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Teaching Tips

Fostering Community and Inclusion in a Team-Based Hybrid Bioengineering Lab Course

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Abstract—As cornerstones of biomedical engineering and bioengineering undergraduate programs, hands-on laboratory experiences promote key skill development and student engagement. Lab courses often involve team-based activities and close communication with instructors, allowing students to build connection and community. Necessitated by the pandemic, changes to class delivery format presented unprecedented challenges to student inclusion and engagement, especially for students from underrepresented minority backgrounds. Here, we present a multi-faceted approach for fostering inclusion and community-building in a hybrid bioengineering laboratory course. A basis for this project was an approach for team-based project work which allowed students to have hands-on experience in the lab and collaborate extensively with peers, while abiding by social distancing guidelines. Members of each student team worked together remotely and synchronously on a project. One team member executed the hands-on portion of each lab activity and the remote student(s) engaged in the project via online communication. The hybrid lab course was supplemented with interventions to further promote inclusivity and community, including instructor modeling on inclusion, team-based course content, attention to lab session logistics, and instructor communication. Students responded positively, as indicated by the median ratings in course evaluations for the four lab sections in the following categories concerning course climate (using a 5.0 scale): their overall comfort with the climate of the course (4.8 to 5.0), feeling valued and respected by lab instructor (4.8 to 5.0) and their peers (4.8 to 5.0), peers helping each other succeed in the course (4.5 to 5.0), and the degree to which the experience in the course contributed to their sense of belonging in engineering (4.2 to 5.0). When asked to describe aspects of the class that contributed to inclusivity towards differences, students cited a collaborative environment, course content on implicit bias and inclusivity, and an approachable teaching team. Overall, our approach was effective in fostering a sense of community and inclusion. We anticipate many of these initiatives can transcend instructional format to positively impact future lab course offerings, irrespective of modality.

Keywords—Community building, Inclusion, Hybrid lab course, Undergraduate education.

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CHALLENGE STATEMENT

Laboratory courses are important components of biomedical engineering and bioengineering undergraduate degree programs, helping develop core competencies necessary for professional practice.[21,25] In addition to fostering skill development, hands-on laboratory experiences promote student interest, motivation, and behavioral engagement.[11] Because lab classes are often team-based and run in-person, they are also important contributors to community building, allowing for frequent, substantial, and organic interactions among peers and with their instructors.

At our university, undergraduate bioengineering students move through the program as a cohort and take eleven core classes together as a complete group. Our students consistently cite the cohort model as a strength of the program and a source of valuable support as they navigate the demands of the curriculum. Similar to other programs,[17] the teaching team worried the pivot to online learning necessitated by the COVID-19 pandemic would disrupt key experiences used to build a sense of community, particularly the face-to-face, substantive interactions involved in our laboratory classes. Building community is especially challenging without face-to-face courses, due to time constraints, varied participation, and missing elements of communication.[29] For the cohort discussed in this paper, the pivot to remote instruction occurred just prior to their first quarter of bioengineering core. Thus, this group lacked the opportunity to make connections and build their cohort-based community via traditional in-person classes.

Changes to class delivery format necessitated by the pandemic presented unprecedented challenges to student inclusion and engagement, especially for underrepresented students.[5,22] Recent data demonstrates that the shift to remote learning was challenging to all students, reducing their ability to focus on academic work and limiting their ability to succeed.[5,19] For underrepresented minority and first-generation students in particular, disparities in remote learning disproportionately exacerbated challenges related to course engagement, participation, and balancing responsibilities.[5] Measures of inclusion and belonging—including feeling respected, welcomed, and valued—were negatively correlated with engineering student self-reported mental health symptoms, emphasizing the importance of cultivating inclusive environments in our programs.[18] In addition to these concerning findings, previous work also demonstrated the importance of a student's sense of community to cognitive learning[27] and persistence.[28]

Thus, the teaching team faced the challenge of how to support students' sense of inclusion and community as we redesigned our core laboratory class, Mass Transport and Systems Laboratory, to address the safety constraints of the pandemic. The overall goal of the laboratory course was to provide hands-on exploration of topics covered in the corequisite lecture-based courses, Transport and Kinetics in Biological Systems and Bioengineering Systems and Control. The ABET student learning outcomes remained the same as prior offerings and included mostly technical competencies, such as the ability to analyze and interpret data. We also addressed the ability to create a collaborative and inclusive teamwork environment. Please refer to Supplementary Material, Online Resource 1 for a complete list of learning outcomes. Normally run in-person as a hand-on, team-based course, the class transitioned to a hybrid in-person and online delivery format in an attempt to maximize the amount of hands-on experiences in the lab and collaborative opportunities for students. In this paper, we describe and reflect upon a comprehensive set of strategies implemented to help foster a sense of inclusivity and community in a hybrid bioengineering laboratory course.

