ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.

Strategies for equitable remote learning communities in graduate STEM classes

E. C. Bhatt[1], M. G. Blevins[1], D. H. Freeman[1], and L. M. Taenzer[1]

[1]MIT-WHOI Joint Program in Oceanography/Applied Ocean Science & Engineering, Cambridge and Woods Hole, MA, USA

Corresponding author: Danielle H. Freeman (dhfreema@mit.edu)

E.C.B., M.G.B., D.H.F, & L.M.T contributed equally to this work

Key points

- There is a history of inequity in STEM classes, especially for students of color, and COVID-19 exacerbates these inequities
- Active learning techniques and community building support student learning outcomes, especially in remote learning
- As graduate students, we pose specific strategies to leverage remote learning technologies to build more equitable STEM environments

ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.

Abstract

For many universities, the emergency transition to remote learning in March 2020 has evolved into full or partial remote teaching for the foreseeable future. Decades of research show that university classrooms, particularly in STEM (science, technology, engineering, and mathematics), are inequitable and non-inclusive spaces for underrepresented students. Without deliberate action from teachers, the transition to remote learning will exacerbate this issue. As STEM graduate students invested in our learning outcomes and dismantling systemic injustices, we propose specific strategies to create more equitable and inclusive remote graduate STEM learning environments through the revaluation of communication methods and classroom structures.

1 Introduction

As STEM graduate students with teaching experience and responsibilities, we are invested in contributing towards optimal learning outcomes as universities begin virtual classes during two public health crises: COVID-19 and racism. Both crises have laid bare the structural inequities of our academic environments and prompted full-throated calls for systemic change. After a summer of reawakened interest for Diversity, Equity, and Inclusion (DEI) committees, we invite a discussion on how professors, TAs, and students together can build equitable remote learning communities. While remote learning technology is generally viewed as a hindrance to inclusivity, we provide several specific strategies to leverage its capabilities to promote belonging and a growth mindset. Conscious adoption of these teaching strategies during remote learning will result in better learning outcomes for all students, transforming the pandemic crisis into an opportunity for creating more equitable STEM environments into the future.

2 Challenges and Solutions in Traditional Classrooms

Our discussion of inequity in the classroom focuses on students who are underrepresented in STEM disciplines as a function of their racial or ethnic identity. However, “students of color” are not a monolithic group. Many students have other identities that inform their classroom experience, rendering a focus on race as the single-axis of analysis inadequate (Constanza-Chock, 2020). We subscribe to a broader definition of underrepresented students to account for the intersectional nature of race, gender, class, and disability, among other identity markers. Similarly, “teachers" encompass anyone formally charged with educating students, such as professors, TAs, instructors, and lecturers.

Graduate education in STEM fields—especially the geosciences—lacks ethnic and racial diversity (Bernard et al., 2018). The typical sink-or-swim culture of STEM classrooms and discriminatory attitudes of teachers and students alike can discourage underrepresented students interested in STEM, resulting in a vicious cycle of exclusion (NASEM, 2016; Archer et al., 2015; Brinkworth et al., 2016). Many STEM environments focus on the importance of inherent ability, rather than growth over time, in dictating an individual’s ability to succeed (NASEM, 2016). This attitude has been recognized as particularly discouraging to underrepresented students and is further exacerbated for any experiencing stereotype threat[1]. A compounding factor for underrepresented students is a feeling of isolation from the scientific community,

[1] Stereotype threat is the fear of confirming negative stereotypes about one’s identity group (NASEM, 2016)

ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.

inside or outside the classroom (Brinkworth et al., 2016). These students navigate an academic landscape that forgives discriminatory messaging from established scientists while lacking role models, from underrepresented groups or not, who will speak out publicly against injustices (Tyson, 2014; Ogbunu, 2019). Since these are just a handful of the problems that underlie STEM environments, it is not surprising that underrepresented students have veered away from these fields of study. We emphasize that these problems were with us long before the onset of the COVID-19 pandemic and that fixing them requires deliberate and institutional change.

