moving from face-to-face to synchronous online learning environments?
2. What strategies did instructors develop to promote equitable participation, and how were these strategies supported by the professional learning community and EQUIP data?

We use data analytics associated with EQUIP to capture the nature of student participation in online learning environments. We supplement these data with the community of inquiry framework as an analytic lens for organizing the types of teaching strategies that instructors developed.

METHODS

Researcher Positionality

The professional learning community was led by the lead author (D.L.R.), who identifies as a white man with multiple disabilities. The coding team consisted of three graduate students (A.S.J., I.W., L.M.S.) and one undergraduate student. They identify as Black woman, Latinx woman, Latinx woman, and Latinx man. The three graduate students are also authors on this article. The final author identifies as an Asian-American man. Given the focus of the learning community on racial and gender equity, it was important for our research team to represent a variety of different identities to allow for a more robust interpretation of results. No faculty members of the learning community are authors on this article.

Participants and Setting

This study took place at a large, research intensive Hispanic-serving institution in the United States. Participants were recruited through an open call to the university. Initially 11 faculty members indicated interest, but only seven could be accommodated due to scheduling constraints. Ultimately, six faculty members participated in the professional learning community. (The seventh faculty member, in mathematics, dropped out of the study during the transition online.) Participants were required to attend seven hour-long meetings, and at the end of the semester, they shared the results of their learning with their home departments for a modest compensation of $1500. The study was conducted under exempt status at San Diego State University (HS-2018-0162).

This study included STEM and non-STEM faculty. Participants' demographics are given in Table 1. Participants taught

TABLE 1. Participant demographics

Name	Gender	Race/ethnicity	Discipline
Ana	Woman	White	Linguistics
Calvin	Man	White	Mathematics
Janice	Woman	White	Medical Anthropology
Mark	Man	White	Environmental Engineering
Nick	Man	Latinx	Journalism
Silvia	Woman	White	Theater

TABLE 2. Gender demographics for students in the observed classes

	Man	Woman	Nonbinary	Total
Ana	7	18	0	25
Calvin	11	22	0	33
Janice	2	16	1	19
Mark	11	6	0	17
Nick	6	23	1	30
Silvia	9	14	4	27
Total	46	99	6	151

small-enrollment courses (40 or fewer students in a section), which EQUIP is designed for. No instructors teaching large lectures applied to the community. The STEM faculty were in the following disciplines related to biology: mathematics, environmental engineering, and medical anthropology. The non-STEM faculty were in the disciplines of theater, journalism, and linguistics. Our rationale was that STEM faculty would benefit from greater interactions with faculty outside STEM (and vice versa). As appropriate, we highlight the unique experiences of STEM faculty.

Instructors collected student demographics for use in EQUIP coding by administering surveys to their students. When instructors did not receive responses, they used their own impressions to fill in missing data. Each survey was customized to the classroom context, but nearly all instructors included race and gender, and individual instructors included other characteristics such as neurostatus (neurotypical vs. neurodiverse), confidence, language spoken in class, and comfort with the language of instruction. Collecting this demographic information allowed us to generate analytics that disaggregated student participation by different groups as an object for instructor reflection. Here, we focus on race and gender, as they allow for comparison across classes (see Tables 2 and 3).

Table 2 shows that approximately two-thirds of the sample was women, one-third was men, and there were six nonbinary-gender students. Table 3 shows the racial demographics for the classes (except Mark, who did not collect racial demographics). We collapsed all racial categories into five categories, to achieve consistency across classes.

Structure of the Learning Community

Faculty received data to improve their practice through iterative reflection and revision via a professional learning community (see Figure 1), as in prior studies with EQUIP (Reinholz *et al.*, 2020). The first two meetings of the semester provided the foundation for future learning by introducing EQUIP, implicit bias, microaggressions, cultural competence, and other related topics. These meetings also provided each instructor with an opportunity to choose demographic variables and discourse dimensions (the aspects of talk being coded).

After the two initial professional learning community meetings, the next five meetings were all debrief meetings (called rounds 1 through 5), in which faculty members and the coding team discussed the analytics that they were provided from the classroom observations. The debrief meetings focused on sense making around the analytics and generating actionable steps to improve equity in teaching. Faculty shared strategies with one another, and the faculty lead (D.L.R.) as well as the coding team shared feedback and strategies. The role of the coding team was also crucial, because the team helped provide qualitative impressions of classroom teaching that augmented feedback from the analytics. Each meeting typically focused on processing analytics from one or two classrooms in depth and all faculty members sharing insights that they gleaned from looking at analytics in their own classrooms. At the end of each meeting, faculty members were to develop goals (or retain their prior goals) and choose actionable changes to their practice that could then be measured in the next cycle. Notably, our approach focused on small, actionable changes to practice that instructors could implement. Thus, they were not intending to overhaul their teaching completely, but rather to make at least one actionable change each round. Practically, this meant that each instructor would only be able to implement a subset of possible strategies from the learning community. There was typically 2 weeks between meetings, which meant that instructors were observed and received feedback within each 2-week cycle before the debrief meetings.