Despite the challenges of pivoting lab instruction to adapt to the constraints of the COVID-19 pandemic, the teaching team took the opportunity to become more intentional about building community and inclusion. We anticipate these initiatives will have applicability to future offerings of lab classes, regardless of instructional format.

NOVEL INITIATIVE

As the teaching team pivoted delivery in response to the pandemic from an in-person lab to a hybrid course, we adopted a multi-faceted, intentional approach in order to foster inclusion and community-building. A basis for this project was the development of a strategy for team-based project work which allowed students to have hands-on experience in the lab and collaborate extensively with peers, while abiding by social distancing guidelines. Members of each student team worked together remotely and synchronously on the class projects. The hybrid lab course structure was supplemented with interventions to further promote inclusivity and community, including instructor leadership on inclusion, team-based course content, attention to lab session logistics, as well as additional course announcements and the use of online forums for improved instructor-to-student communication.

Background for Course Teamwork Structure

Traditionally, this lab course involves a set of team-based projects which allow for hands-on exploration of a wide range of topics, from drug delivery to thermal controllers. Students consistently cite the hands-on experiences, such as a trypsin biosynthesis lab which allows students to gain experience in mouse dissection, as unique and valued learning opportunities in the bioengineering curriculum. Considering this, as well as the goal to facilitate critical student development of proficiency in laboratory technique during bioengineering education,[25] the teaching team was motivated to maximize the opportunity for students to engage in hands-on, psychomotor skill development in the physical lab setting. The importance of team-based work in laboratory classes to reduce perceived isolation in a distance learning environment was also considered.[12] Thus, the teaching team designed a new approach for this course involving collaborative projects in which team members worked together synchronously, but over geographical distance. One team member executed the hands-on portion of the lab activity while the remote student(s) engaged in the project via real-time online communication, completing tasks such as finding and sharing supplemental resources, data processing, protocol planning, and troubleshooting. Team members alternated between remote and in-person roles each week. This structure was opposed to the traditional, fully in-person format in which teams of three worked together at one bench, or the fully remote option in which modules contained lecture-based and computational activities.

Lab Session Logistics

Due to distancing requirements required by COVID-19, our traditional model—where teams of about three students work physically closely together on lab projects at the same benchtop station—was no longer possible. To adapt, the teaching team increased capacity in our teaching labs for additional workstations, which were spaced at least six feet apart. Teams were formed within each lab section to maximize the use of the workstations and the number of times students would be able to engage with in-person learning. Furthermore, the teaching team thought that a smaller group of team members attending via Zoom would encourage communication and participation for those not in class. This meant that teams were typically smaller than prior years, usually pairs of students whose members alternated between remote and in-person work for each lab meeting. Although the vast majority of the cohort were these "in-person" students (63/74), 11 students took the class completely remotely, due to health concerns or travel restrictions. Fully remote students were typically added to a pair of "in-person" students, to ensure that hands-on experimental work could be executed each lab session to advance the project.

Prior to the commencement of the quarter, the teaching team surveyed members of the cohort with regards to their access to communication-related technology, so that we could make inclusive decisions about what outside technology would be required for the class. Students indicated they had ready access to laptops and headsets, likely because they commonly utilized these items given the ubiquitous transition to remote learning for the prior two quarters. The exception was one student, who was able to secure a laptop through our university's technology loaner program. There were no additional course equipment fees beyond the normal amount.