Intentional changes in teaching strategy can create more equitable learning environments with positive impacts for all students and disproportionately positive impacts for underrepresented students. Emphasizing a growth mindset, or the ability of students to improve through practice and experience, can empower students susceptible to stereotype threat (NASEM, 2016) or imposter phenomenon[2] (Chandra et al., 2019). This messaging occurs in the classroom and via individual feedback provided to students. Critical feedback that assures the student of high expectations and emphasizes their ability to meet those expectations through hard work is key for supporting underrepresented students (Cohen et al., 1999). Research also shows teaching practices which require active student engagement, such as discussion or collaborative classroom activities, also improve student experience and performance (NASEM, 2016; hooks, 1994). Such activities may be beneficial in part because they help create a sense of classroom community (hooks, 1994). We emphasize, however, that such activities must be implemented thoughtfully to demonstrate that all students' participation is valued. Restructuring the classroom environment takes time and effort on the part of the teacher but is fundamental for student success.

3 Challenges and Solutions in Remote Classrooms

Remote classrooms present challenges in creating equitable and inclusive learning environments, particularly for teachers accustomed to traditional classrooms. Logistically, remote classrooms must balance student engagement despite varying time zones, familial obligations, access to technology, and work-from-home spaces (CRPE, 2020). But there are also more intangible challenges: How do you facilitate an effective discussion among students who cannot rely on social cues that are obvious in person? What can you do for a struggling student when you cannot sit down with them to identify the problem? How do you even recognize whether students are confused when you can only see their profile image? We know from research that creating an equitable learning environment goes beyond ensuring a reliable internet connection; it requires a sense of classroom community, active engagement with the course material, and obvious investment of the teacher in the student's success. At first glance, remote learning seems antithetical to those goals.

We embrace the shift to remote learning this Fall as a catalyst for making classroom environments more engaging and equitable. We are concerned that, without intentional effort from our teachers, continued remote learning in the Fall will exacerbate the challenges facing underrepresented students in STEM and result in poorer learning outcomes for all students. To address this problem, we introduce strategies below and encourage all teachers to implement them in their remote classrooms.

[2] Imposter phenomenon occurs among high achievers who do not internalize their success, attributing it to chance or fraud instead (Chandra et al., 2019)

ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.

3.1 Communicating Teacher Investment in Student Success

Cultivating trust through academic and personal discussions promotes student success. Providing meaningful feedback to students is a direct way to build academic and personal trust, especially in a remote learning environment. As opposed to grading, which records what a student knew at the time of assessment, narrative feedback contextualizes progress, highlights areas for future improvement, and acknowledges any personal difficulties or circumstances. When teachers intentionally get to know their students, students get to know them as well; this trust lowers the barrier for students to take academic risks and express confusion or curiosity.

Connect with individual students to build trust

1. **Be humble.** Admit your own mistakes when they happen and thank students for correcting the record. This normalizes learning from our mistakes.
2. **Affirm student identities.** Students who are well known by their professors perform better and are more engaged (Darling-Hammond et al., 2020). Facilitate student introductions early on; use student names often and learn their preferred pronouns.
3. **Be mindful of language.** Do the work to recognize and address microaggressions—small in scale of persons and time involved, not impact—in the classroom, most often delivered by teachers (Suárez-Orosco et al, 2015). Avoid using phrases like "it's so easy" or "just do X", as they may trivialize a student's gap in knowledge.
4. **Hold one-on-one or small group check in meetings.** Hold small meetings at a regular cadence, depending on your class size, to check in with students in pre-established forms of communication.

Stimulate transparent communication during class time

1. **Lower the barrier for communication during lectures.** Encourage intentional use of chat boxes for students to ask questions in class and discourage extended dialogue that can be distracting. Make use of yes/no buttons to affirm understanding. Regularly break lectures to check if people are following.
2. **Make your classroom smaller when you can.** Small class sizes lend themselves better to camera-on participation and active learning styles. Class size is not always under the teachers control, but, when possible, holding smaller lectures and discussions will make active learning in virtual classrooms easier.
3. **Act as facilitator (or have a TA act as one) to democratize student input and call on all voices**. A virtual format inherently makes group discussion more stilted and awkward. Having someone responsible for conversation flow and responding to questions in chat boxes can democratize student input.

