Teaching Statement

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My broad vision for the long-term impact of my teaching is to (1) spark curiosity and equip students to engage in quantitative reasoning through creative and interactive learning and (2) to create mathematical spaces in which everyone feels supported, free to participate, and eager to explore mathematics. In Section 1, I will describe my teaching philosophy and strategies for realizing my teaching goals in the classroom. In Section 2, I have included excerpts from end-of-term teaching evaluations. In Section 3, I will describe strategies I have used in organizing undergraduate research experiences to achieve my teaching goals.

1. Teaching philosophy and strategies for classroom success

My teaching experience has ranged from teaching introductory calculus courses for non-mathematics majors at the University of Michigan to teaching a qualifying exam course in algebraic topology for graduate students at Yale University. I will now describe my teaching philosophy and the strategies I use to achieve my teaching goals.

1. Classroom engagement. Lack of engagement is one of the greatest enemies to good pedagogy. Research suggests that if students are not engaged with a question or activity in the first few minutes of class, they are vastly more likely to tune out the lecture.

(1) *Continuity with previous lectures can be used to start classes with engagement.* I begin every class by asking three questions about material that was previously discussed. The questions encourage students to recall a main idea and to work an example, while beginning a class with engagement.

(2) *Examples spark curiosity.* When I taught linear algebra, one of my classes was on the rank-nullity theorem. I began the class by presenting different linear maps and asking my students to compute the rank and nullity. After three examples, the students guessed the rank-nullity theorem and were eager to see the proof. When students have a collection of understandable examples that they have engaged with and which suggest a pattern, they are substantially more interested in understanding the deeper reason for the pattern.

(3) *Learning by doing is compelling.* When I gave a Math Circles talk for middle and high school students last fall, I created a series of games and puzzles for the participants. The students remained energetically engaged throughout a 90 minute evening talk because they were actively learning. In my current course, I implement this strategy by having students assess their comprehension with short worksheets each class. When I taught a graduate course, I would routinely ask students to justify or suggest the next step in proofs that were being presented.

2. Nudging. Students often understand the keys to success in a class, but frequently fail to implement them. Part of good pedagogy is structuring a class to encourage students to engage in these productive behaviors. As one example, the class before an exam, I hold a Jeopardy! style review game in class for bonus points. This incentivizes students to prepare in advance for exams and allows them time to identify points of confusion and address them. In a similar vein, I like to assign frequent short homework so that students are nudged to keep up with the course material.

3. A supportive classroom environment is crucial for students to succeed.

(1) *Avoiding mathematical microaggressions helps support students.* Careless language can inadvertently discourage students whom we wish to inspire. This sentiment is paraphrased from mathematician Francis Su, who identified "mathematical microaggressions", as phrases, such as "trivially" and "obviously" that may reinforce doubts students have about their abilities. Aside from avoiding these constructions in my own speech, at the beginning of any course, I have a brief conversation with students about classroom norms, in which I request that they also avoid microaggressions. When someone lapses, I ask them to rephrase. This technique helps to create a positive learning environment.

(2) *Raising students awareness of where to find support and community is essential.* As teachers, we are often our students' primary source of information about support systems. For example, at the University of Michigan, the Women in Mathematics Society hosts a Bagel Sundays event for undergraduates to encourage them to start their math homework early. Although the event was advertised with flyers, none of my students had heard of it until I mentioned it to them. To better

support my students, I receive the "Math Missive", a list of STEM events for undergraduates, from my department each week, which I cull and send to my students.

(3) *Reframing and restructuring assessments can create a supportive environment.* Grades are an inevitable source of anxiety for students, but creatively framing assessments may help alleviate some of this stress. For example, I often give quizzes worth bonus points to my classes. Instead of having the assessment take away points from students, it gives points back to them.

4. Advice from other teachers. My teaching has improved the most by interacting with other teachers. Discussing "microaggressions" with my students and subscribing to the "Math Missive" are two examples of strategies that I learned from other instructors. Conversely, I have participated in mentoring activities for graduate students both at the University of Michigan and at the University of Chicago, where I volunteered to have a younger graduate student observe my classes and ultimately teach one. A community of teachers supporting each other is one of the best means of ensuring effective teaching.

5. Communication.

(1) *Emphasizing the positive fosters healthy communication.* I regularly pose questions to my students during class and enthusiastically encourage their responses. Even when a response misses the mark, I will find an accurate element of the student's answer to highlight and use as a basis for further conversation. By emphasizing the successful parts of a student's answer, teachers can create a classroom atmosphere in which students feel eager to participate.

(2) *Creating multiple channels for feedback and individual instruction benefits everyone.* As an example, this semester I hold three office hours every week; one on Zoom, one in my office, and one in the undergraduate Math Lab. The different times and locations help ensure that students who want individual instruction can find it. Additionally, I send my students an online survey every few weeks, asking for feedback on any points of confusion and any aspects of the class that can be improved. These surveys allow me to adjust to my class to ensure that it accounts for the needs of all students.

6. Inclusion. It is paramount that teachers create a space where everyone can learn. In my own teaching, this has ranged from meaning problem sets that reinforce more elementary concepts for students with less background to publicly speaking on the work of prominent mathematicians from underrepresented groups, such as Marina Ratner and Maryam Mirzakhani. A fuller description of my beliefs about ensuring the inclusion of students from all backgrounds appears in my Diversity Statement.