The teaching team utilized a variety of logistical approaches to provide instructional support and encourage a sense of inclusion, sustained engagement, and effective communication during lab work. Lab sessions began with all students meeting via Zoom for a synchronous session to provide an orientation to the lab module, as well as live demonstrations of key procedures. Teams then moved to breakout rooms, or chose to use their personal Zoom rooms for project work for the rest of the lab session. In-person students brought laptops and headsets to the lab to communicate with their remote teammate and frequently utilized their cell phones as well. During the lab session, we provided strong instructional support in person (usually two to three teaching team members circulating the lab space for six to nine stations). The instructor or teaching assistants would also have a virtual office via Zoom throughout the lab session, so that student teams could drop into the virtual office to ask questions as needed.

Supporting Positive, Inclusive Teamwork Experiences

The teaching team utilized evidence-based practices to help support positive and engaging teamwork experiences, including balancing team composition by sex to form either female-majority or sex-parity groups.[9] Students also had the option to self-select teams, but team assignments were the default grouping method. To establish expectations and teamwork norms, one of the first assignments of the quarter was a team charter, which has been shown to positively impact team process outcomes, including mutual support and cohesion.[1] Team charter development also allows team members to become familiar with one another as teammates and can serve as a crucial first step in initiating interpersonal relationships within the team.[30] The team charter was adapted from Wolfe[33] to include commitment to safety (including COVID) precautions, team and personal goals, anticipated concerns, policies for managing challenges such as missed deadlines or unacceptable behavior, anticipated tasks and schedule, and plan for ensuring equity and inclusion for the entire team. To emphasize the importance of the equity and inclusion aspect of the team charter and to provide students with ideas of how to be intentional about supporting these during teamwork, the teaching team added a new lesson as an introduction to the team charter assignment. The lesson focused on implicit bias, which can be defined as unconscious bias about social groups.[13] We were inspired to add an implicit bias discussion to our course due in part to the knowledge gains previously demonstrated by attendees of a professional development workshop on diversity, equity, inclusion and implicit bias in academia.[15] After laying ground rules for respectful discussion, during this lesson the teaching team addressed the definition of implicit bias, its impact, literature-supported bias in science and the workplace,[6,23,24,32] ways of exploring our own implicit biases, and possible countermeasures. Students were then asked to reflect on the question as they prepared the team charter: with increased understanding of ourselves, how can we prioritize collaborative approaches in this class that build inclusion?

Since teams remained constant through the entire term, students had the opportunity to work towards optimizing their strategies for teamwork through cycles of reflection and adjustment, specifically prompting students to consider what has been working, what the students have learned, and future adjustments they should make (prompt is included in Supplementary Material, Online Resource 2). Reflection, a teaching approach increasingly recognized in engineering education,[2,3] has been shown to enhance professional skill development[16] and teamwork productivity.[26] To encourage this process, students were assigned a mid-quarter reflection exercise, where they were asked to reflect on their experiences with teamwork in the class thus far as a professional development opportunity (prompt is included in Supplementary Material, Online Resource 2). At the end of the term, the students reflected on their overall teamwork experiences from the quarter and how those might inform future approaches (prompt is included in Supplementary Material, Online Resource 2).

Students utilized a variety of communication and collaboration tools to function effectively as a team and form connections. Outside of the synchronous lab session where communication occurred primarily via Zoom, teams communicated via Facebook and other messaging apps. Teams collaborated real-time and asynchronously using the Google suite of tools, including Google docs and Google sheets. Instructors also provided a tutorial on the use of Kanban for project management so groups could plan tasks, allocate roles and responsibilities, measure progress, and recognize improvement opportunities.[4] Since members of this cohort did not have much opportunity for substantive prior interaction with each other or the instructional team due to the pandemic, and it was often difficult to recognize each other while wearing the required face coverings, we also offered name tags for in-person students to use during lab sessions to indicate their names and pronouns.

To make our new initiatives tractable, the curriculum from the previous year was modified to eliminate one set of oral presentations, and lab protocol planning was completed as a homework assignment instead of an in-person activity. These adjustments created time for the new implicit bias lecture and extra lab time dedicated to the modules. The remaining new measures towards inclusion (e.g., Piazza, team charter, name tags) were additive from previous years.