Rethink grading and feedback in a growth mindset

1. **Incorporate rubric-based narrative feedback.** Purely quantitative grading metrics can cloak implicit bias (Alesina et al, 2018) and in a virtual classroom, may be confounded by privilege, economic stability or familial obligations. Narrative feedback, unlike grades, gives direction for student growth. Personal video or voice calls between student and teacher can applaud progress, highlight areas for improvement, and acknowledge individual learning circumstances. Be aware that narrative feedback can still be subject to

ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.

bias or even simply perceived bias, with negative impacts on students (Cohen et al., 1999). We propose basing narrative feedback on a rubric, with transparent and consistent expectations, as a way to limit bias.

2. **Be more flexible on "participation" grades.** Appreciate student effort, especially if it is asynchronous, offline, and/or unseen.
3. **For particular assignments, adopt deadline windows with the possibility to individualize schedules.** Recognize that the diversity of student experience, especially during the pandemic, may make using common, rigid deadlines for all students impractical. Stay in conversation with students to determine deadlines that each student can reasonably be held accountable for meeting.
4. **Diversify assessment instead of using high stakes, timed exams.** Traditional, high-stakes, timed exams are an inequitable assessment tool (Au, 2013). Implementing such exams in a virtual format, timed on a webcam, is stressful and in many cases simply impractical. More flexible assessments such as open-book take-homes or project-based assignments ameliorate these problems and reinforce a growth mindset.
5. **Provide or suggest additional online resources to reinforce comprehension.** Not all students learn the same way. Providing additional resources, especially if they are interactive or multimedia, can help students connect to the material on their own terms. This may be especially useful for students who struggle to adapt to the virtual classroom.
6. **Provide weekly or monthly assessment questionnaires for students to provide feedback and convey what would need more review.** The growth mindset is a two-way street. There is always room for teachers to learn and improve their teaching, especially in a new classroom format.

Be accessible for student questions and suggestions

1. **Schedule office hours by student availability.** Survey students for their preferred times and pick a set that covers as many students as possible. If appropriate, use a waiting room feature to let students in one at a time for private conversations.
2. **Offer approachable mediums for questions.** In addition to virtual office hours, offer other communication channels that the class prefers, like email, Slack, or even GitHub, where students can ask questions.
3. **Share insights from office hours with the class.** Students will appreciate a distillation from office hours, especially on logistical concerns, if they were not able to make it.

Use the first class to intentionally create a community

1. **Address class format.** Establish norms on how students can raise their hands, ask questions, and offer input. Assert your investment in making the course engaging and active.
2. **Facilitate introductions.** Conduct the first class meeting with all student cameras on and encourage camera-on participation whenever possible.
3. **Make clear that there is an understanding for difficult and diverse circumstances.** Encourage students to be open about their commitments and circumstances in advance so that learning can be tailored to be as stress-free as possible.

3.2 Prioritizing Communal Learning Objectives

ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.

Creativity in structuring lectures and assignments can provide several low stakes opportunities for students (and teachers) to receive feedback and learn from their mistakes. Too often this feedback hinders a growth mindset by being high stakes and evaluative. At the graduate student level, building learning communities involves sharing the responsibility of providing feedback *to* students *with* students (Hodges et al, 2020). This can be achieved through a balance of asynchronous and synchronous[3] mechanisms across lectures and assignments to cater to students' various learning styles.

