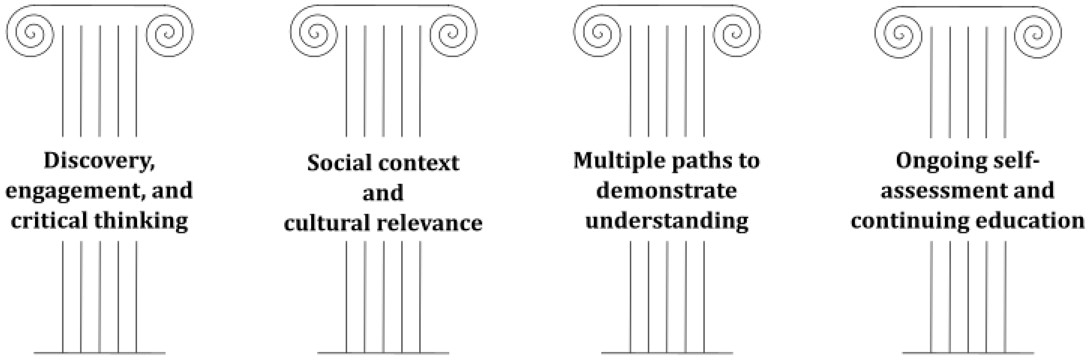
Philosophy for Holistic Student-Centered Teaching



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What makes me stand out as a teacher is the way I treat my students as complex, multifaceted human beings; people who continue to exist outside the bubble of academia. I refer to this philosophy as holistic student-centered teaching, and in my experience it is far from the norm. I have seen many faculty members treat mathematics as something delicate and precious, something reserved for an elite few who are able to struggle through a grueling sequence of trials. They view themselves as defenders of rigor and gatekeepers of knowledge. This is not my vision of education. Mathematics does not need a protector. It is not under attack and its value does not diminish if more people gain access. However, our students *do* need advocates. They need mentors who will patiently help them turn new ideas over in their heads. They need understanding supervisors who recognize that their life outside of school affects their ability to learn. They need knowledgeable discussion partners who can ask and answer questions that open doors to new revelations. They need professors who support their mental and emotional health. They need instructors who adapt to the needs of their students, and who undergo regular coaching, observation, and self-assessment. They need advisors who understand how the mathematics will be applied in a life outside of academia. They need faculty who see that systemic biases affect students differently, and who understand that the combination of bias and power leads to harm for those with less power. As a teacher, I strive to embody each of these roles. My goal is to remove all barriers to learning, to meet my students where they stand, and to create an education experience that adapts to the social context and practical realities of life. I am invested in combating racism and sexism in academia, and to confronting research that leads to downstream bias and discrimination. My philosophy for holistic student-centered teaching is summarized by the following four pillars,

1. **Discovery, engagement, and critical thinking** - Presenting information accurately is not enough to build intuition. Lectures need to include energy, narrative, and suspense. To understand complex topics, students need an opportunity to probe the ideas themselves and to be invested in the outcome.
2. **Social context and cultural relevance** - Mathematics can feel sterile and alien at times, but only when it is studied in a vacuum. Understanding the historical and social context of the development of mathematics helps us to appreciate the theory that we often take for granted. Culturally relevant computational examples anchor these ideas, and practical projects help to develop sophistication and creativity.
3. **Multiple paths to demonstrate understanding** - The ability to understand new ideas is heavily influenced by factors beyond the direct intellectual challenge of the material. Mental and emotional health, family and financial responsibilities, and the high stakes of educational outcomes can all be indirect barriers to building mathematical understanding and intuition. To reduce these challenges, courses need to be flexible, non-judgmental, non-punitive, and offer multiple routes for students to demonstrate their understanding.
4. **Ongoing self-assessment and continuing education** - Education is heavily influenced by the relationship between the teacher and the students. In order to persistently improve, I need to consistently reevaluate my philosophy and implementation. This is aided by self-assessment, continuous 360° feedback from students, coaching from trusted mentors, and continuing education from experts and education researchers.

Supplemental Materials: Philosophy for Holistic Student-Centered Teaching

Let us consider each pillar individually, along with examples of how they have been incorporated into my teaching.

1 Discovery, engagement, and critical thinking

Many instructors bring energy to their lectures, and students certainly appreciate it. I regularly receive feedback in my student evaluations that my charisma and expository lecture style make mathematics feel more approachable, even during early morning lectures. However, I try to go beyond that simple baseline to engage my students. This starts with creating a cohesive narrative for my lectures, typically centered around applications that are relevant to students' lives outside of the university. For example, during a lecture about conditional probability, the lesson starts with a discussion of statistical fallacies, like the prosecutor's fallacy – which students might have unwittingly seen employed on the news or in other media. After discussing why it matters which population one considers when determining how rare an event might be, the scaling term in the definition of conditional probability is no longer entirely abstract. In subsequent class periods students often report back with other places they have found data being misrepresented with statistics. Another in-road to building context and narrative that I have employed is to use active research problems. For example, in a course on programming in Matlab, I began the term with an introduction to one of my projects in activity recognition in videos. Without going into detail in the initial introduction, students could see the value of having a mathematical basis for their programming skills and we were able to refer back to the project to describe more details and nuance as we progressed through the course.