Teaching Team Communication and Access to Instructional Support

The teaching team proactively implemented established best practices with regards to the design and preparation of inclusive lab classes, including utilizing real-time captioning during presentations, providing transcripts for posted video tutorials, and using multiple formats to communicate lab instructions and safety information (e.g., spoken, written, video recorded).[14] Applying universal design of instruction principles,[7] the teaching team also offered a variety of communication methods and opportunities for interaction. For example, based on a request from the cohort in previous bioengineering end-of-course feedback, the question-and-answer platform Piazza was newly linked to our learning management system (Canvas). Piazza allows students to ask questions in a forum-type format. Our students particularly appreciate this tool because it allows for anonymous questions to be posted. Instructors are able to moderate the discussion, along with endorsing accurate answers. The teaching team held office hours both remotely via Zoom as well as in-person, strategically distributed among the days of the week and times of day considering time zones of students, their core class schedule, and prior general timing preferences.

Teaching Team Modeling on Inclusion

In online learning, previous findings demonstrate the critical role that instructor modeling has in building community.[29] In addition to modeling inclusive professional practice by incorporating inclusive pedagogical approaches described above, the instructor from the first day of class outlined goals and expectations for the class with regards to establishing inclusivity in the class. Despite the importance of the first day of class in establishing student impressions of the course and instructor priorities, recent work indicates very few STEM instructors emphasize that diversity and inclusion are important to them during the first class meeting.[20]

Our approach was to convey an explicit and detailed commitment to valuing diversity and inclusion during first day class orientation, as well as the expectation for all the teaching team and students to be positive contributors to a course climate of inclusivity. The instructor also created a new page on Canvas outlining commitment to fostering inclusion that quarter, including describing the instructor's ongoing reflection on privilege,[8] education and training in the realm of diversity, equity, and inclusion, commitment to diversity and accommodations (e.g., religious and disability), and examples of teaching approaches that would be adopted in the class to foster an inclusive and accessible environment. Before the quarter began, the instructor proactively contacted students who activated disability accommodations for the course to convey support and initiate planning steps.

Throughout the course, the teaching team adopted a set of actions to intentionally demonstrate interest in and respect for the students in our class, including prioritizing organization, using students' names, modeling the sharing of pronouns, and acknowledging the difficult circumstances that students may be facing.[10] The teaching team also modeled authenticity and vulnerability by sharing aspects of our own personal and professional challenges related to the pandemic and soliciting student feedback on the course.[22] In addition to soliciting informal suggestions, the teaching team asked for feedback on learning, climate, and inclusion via an anonymous mid-quarter online survey so we could have the opportunity to make adjustments before the term ended.

Lastly, knowing that students would have varied amounts of previous lab experience and comfort levels with lab technique, the teaching team deliberately messaged the expectation of zero prior lab experience, in an effort to proactively combat feelings of intimidation during this first in-person lab of the bioengineering curriculum. The teaching team also worked to destigmatize the need to seek help by embracing questions during lab sessions, welcoming students to office hours, providing multiple modes to ask questions (including anonymously via Piazza) and consistently praising students who asked questions.[22]

REFLECTION

Ethics Approval

Assessment of this work involved results from student assignments and anonymous course evaluation surveys. The University of Washington Human Subjects Division determined that the activity of human subjects research described in this manuscript qualifies for exempt status (IRB ID: STUDY00013973).

Mid-Quarter and End-of-Quarter Student Reflections

Considering the unfamiliar teamwork structure of the class necessitated by the pandemic, the teaching team assigned an individually based reflection exercise mid-quarter to encourage students to analyze critical aspects of their collaboration. Given recent findings on COVID-related teamwork challenges related to outside distractions, geographical differences, and widesweeping adjustments to communication,[31] the teaching team wanted students to have the opportunity to reflect on their team's performance and revisit established team norms, so they could make any necessary adjustments. Students were asked to address aspects working well, challenges faced individually or as a team, and plans for future approaches to teamwork.

To analyze the responses, 37 out of 74 total submissions were randomly sampled and coded the open-ended responses into broad themes using an emergent coding strategy modeled after Wildman *et al.*[31] Briefly, all responses were read for familiarity, and then broad themes were identified. The student responses were grouped into these initial themes. The initial themes were iteratively reviewed to form larger distinguishable themes that best represented the responses. Sub-themes were defined in each theme and used to further delineate responses. The emergent themes for positive aspects of teamwork identified from the student mid-quarter reflections are described in Table 1. Responses from students indicated that the overall teamwork structure was working to support inclusivity and positive climate supported by fellow students in addition to the efforts from the teaching team. The most common themes for aspects working well included: communication, forming connections with teammates, team member cooperation, peer-peer learning, meeting expectations outlined in the team charter, and general course structure. Examples of corresponding subthemes are also provided in Table 1.