Halfway through the semester, all instruction on the target campus was moved online, as a result of the SARS-CoV-2 outbreak. Accordingly, the first two rounds of observations were conducted in person, while the final three rounds were all

TABLE 3. Racial demographics for students in the observed classes

	Asian/Pacific Islander	Black	Latinx	Middle Eastern	White	Unknown	Total
Ana	13	0	2	4	6	0	25
Calvin	6	0	9	0	12	6	33
Janice	4	0	8	0	7	0	19
Mark	—	—	—	—	—	—	—
Nick	0	1	25	0	2	2	30
Silvia	1	2	4	0	20	0	27
Total	24	3	48	4	47	25	151

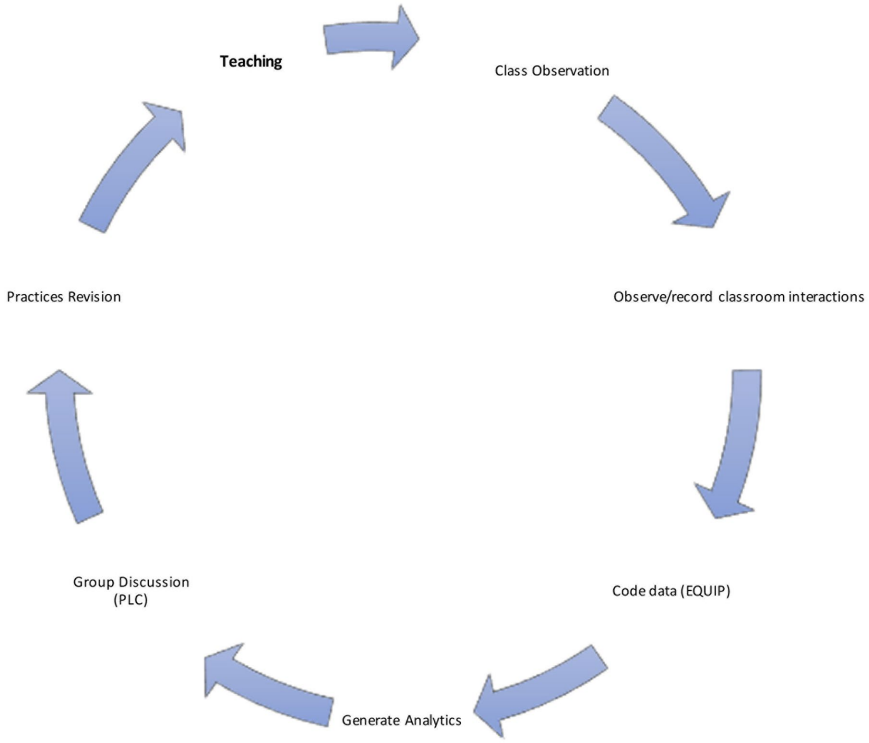

FIGURE 1. Structure of iterative feedback and reflection on teaching practices.

conducted virtually. With the transition online, we included a new discourse dimension "venue," which allowed us to distinguish between student participation in a variety of online venues (whole class, breakout room, and chat). All faculty members used Zoom for synchronous meetings. Zoom has a variety of features to mimic a real classroom, including whole-group discussions, polls, chat, participant reactions, and breakout rooms. The use of Zoom also led to new challenges. For instance, in a breakout room, an instructor cannot see the other breakout rooms and therefore cannot fluidly listen to student conversations and share back with the whole class as in a face-to-face classroom. Similarly, techniques like think–pair–share become overly cumbersome with Zoom.

While the goal was to conduct at least one video observation for each faculty member during each cycle, in practice, not all faculty were observed in all cycles (e.g., due to international travel, taking a week off to move instruction online). In addition, some faculty members submitted multiple videos during a single round of coding. A total of 36 observations were conducted (see Table 4), and all faculty members received feedback over multiple rounds of reflection and revision. Even during the cycles in which some faculty members were not observed, they actively participated in the discussion and considered revisions to their own practice. Table 4 also shows the venues used for teaching. Notably, not all faculty used/recorded breakout rooms.

Data-Collection Process

Most instructors chose default EQUIP discourse dimensions of teacher question, solicitation method, student talk length, and student talk type (Reinholz and Shah, 2018). In addition, some instructors chose discourse dimensions that captured how they responded (teacher response) to students' contributions, the time between a question being posed and a student responding to it (wait time), and the language (language) in which the students engaged. In this article, we report on general student contributions (rather than specific discourse dimensions) to support comparisons across classes.

Classroom observations commenced after the second learning community meeting. Each instructor's class was recorded on video and coded using EQUIP by a coding team of four students. The lead coder had extensive prior experience with EQUIP, so when issues arose related to coding, this team member provided support and calibration. In addition, the entire coding team went through a training process at the beginning of the semester, practicing their coding and achieving interrater agreement over a number of videos. Because this was an intervention study, each video was coded only once. The goal was to provide actionable data for revision on teaching practices, so interrater reliability was less of a concern.

The EQUIP analytics were automatically generated through the Web app, and a report of the findings was shared with each faculty member. The reports included a summary of quantitative findings, the observer's qualitative impressions, and suggested teaching practices. In addition, faculty members

TABLE 4. Number of observations by instructor and observation type

Instructor	Face-to-face observations	Virtual observations	Breakouts	Chat	Whole class
Ana	2	4	Y	Y	Y
Calvin	2	2	Y	Y	Y
Janice	1	2	Y	Y	Y
Mark	1	5	Y	Y	Y
Nick	1	8	Y	N	Y
Silvia	2	6	N	Y	Y
Total	9	27			

could log into the EQUIP app to explore interactive visualizations of participation for their own classes.