Create a community which values student input, leadership, and growth

1. **Develop class rituals.** A consistent format to begin or end a class can engage students together and highlight specific gaps in understanding. This could be a question, check-in response, design exercise, or a relevant and recent abstract to draw students' attention to. If collaborative, encourage that this ritual happens with cameras on.
2. **Assign roles in breakout groups.** Small groups allow for more free-flowing conversation but are susceptible to inequity or exclusion. Democratize roles in the group (manager starts the discussion and ensures everyone's ideas are considered, timekeeper facilitates discussion in the allotted time, reporter takes notes and shares with the class).
3. **Create collaborative, running documents for breakout groups.** Send out a specific document for reporters to keep track of the discussion or solutions in a breakout group. This becomes a dynamic record and students can see how their peers may have approached a problem differently. If discussions are more computational, utilize code notebooks through GitHub or Google CoLab.
4. **Invite students, and work with them, to introduce a lecture.** On a rotating schedule, have students give brief presentations on recent papers or news related to the course content. Even if these preface a given lecture, they will give students a chance to address the class and share their perspective with their own flair.
5. **Acknowledge scientific greats as people.** Do not laud scientific greats as geniuses, as this is antithetical to the growth mindset. Discuss how science was accomplished and the often communal nature of scientific breakthroughs. Contextualize moral shortcomings of scientists and the broader impacts of scientific research or stature. These conversations normalize equity and ethics as part of an academic career.

Restructure assignments to be more flexible and collaborative

1. **Flip, or partially flip, the classroom.** Let students download information on their own time, at their own pace. Provide content, if possible, through different mediums in small, easily digestible chunks. If lectures will be recorded for later use anyway, optimize the time students are together for discussion, collaborative problem solving, or student-led lectures. In a traditional classroom, if a student leaves a lecture confused, the assignments may not clarify the material. A flipped classroom converges teacher and peer engagement if a student is not sure how to begin an assignment.

[3]Asynchronous means that the learning outcome from the task is independent of when it is finished (as long as it is finished before the due date). Message boards are not effective asynchronous tools; a student who contributes first misses the progression of ideas and a student who contributes last had to have stayed in the loop to contribute meaningfully. Synchronous means that the learning outcome from the task depends on students doing it together in a specific period of time.

ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.

2. **Challenge students to become mini-experts and educate their peers in rotating small groups.** Divide the class into groups and task each group member to prepare a solution to a different concept question. Give time for each student to coach their group members to solve the unseen problem. This technique stimulates free flowing conversation while encouraging students to problem solve on their feet. This can prepare students for oral examinations or conversations at a conference.
3. **Assign students different context on the same topic to share with their peers.** Divvy up models, techniques, time periods, and/or regions for students to explore a topic and have them share their findings with the class. For example, if studying sea surface temperature, assign students different data products, models, and regions.
4. **Scaffold assignments such that students practice techniques they will use in their final project or in their research careers.** Assignments that build on each other and/or dive into different techniques on the same dataset become templates for future work. For example, if studying sea surface temperature, constrain one assignment to introduce relevant data or model products, one on time-series analysis, and another on spatial variability.
5. **Run a peer review for students to practice giving and receiving feedback.** Students will gain practice as a reviewer in a low stakes environment, learn from their peers, and contribute to their success. Students can respond to peer reviewer suggestions in their final product.
6. **Have students write a mock research proposal.** Naturally paired with a peer review, this process prepares graduate students for the next stages in their career. If appropriate, share a recent, successful research proposal so students understand the structure, brevity, and fluidity between technical and non-technical language.

4 Conclusion

We appreciate the flexibility and hard work our teachers showed as they virtualized classes amidst the beginnings of the COVID-19 pandemic. Implementing the strategies described above will require further flexibility and hard work. As graduate students, we share that responsibility to transform our classrooms into equitable remote learning communities and know this will be more rewarding for students and teachers alike. The ruptures in our educational fabric caused by COVID-19 provide an opportunity to do the hard work that researchers and teachers committed to equity have championed for decades. We hope this paradigm shift will have lasting effects on how our field runs STEM classrooms beyond the COVID-19 crisis, to pursue equitable learning communities—and science—for those who need it most.

Acknowledgements

This paper resulted from a discussion on *Inclusive Classrooms* led by DHF and LMT, part of a grassroots student-led monthly discussion series, the JEDI (Justice, Equity, Diversity, and Inclusion) Academy. The authors are grateful to their peers in the MIT-WHOI Joint Program for participating in a thoughtful discussion, the JEDI Academy for providing such a forum, and many faculty over the years who have been inspirational educators. This work is not supported in any way and was done during the authors' freetime. There are no real or perceived financial conflicts of interest for any author.

ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.

We also acknowledge the MIT Teaching + Learning Lab, MIT Open Learning, and Jennifer Gonzalez's Cult of Pedagogy podcast as useful resources.

References

Alesina, A., Carlana, M., La Ferrara, E., Pinotti, P., Carlana Harvard Kennedy School, M., & Kennedy St, J. F. (2018). Revealing Stereotypes: Evidence from Immigrants in Schools. *NBER Working Paper No. 25333*. https://doi.org/10.3386/w25333

Archer, L., Dewitt, J., Osborne, J. (2015). Is Science for Us? Black Students' and Parents' Views of Science and Science Careers. *Science Education. 99*(2), 199-237. https://doi.org/10.1002/sce.21146

Au, W. (2013). Hiding behind high-stakes testing: Meritocracy, objectivity, and inequality in U.S. education. *The International Education Journal: Comparative Perspectives. 12*(2), 7-19. https://doi.org/10.1177/0895904815614916

Bernard, R.E. and Cooperdock, E.H.G. (2018). No progress on diversity in 40 years. *Nature Geoscience*. *11*, 292-295. https://doi.org/10.1038/s41561-018-0116-6

Brinkworth, C., Skaer, A.B., Prescod-Weinstein, C., Teske, J., Tuttle, S. (2016) Building an inclusive AAS — The Critical Role of Diversity and Inclusion Training for AAS Council and Astronomy Leadership. https://arxiv.org/abs/1610.02916

Chandra, S., Huebert, C.A., Crowley, E., Das, A.M. (2019). Imposter Syndrome: Could It Be Holding You or Your Mentees Back? *CHEST. 156*(1), 26-32. https://doi.org/10.1016/j.chest.2019.02.325

Gross, B., and Opalka, A. (2020). Too Many Schools Leave Learning to Chance During the Pandemic. Center on Reinventing Public Education.

Costanza-Chock, S. (2020) *Design Justice: Community-Led Practices to Build the Worlds We Need*. The MIT Press, Cambridge, MA

Cohen, G. L., Steele, C. M., & Ross, L. D. (1999). The Mentor's Dilemma: Providing Critical Feedback Across the Racial Divide. Personality and Social Psychology Bulletin, 25(10), 1302–1318. https://doi.org/10.1177/0146167299258011

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020) Implications for educational practice of the science of learning and development, *Applied Developmental Science, 24:2, 97-140,* https://doi.org/10.1080/10888691.2018.1537791

ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.

Hodges, C., Moore, S., Lockee, B., Trust, T. & Bond, A., (2020). The Difference Between Emergency Remote Teaching and Online Learning. *EDUCAUSE Review*. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

hooks, b. (1994). Teaching to Transgress. New York: Routledge.

National Academies of Sciences, Engineering, and Medicine (NASEM). (2016). Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways. Washington, DC: *The National Academies Press.* https://doi.org/10.17226/21739

Ogbunu, C. B. (Host). (2019, December 6). The Liberation of RNA. [Audio podcast episode] In *The Story Collider: True, Personal, Stories about Science*. The Story Collider. https://www.wnycstudios.org/podcasts/radiolab/articles/liberation-rnahttps://www.storycollider.org/stories/2019/12/3/justice-stories-about-righteous-determination

Suárez-Orozco, C., Casanova, S., Martin, M., Katsiaficas, D., Cuellar, V., Smith, N. A., & Dias, S. I. (2015). Toxic Rain in Class: Classroom Interpersonal Microaggressions. Educational Researcher, 44(3), 151–160. https://doi.org/10.3102/0013189X15580314

Tyson, N. D. (2014, April 21) *Neil Degrasse Tyson on being Black, and Women in Science* [Video] Youtube. https://www.youtube.com/watch?v=z7ihNLEDiuM

ESSOAr | https://doi.org/10.1002/essoar.10504073.1 | CC_BY_NC_4.0 | First posted online: Wed, 2 Sep 2020 05:24:01 | This content has not been peer reviewed.