The teaching team was encouraged to see that students were thoughtful about the exercise, identifying challenges and proposing adjustments to address them. The emergent themes identified for challenges and example adjustments are described in Table 2. The most common challenges were related to remote learning logistical obstacles, geographical differences, and personal hesitancy with project skills or feelings of inadequacy in comparison to teammates. Though most students indicated their intention to continue the good practices they had worked to establish (e.g., communication and frequent meetings), a number of students described adjustments they planned to make, including utilizing electronic tools for asynchronous collaboration, debriefing after each lab session, and more deliberate planning and preparation for lab (Table 2). The identified theme of the students' challenge with perceived inadequacy may suggest an issue with peer-to-peer inclusivity. However, these students also identified a need to review the content as an adjustment to make, indicating that this perceived inadequacy is a source of hesitancy with subject matter, rather than an issue with inclusivity (Table 2).

In a final end-of-quarter reflection, students were asked to describe "something they were appreciative of for the past winter quarter." The teaching team did not specify that answers needed to be class related. To analyze the responses, 37 out of 74 total submissions were randomly sampled and coded the open-ended responses into broad themes using an emergent coding strategy modeled after Wildman *et al.*[31] Students indicated appreciation for a wide range of aspects, from development of lab skills to personal circumstances, which we ultimately binned into six main themes (Table 3). In regard to this course specifically,

TABLE 1. Emergent themes from mid-quarter reflection assignments regarding aspects working well in teamwork.

Emergent theme	Subthemes
Communication	Communicating intentions ahead of time
	Learning to prioritize communication
	Communicating expectations and concerns
Forming connections with teammates	Understanding partner's work ethic due to longer term pairing
	Demonstrating mutual respect
Team member cooperation	Delegating work for write ups
	Dividing work equally
	In-person teammate keeping remote member engaged in lab with pictures and drawings
Peer-peer learning	Asking each other questions
	Learning more than would alone
Meeting expectations (outlined in team charter)	Meeting deadlines
	Adhering to team charter to track work and respect each other's time
General course structure	Smaller teams are easier to manage
	Ability to coordinate with group via Zoom during lab sessions helpful and engaging
Getting work done early	Working on an assignment early leaving ample time for revision
Preparing for lab sessions	Meeting to review tasks that need to be completed before and during lab session

TABLE 2. Emergent themes from mid-quarter reflection assignments regarding challenges faced in teamwork, and proposed adjustments.

Emergent theme	Examples of adjustments
Remote learning logistical obstacles	Doing extra research prior to lab to prepare as individuals and groups
	Dividing work during lab sessions
	Debriefing after each lab session
Geographical differences	Working outside of lab sessions asynchronously via Google Docs
Hesitancy with subject matter, Perceived inadequacy compared to teammates	Looking up background knowledge
	Reviewing content in more detail

students indicated an overwhelmingly positive response towards the community and relationship building aspects and the supportive environment fostered by the teaching team. Further, students expressed appreciation for the ability to engage in hands-on experience in the lab, the flexibility, and acknowledgement by the teaching team of the challenging circumstances students were facing. Students indicated that the course continued to support positive teamwork experiences and climate throughout the quarter. Students cited the importance of communication, flexibility, and establishing expectations as a team in order to foster a supportive environment and successful teamwork experience. A few students highlighted the positive aspects of the remote teamwork structure, citing convenience or ability to hone in on new skills (e.g., "I think because I was fully remote, this past quarter has really helped develop my listening skills further.").

Similar to the mid-quarter reflection, the final end-of-quarter reflection also asked students to discuss any proposed adjustments for future teamwork approaches. Challenges and proposed adjustments for future work described in these student reflections provide inspiration for improving the team charter assignment for the next course offering. For example, the teaching team will suggest that students create a detailed plan for meeting and communicating outside of lab sessions. Other suggestions from students that the teaching team plan to scaffold through the team charter include discussing respective strengths and weaknesses of team members and setting the expectation that all team members review the assignment rubrics in detail.