Data Sources and Approach

Multiple sources of data were collected to understand the learning experiences of faculty members. To begin, all faculty completed an application form that described their interest in the learning community, their conceptions of equity, and concrete practices that they used in their teaching to promote equity. Similarly, faculty completed an end-of-semester survey describing their learning experiences and changes in conceptions. All of the video observations and corresponding EQUIP analytics were also data sources. In addition, detailed notes were compiled for all coding meetings and professional learning community meetings. Finally, artifacts generated for faculty presentations to their home departments were collected.

This study used a mixed-methods approach to analyze these data to address our two research goals: 1) characterizing student participation in face-to-face and synchronous online settings and 2) documenting strategies for promoting equitable instruction. Our quantitative analysis directly leveraged the analytics generated by EQUIP. By comparing student participation from one round to the next, we had a rough measure of the impact of an instructor's change in teaching practices. Quantitative data were supplemented by a qualitative analysis of classroom teaching and instructor meetings.

Analysis

To document changes in student participation moving from face-to-face, we completed a number of quantitative analyses. First, we compared the participation rates in the last face-to-face class session and the first online class session for each instructor. We only considered participation in whole-class discussion, because small groups were not coded in the face-to-face class observations. This allowed us to quantify the immediate impact on participation before faculty implemented new strategies to promote equitable participation. We did not aggregate over multiple rounds in-person or online, because the nature of the study was designed to invoke changes in practice, so aggregating across rounds would be inappropriate. Next, we performed the same analyses but disaggregated for women and students of color. Our final sets of quantitative analysis focused on how student participation compared in different online teaching venues. For all these analyses, we only focused on total student participation, rather than looking at specific dimensions like the type of student talk.

To document strategies used to promote equitable instruction, we first drew from the instructor end-of-semester surveys and learning community meeting notes, in which instructors described the teaching practices that they were working on. We corroborated instructor experiences by watching classroom video segments again to draw out appropriate vignettes for highlighting the strategies. Our goal was not to capture every strategy, but rather to focus on a subset of strategies that instructors found salient and particularly productive. Each strategy was characterized according to the community of inquiry framework, drawing from three conceptual categories: social presence, cognitive presence, and teaching presence. Each time that we encountered a teaching challenge or solution, the coding team discussed the particular instance and categorized it according to the community of inquiry framework. When strategies were used by multiple instructors, we then consulted the meeting notes and end-of-semester surveys again to find instances that discussed the rationale for instructors using the techniques.

RESULTS

Our results are organized into two sections. First, we focus on the nature of student participation as a result of the transition online. Second, we focus on the teaching strategies adopted by instructors in response to EQUIP data and learning community discussions.

Student Participation in Online Settings

Here we describe general patterns we found in student participation as the instructors moved from face-to-face to online settings.

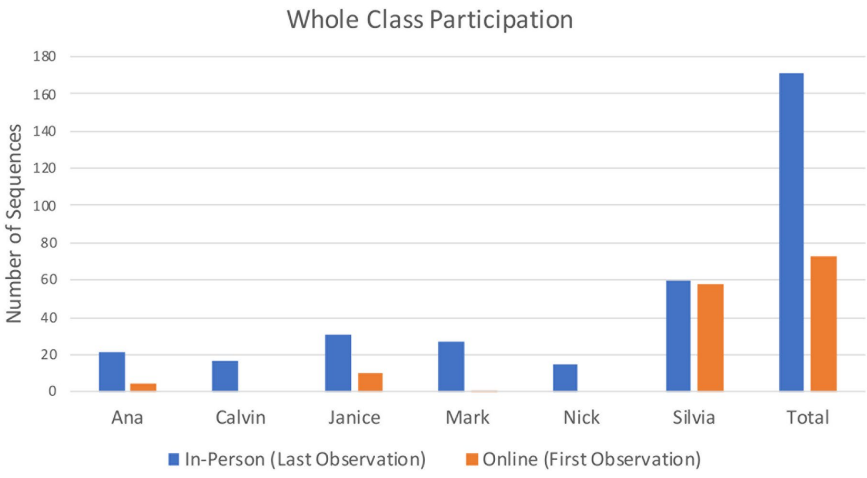

FIGURE 2. Comparison of whole-class participation from the last face-to-face (~7 weeks in the semester) and online (~9 weeks) observations.

Changes in Participation from Moving Online. All instructors described a decrease in participation in moving online. The EQUIP data corroborated this sentiment, showing participation dropped more than 50%. See Figure 2, which compares the participation rates for the last observed face-to-face session with those for the first online session for each instructor. We used a paired-samples t test and found significant differences ($t = 4.98$, $df = 5$, $p < 0.01$) in participation between the last face-to-face session (M = 28.5, SD = 16.562) and the first online session (M = 12.17, SD = 22.77).