7. Assessments

(1) *Practice materials help clearly articulate expectations.* Before exams, I distribute a list of skills I expect my students to have mastered and a practice exam that reflects the topics covered on the actual one. These materials help students succeed by clearly communicating expectations.

(2) *Assessments should encourage students to succeed.* One method that encourages students is ensuring that assessments closely parallel material covered in class. Another method, which I am using in my current course, is mastery assessments, wherein students have a limitless number of attempts at an exam (comprised of randomly generated questions), but the students only receive credit if they achieve a near-perfect score. Mastery assessments encourage students to persevere and allow assessments to be a powerful pedagogical tool.

2. Student Evaluation Excerpts

In this section, I have compiled excerpts from end-of-course student evaluations for the courses that I have taught. The bold heading is the question that prompted the responses.

Would you recommend this course to others? Why?

- "Yes because this teacher tries to work with you and I've never met a more patient teacher in my life."
- "Yes, it's FUN."
- "Yes, because Paul is a very intelligent teacher who can explain pretty much any concept."

What were the instructors strengths? Weaknesses?

- "The instructor is very passionate about what he is teaching and tried to get us to be as well."

- "Lectures were interesting. He genuinely tried to explain questions in class. He was very well-prepared as far as review/HW went."
- "Paul has a really positive attitude and genuinely cares about his students."
- "I felt like he challenged us and provided useful "pre-exam" materials such as pop quizzes and "study games" before tests."
- "Engaging, positive, and upbeat."
- "Strengths: Positivity, excitement about topics, patience with students, responsive to student feedback."
- "Very engaging, passionate, interesting, lectures were clear and organized, very knowledgeable."
- "Paul really cares that his students learn."
- "The instructor is always wiling to help and provides enough resources to generate a good understanding of the content."
- "You could tell Apisa cares about the success of his students and prepared for class."

3. Beyond the Classroom: Undergraduate Research

Undergraduate research encourages students to explore mathematics creatively and interactively. I have promoted undergraduate research by co-organizing (1) the Summer@ICERM 2021 REU, (2) a project at the 2020 Michigan REU, and (3) a Laboratory of Geometry (LoG(M)) undergraduate research course. I was also a graduate mentor at the 2013 Cornell REU. In the two REUs that I organized, all five of the projects that I proposed resulted in work that will be submitted for publication. I will identify several factors that made these projects successful.

1. An emphasis on computation and experimentation. In undergraduate research, students often must quickly learn a tremendous amount of new material. This can lead students to feel like their understanding is tenuous, which bridles their creativity. Fortunately, in my research area, extensive software exists to visualize and experiment with the fundamental objects of study. This empowers students to test their understanding by experimenting with tangible objects. For this reason, at Summer@ICERM, in the opening week we held five hour-long "Sage day" training sessions for the students together with coding challenges. We employed a similar model at the Cornell REU with GAP and Magma. At LoG(M), where the emphasis was on engaging students who are less advanced than typical REU students, the focus on algorithm development and computation gave our participants, some of whom had not taken any mathematics course beyond linear algebra, an entry point for conducting research.

2. The creation of a trove of accessible material and problems for undergraduates. Since my field has rapidly developed recently, very few up-to-date references exist for undergraduates. To rectify this deficit, during the Michigan REU, my fellow co-organizers and our graduate student TAs developed a 12 part video lecture series designed for an audience of advanced undergraduates. This material formed background viewing for the students in LoG(M) and Summer@ICERM. To supplement this material, at Summer@ICERM, we created problem sets (including coding problems) and held daily problem sessions that corresponded to each introductory lecture. A trove of accessible material and problems for undergraduate researchers is essential for them to succeed.

3. Regular direction. For the three research experiences I organized, I scheduled hour-long meetings with the undergraduate researchers once or twice a week per project. I also recruited graduate students (and postdocs in the case of Summer@ICERM) to work more closely on each project, in many cases on a daily basis. Regular guidance helps keep young researchers engaged and working in productive directions.

4. The creation of a support system for the participants. Creating a healthy culture facilitated the success of the Summer@ICERM 2021 REU. On the first day, Diana Davis and I set aside 20 minutes to have a interactive discussion with the students about setting norms to govern behavior. We also queried graduate student and postdoctoral mentors for topics that would be useful for a weekly professional development seminar. These included topics like "Building community and finding support", "Impostor syndrome and self-doubt", and "Avoiding mathematical microaggressions". We surveyed the participants every other week about whether there were any mathematical or interpersonal issues. These surveys revealed several unhealthy dynamics that we were able to fix before they grew out of control. All of these factors helped to a create a supportive environment in which students could thrive.

4. Conclusion

In the future, I intend to implement the strategies outlined here and in the Diversity Statement for creating an inclusive mathematical community in which every student feels empowered to succeed. Specifically, I plan to continue using active learning methods in the classroom, to mentor graduate students, and to spearhead undergraduate research experiences.

One especially rewarding aspect of these activities is the relationships they create. Even now, several months after the end of the Summer@ICERM REU, I am still meeting with three research groups every other week and advising the students on topics ranging from graduate school admissions to poster sessions. Interacting with the next generation of mathematicians is exciting and inspiring. I look forward to continuing to both teach and learn from students and talented young researchers in the future!