Student Feedback via Anonymous Course Evaluations

Students responded positively to our interventions, as indicated by the median ratings in end-of-course course evaluations regarding course inclusivity, climate, and interactions with the teaching team (Table 4). Students highly scored questions stating that they felt valued and respected by the lab instructor (average 4.71 ± 0.56) and other students in the lab (average 4.80 ± 0.40) (Table 4). These responses suggest that the inclusive environment was fostered by both the instructor and fellow students. Students had the opportunity to provide explanations for their

TABLE 3. Emergent themes and subthemes from end-of-course reflection prompt on appreciation.

Emergent theme	Subthemes
Forming connections with peers	Teamwork and collaboration Fostered by teaching team Considerate partner Community building Relationships with peers
Supportive teaching team	Time to explore and ask questions Hard working teaching team Support and guidance Taking different background knowledge into account Understanding and accommodating
Engaging, hands-on experience	Hands-on experience in lab Course format
Empathy and accommodation	Continued flexibility Consideration for students' surrounding experiences Acknowledgement and accommodation of circumstances Appreciation of workload and allocation of extra time Reasonable expectations
Applicable skills and experience	Lab modules with exciting challenges Opportunities for experimental design and creating solutions Having the opportunity to apply theory
Personal commentary	Securing a research lab position Continuing education Ability to utilize makerspaces on campus

TABLE 4. End-of-course evaluation results regarding course inclusivity, climate, and interactions with the teaching team.

	Evaluation score (Likert (5 pt), 1 = strongly disagree, 3 = no opinion, 5 = strongly agree)		
Course evaluation question	Average score(mean ± standard deviation, n = 20 responses)	Individual score range (min–max, n = 20 responses)	Median score range (min–max,n = 4 sections)
"Overall, I am comfortable with the climate in this lab section. (Climate is defined as attitudes, behaviors, and standards of staff and students concerning the access for, inclusion of, and level of respect for individual and group needs, abilities, and potential)"	4.85 ± 0.36	4–5	4.8–5
"I feel valued and respected by other students in this lab section."	4.80 ± 0.40	3–5	4.8–5
"I feel valued and respected by the lab instructor."	4.71 ± 0.56	4–5	4.8–5
"Students help each other succeed in this lab section (to the extent permitted by academic integrity policy)."	4.70 ± 0.56	3–5	4.5–5
"My experience in this lab section contributes to my sense of belonging in engineering."	4.90 ± 0.54	4–5	4.2–5

Likert scale ratings, which affirmed our teaching approach. Representative comments included:

> Peers were helpful with each other, between groups too
> Teaching team came without expectations about how much lab work each student had, so I felt like I was able to ask questions without judgment.

In the end-of-quarter evaluation, students were asked to qualitatively describe aspects of the class that contributed to inclusivity towards differences. Students cited a collaborative environment, course content on implicit bias and inclusivity, and an approachable teaching team. Representative comments included:

> Really liked that instructor took class time to discuss those [diversity, equity and inclusion] issue[s] and they were reinforced throughout the quarter

> Implicit bias lecture is very helpful in promoting inclusivity in this class
> Even though I am in a different time zone, my teammates are helping me to finish my lab assignment

Besides these summative assessments, the teaching team also gathered anonymous feedback midterm to gauge the success of our interventions and identify adjustments that might be needed towards fostering inclusivity in the class. Students were asked to reflect on their experiences thus far in the class and describe aspects that contributed most to inclusivity towards differences and course climate. Respondents ($n = 19/74$) provided insights into which practices helped build a sense of inclusivity and a positive course climate. Examples include:

"Having name tags with our pronouns, makes me feel accepted for who I am and how I identify myself as." (Author commentary: the teaching team found this feedback compelling because it identified an unforeseen benefit of providing name tags, which we would not have provided in a traditional offering.)

> I love the heavy teamwork aspect of this class! To be really honest it has helped me bond and create my own small community within bioengineering and we even do study groups outside of [class] for our other bioengineering classes.
> The reiterated emphasis on inclusivity and Dr. Taylor reminding us constantly that these are important topics to consider and be mindful of.