Table 5 shows that there were no consistent changes in patterns for women or students of color in the proportion of participation as a result of the transition online. In three of the classes, participation

TABLE 5. Proportion of participation in whole-class discussions by women and students of color in the last face-to-face and first online class sessions[a]

	Women		Students of color	
	Face-to-face	Online	Face-to-face	Online
Ana	52%	50%	66%	66%
Calvin	58%	—	29%	—
Janice	93%	100%	35%	50%
Mark	7%	0%	—	—
Nick	69%	—	100%	—
Silvia	62%	45%	33%	26%

[a]Calvin and Nick had no participation in their first online session. Mark was unable to collect race data for his students.

by women decreased; in one, it increased; and in the other two, there was no participation in the first online session, so comparison was not possible. For students of color, in one class, the proportion of participation remained the same; in one class, it increased; and in one, it decreased. From these patterns, we do not find evidence in our sample that the transition online seemed to disproportionately impact one population more than another, but there are potentially other impacts on student participation that we could not measure.

Participation by Venue. As instructors learned to teach online more effectively, they were able to increase participation. While the amount of public participation (whole-class discussion and public chat) in the first virtual session (round 3) was 12.83 participation sequences on average per class, this number increased to an average of 24.33 sequences during rounds 4 and 5 (the later virtual sessions). One of the primary mechanisms for supporting increased participation was the use of chat, which lowered barriers to participation (see Figure 3).

While the use of different venues increased participation overall, we were curious to understand whether or not particular groups of students (by gender or race) used certain venues more than others in the online classes (see Tables 6 and 7). Across classes, we found no consistent patterns. In some classes, such as Ana's, men had higher levels of participation in breakout rooms and chat, as compared with whole class. Yet, in other classes, such as Mark's, which tended to be dominated by men, the use of breakout rooms and chat provided some additional opportunities for women to participate that were not present in the whole-class discussions.

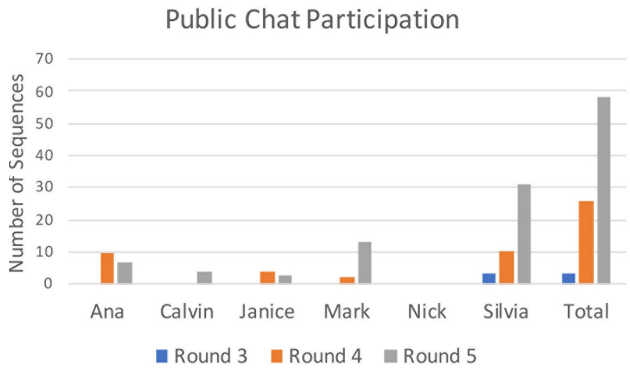

FIGURE 3. Public chat-based participation increases across the virtual rounds (rounds 3–5). Each round consisted of a classroom observation, feedback, and debrief meeting with the learning community.

Table 7 tells a similar story by race. In this case, in Ana's class, students of color used the breakout rooms and chat more than the whole-class discussion. This trend flipped for Janice's and Silvia's classes, in which students of color had proportionately more participation in the whole class than in chat.

Strategies for Promoting Equitable Participation

In each debrief meeting with the learning community, instructors discussed the inequities in their classroom participation as evidenced by EQUIP analytics. In response to these data, instructors adopted a range of practices to promote equitable participation online. We highlight a number of key practices related to social presence, teaching presence, and cognitive presence. These practices were: 1) re-establishing norms, 2) using student names, 3) using breakout rooms, 4) leveraging chat-based participation, 5) using polling software, 6) creating an inclusive curriculum, and 7) cutting content to maintain rigor.

Re-establishing Norms. Moving online, it was critical for instructors to re-establish classroom norms to create social presence, especially as many students had no prior experience learning online. Common classroom norms such as students raising their hands when they have questions or participating in whole-class and small-group discussion had to be adapted to the new online environment. Two instructors in particular dedicated a modest amount of class time to re-establish norms in their online classrooms. During one of her first online sessions, Ana discussed new ways to communicate between her and her students,

> Ana: There is an option [in Zoom] to like raise your hand and you can give me an answer or ask a question, and I think that will bring it to my attention so that way I can be like "oh so and so have a question."

> Ana used this opportunity to re-establish the norm of raising one's hand with a question. Since this feature is nonintuitive, Ana's explicit renorming in the context of Zoom let students know how to participate as they would normally in a face-to-face setting.

Another instructor, Silvia, also engaged in multiple examples of renorming in moving online. Using Zoom features such as breakout rooms, chat, polling software, and "reactions" (e.g., thumbs up, clap, raise your hand) allowed Sylvia to renorm her online classroom (creating social presence). As evident in classroom observations, in the face-to-face setting, Silvia engaged students using instructional practices such as "go around the room" (where each student makes a brief comment as Silvia goes around the room) and "five hands" (where she waits for five hands to be raised before calling on a student—a strategy suggested in the first learning community meeting). To employ these techniques in the online setting, Silvia had to re-establish her teaching presence. In doing so, Sylvia was able to increase participation in the virtual environment. We can see in Figure 4 that this helped increase the percentage of students participating

TABLE 6. Aggregate number of participation sequences by venue and gender across online classes[a]

	Men			Women			Nonbinary		
	Whole class	Breakout	Chat	Whole class	Breakout	Chat	Whole class	Breakout	Chat
Ana	8	8	10	26	10	16	0	0	0
Calvin	0	12	1	0	45	3	0	0	0
Janice	1	0	0	21	1	7	0	0	0
Mark	15	12	15	0	5	5	0	0	0
Nick	14	22	0	34	62	0	0	2	0
Silvia	84	0	21	113	0	31	74	0	16

TABLE 7. Aggregate number of participation sequences by venue and race across online classes[a]

	White			Students of color		
	Whole class	Breakout	Chat	Whole class	Breakout	Chat
Ana	15	4	7	12	10	19
Calvin	0	16	2	0	23	2
Janice	6	1	6	16	0	1
Mark	0	0	0	0	0	0
Nick	0	0	0	47	81	0
Silvia	149	0	42	122	0	26

[a]participation sequence constitutes a segment of student talk that is uninterrupted by any other student in the class.

