Teaching Philosophy

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I teach students whose primary academic identities lie outside my classroom. In my 600-student Physics 132 course, I teach life-science students fundamentals of electricity, optics, and quantum mechanics. In my 691G seminar, first-semester graduate students develop professional skills through the lens of learning about evidence-based teaching practices. In both courses, I am striving to get students to develop and value what Rendón in her *Sentipensante (Sensing/Thinking) Pedagogy* describes as "diverse disciplinary forms of learning and [recognize] that learning can be enhanced with access to diverse forms of knowledge." (p. 135) [1] . My collaboration with Chemistry, Biology, and Mathematics lecturers in the Mutual Mentoring Grant funded Integrated Introductory Life-Science Education (I^2LSE) group I founded has helped me appreciate the significance of these differences. Not only do different sciences have different perspectives on the same phenomena, but they also have different values. Consider the connection between the pressure, volume, and temperature for an amount of gas. Chemistry frames this relationship in terms of quantities relevant in the lab. Physics, in contrast, describes the same mathematical expression through the application of Newton's Laws to individual molecules. In terms of values, Naureen Ghani summarizes it nicely, "physics derives beauty from simple reductionist elegance, biology finds beauty in complexity and richness" [2]. I, therefore, now center these disciplinary differences in my course goals, activities, and assessments. Moreover, I have found that this centering not only naturally segues into other more traditional discussions of diversity and inclusion, but also informs my improvement goals as an educator.

My physics 132 students often feel that physics is "scary," and "not relevant for them" [3]. My goal is to help them see that physics can provide a new way of looking at familiar phenomena, resulting in novel insights. Each unit is therefore centered on a biological or chemical concept. The unit on quantum mechanics, for example, explicitly calculates the energy levels of some of the same molecules that effectively all students have seen in organic chemistry. Through I^2LSE, I have even been able to ensure that the large number of students concurrently taking organic chemistry and 132 see these two approaches at roughly the same time in the semester. However, these centering examples alone are insufficient. I must also use the biological and chemical disciplinary language with which my students are familiar: I must speak of the conjugated π-bonds of a carbon chain as opposed to delocalized electrons in a box. This process begins in the reading, which reviews the relevant biology or chemistry using authentic sources including problem solving example videos from my UMass Chemistry colleagues. I can then spend class time explicitly exploring the differences of the physics approach and the insights it provides. Exams continue this emphasis, requiring students to explain a phenomena or apparatus familiar from biology or chemistry but not explicitly discussed in class. For example, on the Fall 2020 final exam, students used material from throughout the course to explore the operation of the transmission electron microscope.

In contrast, thinking like a physicist is the default for the first-semester graduate students in my 691G. My goal in this case is to facilitate exploration and appreciation of ways of thinking perhaps more natural to Education or the Humanities. For example, in exploring the challenges and biases inherent in evaluating teaching, I first assign students to read Stark and Freishtat [4]. This text focuses purely on the statistical problems with traditional course evaluations, a framework familiar to 691G students. Only after appealing to their physicist training, do I then have them read Handley et al. which explores the culture of bias within STEM [5]. Assigning these readings in this order seems to help students recognize the reality of bias and gives them a familiar language about which to speak about it. During class, teams of students then develop and critique their own methods for evaluating teaching using a gallery walk activity [6]. I tell them to "be theoretical physicists" and determine what would be evidence for good teaching completely without regard for feasibility. Then, I tell them to be "experimentalists" and figure out how to measure that evidence and to consider how their methods might be biased. This "physicist language" provides a touchstone for the creation and critique process.

Centering disciplinary diversity makes integration of other aspects of equity and inclusion more natural and drives my approach to instructional challenges. Developing my own custom free textbooks has resulted in student savings of over a quarter-million dollars over the past four years, making the course more accessible to students with limited means. The use of multiple representations including video in the text, demos, and 3-D printed models, also promotes accessibility. Even the flipped model of the course has an equity component: before-class readings and formative assessments help smooth out differences in preparation. Ultimately, I want all my students, regardless of their identity or career goals, to see themselves as members of the scientific community. The COVID-19 pandemic has encouraged me to add explicit discussion with my students on their perception of their own scientific identity and on the power that being seen as a scientist by the general public can bestow. As one student put it, "I'd never really thought of myself as a scientist before, and the class discussions where we took time to discuss how we are scientists and the impact we could have were incredibly inspiring for me" [7]. In my view, statements like these are exceptionally powerful.

This philosophy has been an evolution. Formal programs both on campus, such as our Center for Teaching and Learning's Teaching for Inclusiveness, Diversity, & Equity program, and off, such as the Living Physics Portal Working Group, have played a key role. More importantly, however, have been self-structured groups of faculty such as I^2LSE and my 5-College Physics Education Research Discussion group with interested physics faculty from Amherst, Hampshire, Mount Holyoke, and Smith Colleges as well as the University of Massachusetts Amherst. Also key to my evolution has been regular reflection on my blog and integration of insights from my own scholarship such as my work on self-efficacy [8] [9]. Going forward, I hope to expand my own scholarship and collaborations to further explore how disciplinary diversity can be used for promoting equity in physics.

References and Notes

[1] L. I. Rendón, *Sentipensante (Sensing/Thinking) Pedagogy: Educating for Wholeness, Social Justice, and Liberation.* Sterling, VA: Stylus, 2009. (This is one of several texts I read as part of my Teaching for Inclusion, Diversity, and Equity Ambassadorship.).

[2] N. Ghani, "Why We Need Computational Models in Biology." PLOS Blog. ECR Community (blog), July 29 2016. https://ecrcommunity.plos.org/2016/07/29/why-we-need-computational-models-in-biology/.

[3] These are direct student quotes from course evaluations.

[4] P.B. Stark and R. Freishtat, "An evaluation of course evaluations," *ScienceOpen Research*, September 2014. doi: 10.14293/S2199-1006.1.SOR-EDU.AOFRQA.v1.

[5] Ian M. Handley, Elizabeth R. Brown, Corinne A. Moss-Racusin, and Jessi L. Smith, "Quality of Evidence Revealing Subtle Gender Biases in Science Is in the Eye of the Beholder," *Proceedings of the National Academy of Sciences*, pp. 13201–6, October 2015. https://doi.org/10.1073/pnas.1510649112.

[6] Janet L. Kolodner, "Facilitating the Learning of Design Practices: Lessons Learned from an Inquiry into Science Education," *Journal of Industrial Teacher Education*, no. 3, pp. 9–40, 2009.

[7] A comment from a student on the end-of-semester Forward FOCUS survey developed by our Center for Teaching and Learning in response to the prompt "What were the three MOST VALUABLE things that you learned, or learned to do, in this course?".

[8] https://physedgroup.umasscreate.net/blog/.

[9] Brokk Toggerson, Samyukta Krishnamurthy, Emily Hansen, and Chasya Church, "Positive Impacts on Student Self-Efficacy from an Introductory Physics for Life Science Course Using the Team-Based Learning Pedagogy." https://arxiv.org/abs/2001.07277, January 2020.