Importantly, one of the shortcomings of this assessment method is that we are unable to discern whether evaluation results differ by demographics. In this cohort, approximately 56% identify as female, 15% as first-generation college students, and 13% as African-American, American-Indian, Hispanic, and/or Hawaiian/Pacific Islander. Although the teaching team did not receive student feedback that indicated issues with student inclusion or belonging, we understand that we may not learn about negative experiences through these surveys. Additionally, although the feedback was overall positive with regards to climate and inclusivity, two out of 100 student responses consisted of 'no opinion' ratings for the end-of-course climate and inclusivity questions presented in Table 4. Another consideration is the relatively low response rate for course evaluations this year. In light of unprecedented and exacerbated challenges particularly faced by underrepresented students in the pandemic, we want to ensure that these methods are successful in fostering inclusion and community building for *all* students.

In addition to implementing evidence-based teaching practices, the teaching team also ensured that the course feedback surveys provided ample opportunity to provide anonymous feedback regarding aspects that could be improved to support course inclusivity and climate. Students provided general suggestions for course improvement which may further contribute to student inclusion and comfort in the next offering. In the mid-quarter feedback survey, students suggested providing more guidance for the remote team member's role during each lab session, beyond the summaries provided in the lab handouts. In response, for the last lab module the teaching team outlined more detailed suggestions for precise tasks and contributions for the remote team member during the lab session, such as real-time information gathering, protocol troubleshooting, and real-time data analysis. In future offerings, the teaching team will continue to identify ways to outline expectations for all members of the team to be active contributors to the project's execution and provide clear guidance for the remote student's responsibilities for each specific lab module. The teaching team can also offer tips to students on optimizing remote teamwork based on our experiences this year, such as supplementing Zoom video feed with static higher-resolution pictures and encouraging teams to debrief after the lab session so in-person students can share their insights.

From the instructor's perspective, the reflections, implicit bias lecture, along with the team charter, and the additional platforms for communication like Piazza were considered to be the most valuable interventions and will be used in future classes. However, an important limitation of our assessment is that we do not have a comparison group for the student work (e.g., corresponding reflection data from an offering without these initiatives). We also note that the evidence presented here cannot delineate the individual impact each of these elements had on perceptions of inclusivity. To determine this in the future, an additional survey could ask students to rank the elements of the course by their perceived impact on inclusivity. Since this is a cohort-based set of students, there is also the opportunity to follow up with students in their future classes to gain insight into any peer-peer inclusive practices maintained after this course.

The resource intensive nature of this hybrid format is a recognized challenge with this approach. However, the additional supplies and instructional support were necessary to meet course objectives while following the strict physical distancing requirements of the time. With these measures, the class succeeded in achieving at least basic competency in the same course objectives taught in previous years. As classes return to their pre-pandemic modality, this hybrid course format can still facilitate student participation considering the ongoing need for students to quarantine, and it could be used in future online curriculum to increase the accessibility to university education.

In conclusion, the course structure, activities, and approaches described in this paper effectively fostered a sense of community and inclusion in a hybrid bioengineering lab course. The evidence collected here measures the positive student response towards intentionally building community and a positive class climate. Many of the practices discussed translate across instructional modality or type of course, and therefore can be adopted in a wide range of future offerings to help foster community and inclusion. Even upon return to fully in-person learning, the continuation of teamwork reflections and implicit bias emphasis can further promote the community building aspects of laboratory courses.

SUPPLEMENTARY INFORMATION

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AUTHOR CONTRIBUTIONS

The first draft of the manuscript was written by AT. JH revised the manuscript evaluating it critically for intellectual content. Both authors commented on previous versions of the manuscript and read and approved the final manuscript.

AVAILABILITY OF DATA AND MATERIAL

Not applicable.

CODE AVAILABILITY

Not applicable.

CONFLICT OF INTEREST

The authors do not have any conflicts of interest to disclose.

CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

ETHICAL APPROVAL

The manuscript includes results from anonymous course evaluation surveys and de-identified student assignments. The University of Washington Human Subjects Division has determined that the activity of human subjects research described in the submitted manuscript qualifies for exempt status (IRB ID: STUDY00013973).

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