(compare round 3 with round 4, as the average percentage of students participating increases from 53.6% to 71.6%).

In the following episode from Silvia's third online observation (round 3 in Figure 3), she started recognizing students' reluctance to participate in the discussion,

> Silvia: If anybody who hasn't spoken yet wants to jump in, I would welcome…. I know it's hard, it's kind of tempting to kind of make this like a podcast or whatever. But I'm hopeful we can still have everybody as we would in the room. Yeah maybe if you haven't spoken yet, I would love to hear your voice, proof of life kind of thing. Do you want me to call on people? I don't want to call on you, but if I were in the classroom I would.

After about a minute, she employed a modified version of the five hands technique by re-establishing the norm of having students raise their hands (either physically or using the Zoom feature).

> Silvia: Let me just ask this easy question … I'll wait until I have five hands on that. You can do your real hand, your fake hand … And if you want to raise your hand with the technology you can go to Participants and you'll see an option to raise your hand. Okay, I see one hand from Velma, I see a hand from David, I see Muna's hand, so I've got three hooray! Thank you. I've got Malvika and Joy. Okay, good I've got five hands, yay!! I think I haven't heard a lot from Velma, and then maybe David if you have something to follow up too. So go ahead Velma.

This episode illustrates the use of renorming to encourage participation in the context of an online synchronous classroom. After some time, the classroom norms were re-established, and students started engaging more in the online setting. This is evident in Figure 3, which shows more than 70% of the students on average contributed to the classroom discourse in the final two rounds.

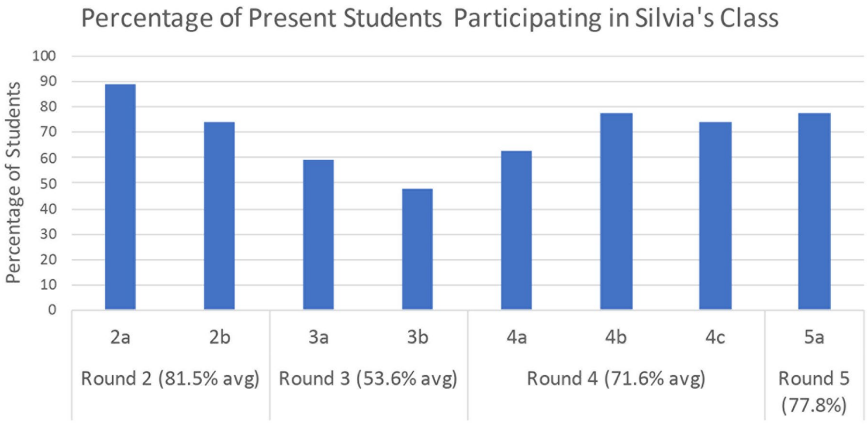

FIGURE 4. Percentage of students participating in Silvia's class per observation. Note, Silvia was not observed in the first round (cycle of observation–feedback–debrief), and during rounds 2, 3, and 4, she was observed multiple times before debriefing.

Using Student Names. Multiple instructors, especially those in STEM, noted that they infrequently used student names, even late into the semester. This could be a barrier for social presence. For instance, we never observed Calvin use a single student name in his first three recorded sessions (two face-to-face and one online). Similarly, Nick rarely used student names. Nick's round 4 EQUIP data evidence that a small subset of the students in his class were participating, and accordingly, it was

suggested during a learning community meeting that he could use student names as a strategy to bring particular individuals into the classroom discussion. Nick did take up this strategy and reflected on it as an important insight in his end-of-semester survey.

Nick noted that he rarely used student names, because he typically did not know them, even late into the semester. However, in the online sessions, he could see student names on the video feed. This allowed him to use these student names as a way to intentionally call on particular students who were not previously participating as a way to bring them into the conversation. Calvin also described the value of using student names and noted how it helped him become a more "sociological teacher."

Consider the following episode where Nick used student names to acknowledge particular students. He began by interacting with students in a breakout room and then transitioned to whole class.

> [In the breakout room]
>
> Nick: This group is good! This is the last group I visited, and the best for last.
>
> [Back to whole class]
>
> Nick: The one that I had not thought of, that *Jay* mentioned…

In this instance, the student brings up a point that the instructor had not thought of previously. In the share out, Nick then explicitly used the student's name publicly, which elevated the student's comment from the breakout group to the whole class. Using the student's name affords a positive sense of belonging and success for that student in the larger classroom setting (related to social presence).

Like Nick, Mark began using students' names in response to the learning community discussion in round 4. In a subsequent observation, Mark posted a prompt for students to respond to. Four students responded in the chat and instead of anonymously validating the responses in the chat, he announced "Okay, Sam and James both said 25 gallons, and that's the same one as Jeremy's 94.6 liters. Great job Jeremy, Sam, James, and David. Excellent job!" This explicit move of validating students' contributions is another example of assigning competence.

Using Breakout Rooms. Many students refrained from participating in whole-class discussions online (see Figure 1). Accordingly, breakout rooms allowed students to interact in a smaller, more personal setting with their peers, creating greater social presence. Also, in moving between the rooms, instructors could give more consistent personalized attention to particular students. Calvin used a strategy of consistent student groupings for breakouts to maintain social bonds that students had formed before the pandemic. This helped reduce isolation and provided students with social support in case they were struggling or needed help on the homework.

Given that students were more comfortable participating in breakout rooms, instructors needed to develop strategies to scaffold participation from the breakout rooms back to the whole class (to elevate their teaching presence). This was a strategy described by the learning community leader during the very first meetings, as he discussed strategies for orchestrating classroom discussions in moving from small group to whole class (Reinholz, 2018). These strategies were discussed again after transitioning online postpandemic and were found to be productive by participants. Consider the following episode, in which Janice was connecting the coronavirus pandemic to societal perceptions of illness,

> Janice: So we have been thinking about how illness affects people, how our society affects the way that people experience illness, and this is like a really great example for us to use in real time. Can we identify different choices about the virus? We often talk about discourse. That's about a group of people or an ethnicity or a racial group. We can think about the discourse about the coronavirus. I want you to think about who or what are people blaming for the pandemic. I want you to think about how our healthcare system in the U.S. is shaping the pandemic.

After this introduction, Janice broke the students into breakout rooms and then brought them back together. Janice asked for students to share their experiences about how people are not social distancing and how that has to do with an aspect of the American culture. In the following excerpt, we see her explicitly bring out student ideas from one of the breakout rooms, encouraging other voices to join the conversation.

> Janice: Then I heard Yoshi and Hannah [in the breakout] talking about this concept of individualism in our culture. Do either of you want to talk about that?
>
> Hannah: We were just talking about in American culture, things are very individualistic versus collective, it's always very me first. You know, I am an individual, my rights are being taken away, instead of [people] recognizing [that they also have an obligation to others in society] … I'd like to think most people are social distancing. It's not just about each individual in each person and they are right. It's about everybody protecting those arounds us.
>
> Janice: Okay, so this idea of my rights are being violated, my right to go out without a mask and be around people versus the idea that maybe we need to be a little bit uncomfortable … I think we have a very strong culture of individualism in the United States. This is part of our history. People are thinking of themselves and maybe their families and less of what can we do that's going to protect the entire community.
>
> This strategy of explicitly bringing out student ideas from the breakout room was a mechanism for validating the contributions of students who might otherwise be hesitant to participate publicly to the whole class.

As described earlier, all instructors were committed to maintaining active engagement in their classes (related to cognitive presence). However, as was visible in the first synchronous online meeting, some instructors did revert to using nearly pure lecture with no student participation in whole class (particularly Nick and Calvin). This was due to a lack of familiarity with the tools and how they might maintain engagement online. As we described earlier when discussing teaching presence, once the instructors became familiar with the tools, they continued to use breakouts, sample problems, and classroom discussions

as before, via the online tools. This helped maintain a higher level of cognitive presence. This adoption of tools was facilitated by the learning community. For instance, Janice described her experience using breakouts in her first online session as "awkward," and it was not until much later in the semester that she tried using breakouts again, because she was encouraged by the ways in which her fellow participants used them. As we can see from the sample episode, when Janice reincorporated breakouts, she was able to use them productively to broaden student participation.

Leveraging Chat-Based Participation. Chat was a very flexible method for broadening participation (related to teaching presence). In contrast to speaking up during a discussion, it was a lower barrier for students to type responses—especially those who might have limited access to particular technologies. In the context of the learning community, Janice was the first participant to begin using chat when instruction moved online. She was motivated, at least in part, by feedback during round 2 showing a particular student was dominating her class discussions, and she was looking for methods to get more students involved. She was initially using a third-party solution for chat and suggested to the other participants that students felt more comfortable using chat. This was the seed within the community that prompted other faculty to use chat, and ultimately the research team began coding chat as another venue for student participation. As instructors began to use chat and saw through the EQUIP data that it became an important venue for students to talk, the use of chat proliferated to even more instructors.

One way that instructors used chat was to elicit participation, which then could be elaborated through verbal talk. Consider the following episode in which Silvia has a student share an idea from chat for elaboration.

> [Silvia has student first respond in chat.]
>
> Silvia: Let's see, so Cassie do you want to say that out loud, or you just want to have it on the comment there? You are correct, do you want to say it out loud?
>
> Cassie: Sorry, there are planes that go over, it gets kind of noisy. I was just saying…

As we see in this episode, the student chose initially not to speak verbally, being mindful of background noise and not wanting to disturb the class. Yet, as Silvia responded to the chat contribution, she made space for the student to share verbally. The next episode provides another example of this.

> [Student types an unprompted comment in the chat.]
>
> Silvia: I see Jim noted … Do you want to talk about that for a second Jim?
>
> Jim: Yep, okay. So basically…

Here, Silvia asks, "Do you want to talk about that?," and invites Jim to participate vocally based on his chat contribution. This was an effective mechanism of explicitly creating space for students who may otherwise not have felt comfortable taking the step to initially participate verbally (enhancing social presence).

Using Polling Software. While polls can be used in a face-to-face classroom, instructors in the study were not previously doing so. Thus, the challenges of teaching online pushed instructors to experiment more with new methods to enhance teaching presence to promote equity. In particular, in Mark's class, the EQUIP data consistently showed low levels of participation from women, and Mark discussed challenges to get them engaged in his discussions. During the learning community meeting after round 3, it was suggested that Mark could try use polling software to change his classroom dynamics. This was a suggestion he took up.

During the class, Mark provided the link to a Poll-Everywhere poll to students using the public chat. Mark invited students to access the poll and solve some problems related to the class topic (chemistry of chlorination). He gave students some time to work on the exercises, and after he saw that most of the students completed the poll, he read the answers, gave some ideas of how to solve the problem, and built consensus on the correct answers. By using this software, Mark provided all students with an anonymous way to engage and participate in the class, which could be beneficial for those students who are not that comfortable sharing information to the whole class and allows everybody to participate simultaneously.

Mark also used polling software in conjunction with other new teaching strategies, like leveraging chat. For instance, during one class period, Mark posed a question to the class (calculating change in flux). As students began to respond, Mark noted, "I got one person who has responded [in chat], waiting for two more. I just sent a quick poll to see if anyone is having challenges with this problem."

Here, we see Mark use a handful of equity-focused techniques discussed in the learning community. First, he was using chat to lower the barrier of entry for students. Second, he used the strategy of waiting for three responses (similar to Silvia's five hands strategy) to make sure that he was not just moving ahead when he got a single student response and leaving other students behind. Finally, recognizing that it was difficult to check in with individual students, Mark sent a poll, separate from the question, to see how the students were doing (related to social presence).

Creating an Inclusive Curriculum. Instructors worked to create social presence by connecting their curricula directly to their students' lived experiences. For example, Janice facilitated a discussion about "illness narratives" and contrasting biomedicine with traditional medicine. In this context, Melanie shared a story of her mother getting breast cancer. We see that Janice used this as an opportunity to push for deeper discussion of American culture, creating opportunities for other students to respond,

> Janice: Okay, so, does anyone have an idea about how Melanie might analyze her mother's breast cancer narrative. What can this tell us about our culture?
>
> Melanie: I think in our culture we focus on the biomedical because once we start kind of trying to go into other realms … It's almost like an attempt to dissociate from it by putting in these really medicalized [*sic*] terms and it's trying to keep emotions out of it, because otherwise you are going to kind of have to feel them … I feel like Western culture kind of allows

> us to do that a little bit more because it is so clinical medicalized mechanized [*sic*] that it's not always a bad thing.
>
> Janice: This is how we have been trained to respond through our culture. This is how biomedicine trains us to respond. These are sort of the scientific details of the disease. Here is the prognosis. Here is what we are going to do about it … Not everyone would respond in the same way, but it's a very culturally appropriate response to put this kind of trust in biomedicine to let the doctor worry about it so that you don't have to worry about it yourself.

As we can see, Janice's language that this was a "culturally appropriate response" served to validate the student's experience and make that student feel more connected to the class.

Equity in a classroom is not only reflected in the participation of students but also how an instructor validates different ideas, identities, and cultures (e.g., through the choice of course content, through the use of affirming language). Janice continued to build a safe and inclusive environment for her students, which resulted in deep and complex contributions related to social justice and human rights as it related to students' experiences during the global pandemic.

Cutting Content to Maintain Rigor. Instructors noted the lack of time in moving online. For example, Mark frequently lamented how it would take longer to complete sample problems in class. However, rather than quickly rushing through the same number of examples, he instead opted to reduce the number of examples in class and still gave students time to interactively engage with the material. This allowed them to have a deeper cognitive presence during class, and then additional sample problems could be shared later. Ana brought up the challenge of determining which content to focus on during the initial learning community meeting, and it was a theme that came up throughout the semester. Ana described her insights into the issue in her final reflection.

> Ana: I think that I now see a big part of equitable teaching as having a more stripped-down, thoughtful, deliberate curriculum that gives enough space to adequately explore ideas that come up in a course. This has been a thought lurking in the back of my head, and it's really become so much more obvious this semester.

As Ana articulated, she saw one of the barriers to equitable participation was simply trying to do too much in a course rather than doing fewer things well.

OPPORTUNITIES FOR SUSTAINED LEARNING

We found limited evidence that the learning community continues to be meaningful for the participants and may have a long-term impact beyond Spring 2020. For example, two faculty members actually decided to continue through the next semester, even without incentives. Ana recruited a graduate assistant to code her classes with EQUIP (independently of the author team), and Mark continued to work with the lead author during Fall 2020. Mark even recruited two more participants from engineering and secured internal funding from his college to support the coding of classroom video, because he valued the EQUIP data and thought his colleagues would benefit from the system. Similarly, in spontaneous communications with Silvia, she indicated how she was thinking about using lessons learned from the learning community in her fall planning. While there was no formal delayed follow-up survey, these informal interactions are strongly indicative of the value for participants.

LIMITATIONS

This study describes a unique set of circumstances during a pandemic. For instance, multiple participating faculty members managed their teaching responsibilities while lacking access to childcare for their young children. Students also faced issues due to pandemic stress and moving or renegotiating shared living space. Thus, there is some limit to generalizing the results to online teaching as a whole. Nonetheless, many institutions have remained online through Fall 2020, and many will remain online through Spring 2021, as the pandemic rages on. In addition, the longitudinal benefits to faculty were not a focus of this study but are an area for future study. Nonetheless, teaching strategies identified should be of broad utility.

Given the differences in disciplines, classroom demographics, and teaching styles, it is difficult to generalize the impact of venue across classes. Nonetheless, as our data do highlight, the introduction of new modalities helped increased participation overall, and in some classes, this supported women and students of color to participate more than would have been possible in whole class alone. Thus, we conclude that the use of different modalities can promote participatory equity, but more research is required to understand how to most effectively support different groups of students in different venues.

DISCUSSION

This study used a community of inquiry framework to understand how faculty focused on equitable participation as they transitioned to teaching online. The two main goals were to understand 1) how student participation was impacted in moving online and 2) the impact of EQUIP data and a professional learning community on supporting instructors to teach more equitably. Here, we summarize our results and provide actionable suggestions for researchers and practitioners.

It was clear from the EQUIP data that student participation was significantly impacted in moving online. Across the board, student participation decreased, but there were no clear patterns for women or students of color. The decrease can likely be attributed, at least in part, to the challenges of teaching and learning during a global pandemic. Nonetheless, despite these challenges, instructors did make considerable progress in broadening participation in their classes through implementing new teaching techniques. This also suggests that instructors have the capacity to make significant and meaningful differences for their students, even under the most challenging circumstances.

At the foundation of the learning community were the EQUIP data. Instructors received EQUIP data during each round of the observation, and these data helped anchor learning community discussions around participatory equity. The types of inequities took on a variety of forms, as highlighted earlier: Silvia and Nick noticing lower proportions of students participating, Janice having a single dominant student, and Mark having lower levels of participation from women. As participants engaged with the data, they were able to bring concrete issues to their peers for discussion and collectively develop strategies to improve equity.

In their reflections, faculty noted both how the EQUIP data helped draw attention to concrete issues that they needed to address and how the data validated their attempts when they successfully made changes.

In general, we found that most changes in faculty teaching practices could be traced directly to the EQUIP data and learning community discussions. For example, strategies such as the use of "five hands" and scaffolding breakouts were directly suggested by the community leader. Other strategies, such as the use of chat suggested by Janice and mechanisms for elevating chat to verbal participation shared by Silvia, came from the instructors. As instructors implemented new strategies, they shared them with their peers, which encouraged further revisions to practice. For instance, Janice initially abandoned breakouts, but used them again later, because she saw how her peers were using them effectively. For Nick and Calvin, discussions about student names in the learning community were particularly salient and influenced how they thought about building social presence with their students. Although this article does not provide an exhaustive catalogue of revisions to practice, the data illustrated that all six participating instructors made measurable changes to their teaching.

The community of inquiry framework provides a tool to help make sense of the changes to their teaching that faculty implemented. All faculty noted the challenges in establishing social presence in moving online, but they developed some strategies, like using student names, keeping consistent breakout rooms, and re-establishing norms and expectations. Compared with a fully asynchronous course, it is likely that having synchronous video meetings (although they were limited) helped provide social presence during the pandemic. Faculty also established a variety of practices—chats polling software, and scaffolding breakouts—to establish teaching presence. Given the challenges of moving online, instructors made compromises, like cutting content to maintain active engagement, to sustain cognitive presence. Although this framework was not directly shared with participants, in future studies, it would be a useful framework to help instructors think about multiple dimensions of their practice that require attention to promote equity.

Our work also makes valuable contributions to incorporating equity into the community of inquiry framework. Although we initially hypothesized that racial and gender equities would be exacerbated in moving online, we found mixed evidence in support of this. We suspect that, if instructors pay attention to possible equity pitfalls in moving online and make explicit effort to establish social, teaching, and cognitive presence, they can fend off inequity. In particular, we found that, although teaching online introduced new challenges, it also introduced new opportunities. As instructors became more comfortable with the technological tools they suddenly had at their disposal—polls, reactions, chat, breakout rooms, and whole-class discussion—their use of mechanisms for students to participate proliferated. Of course, these tools do not necessarily promote equity, but when they are used in intentional ways (such as scaffolding the breakouts or elevating the chat participation), then they become powerful tools in service of equitable teaching. Thus, our study helps highlight how equitable teaching strategies play a role in establishing different forms of presence in a community of inquiry.

While some of these technological tools (like polling) could also be used in a face-to-face classroom, the necessity to incorporate more voices and the easy access of such tools made faculty more likely to adopt them. We saw great strength in having multiple modalities to elicit and build on student thinking. We imagine that, as instructors in the study ultimately transition back to face-to-face teaching in the future, they may be able to take away useful lessons about equitable instruction from teaching online.

Finally, this article provides a set of concrete techniques that others can use to improve equity in online biology education. We recognize that the list of practices is far from exhaustive. At the same time, these are relatively simple strategies that participating faculty members were able to learn, use, and implement effectively in a short amount of time during a global pandemic. This suggests that the strategies described are low-hanging fruit that nearly any faculty member should be able to use online. Given the dearth of studies on teaching equitably in STEM online environments, and the present state of the global pandemic, we find this is a productive starting point for future research projects.

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