In addition to story-building, I try to engage students with mixed-media lectures. During the past year, I chose to support students both in the classroom and remotely, although it was not actively encouraged by the department. In order to move beyond the blackboard, but also not regress to simply reading presentation slides, I developed a set of slides that were minimally annotated. The lectures were anchored by the sparse keywords and definitions included on the slides, but driven by handwritten examples and proofs to help with pacing and to be adaptable to student questions. I also developed geometric animations when possible to move beyond the limitations of my drawing abilities. After each lecture period, the handwritten notes, examples, and animations would be collected into a more comprehensive slide deck for students to reference on their own time or while watching the available lecture recording. To contrast the passive learning during lectures, I also created an independent meeting time where students and I would solve additional examples together. This allowed students to move beyond pattern matching and find their own solution methods. Since the problems were always ones I had not seen before, we could all begin with fresh eyes. I was transparent about my thought process and would talk through the steps I take when I approach a new problem, so students could see that I didn't magically know the answer to everything without effort.

I have also had success including open-ended projects so that students have an opportunity to explore the course ideas in practice. To do so, I identified research areas that had enough associated literature to be approachable, and which represented relevant applications of course material. This gave students a jumping off point to devise their own project or propose an entirely different topic. This was the main focus of the Topics in Signal Processing course that I taught to the Master's students during my time at Universität Paderborn.

An area for improvement under the first pillar: *incorporating inquiry-based learning into my lectures*. Collaborative learning has been fundamental to my career in both teaching and research. At Colorado State University I was a regular participant in the math education seminar series where many lectures fell under the broad umbrella of inquiry-based (or active) learning. The benefits in conceptual understanding that arise from active learning are well-documented[1], but they come at the expense of speed. Traditional lecture styles progress more quickly through material, but they move forward even when the ideas have not yet been mastered. Particularly during the 10 week term structure at Oregon State University, such a lecture style requires a great deal of practice and planning to implement effectively. In an attempt to progress more towards inquiry-based learning, I turned one of my office hours into a period for theoretical discussion, rather than homework help. Students experimented with violating the assumptions of theorems to see how the results failed. They would discuss ways to tackle problems if the existing formulas were unknown, and conversely how to generalize the solutions to specific problems into new formulas. The feedback was quite positive, however that may also be the result of selection bias. The students who preferred not to play with theoretical ideas attended the more explicitly homework focused office hours instead.

[1] M. Prince. "Does active learning work? A review of the research". In: *Journal of engineering education* 93.3 (2004), pp. 223–231.

2 Social context and cultural relevance

Each of the pillars in my philosophy for holistic student-centered teaching is necessary, however social context and cultural relevance both play a very prominent role for me. Quantitative research[2] and countless personal anecdotes have shown that even when institutional hurdles are removed, women and non-white men leave mathematics at higher rates. Additionally, underrepresented students innovate at higher rates, but are less likely to earn permanent academic positions[3]. For me, this means that creating a welcoming environment and treating students equally in the classroom is not sufficient for creating equal outcomes. Many faculty imagine mathematics to be a neutral space, disconnected from social history or politics. This simply is not true, and for holistic student-centered teaching to live up to its name, it needs to address that ways in which historical power structures, gender bias, and racism have influenced the modern practice of mathematics and the students who are trying to learn it.

To start with, the curriculum of most mathematics courses is written with a focus on the achievements of white men, without regard for the contributions of historically excluded mathematicians or of the external harm that some of these well-known researchers caused. How can a course, or a field of research, claim to be welcoming or unbiased when its history is written by a homogeneous group that erased the developments of non-Europeans and intentionally excluded women, queers, and Black intellectuals, amongst others, from academia? To begin to address these issues, I initiated a review of my own course materials, inspired in part by the efforts of Theodore Kim[4]. Many of the results in an introductory probability and statistics course, such as the one I was teaching, are tied to researchers who were proponents of eugenics and phrenology. To introduce their work without caveat and reference examples that featured prominently in their false theory of scientific racism is irresponsible at best. In my course, we began the term with a discussion of how statistics was abused in an attempt connect biological and genetic attributes with abstract human qualities and social attributes that are not determined by biology. To preempt any student attempts to play devil's advocate, I included the statements denouncing scientific racism from the American Anthropological Association[5] as well as the National Human Genome Research Institute[6], who have consistently had to shoot down such rhetoric. As the course progressed and the mathematical sophistication of the students grew, we also talked about how many modern applications of machine learning and artificial intelligence fall into the trap of phrenology.

Rather than merely discussing the harmful misuses of statistics, I also created a weekly section that devoted to Notable Engineers, Mathematicians, or Statisticians (NEMOS). During this portion of the lecture I would introduce the positive contributions of researchers who were often left out of the historical narrative. In addition to my short lectures, I created folders for the students to peruse of the actual work of the NEMOS, articles on the historical ramifications of their work, and my own brief summaries and biographies. I spent time outside of the university to gather information about NEMOS that I otherwise would not have known. The people discussed included classical researchers like Yesudas Ramchandra and Ada Lovelace, as well as modern scientists like Timnit Gebru, to name a few. Additionally, I reviewed and interrogated the examples used throughout my courses to remove connections to harmful ideologies. In particular, I noticed that ableist examples are common in probability theory, so I removed examples related to Body Mass Index and examples that assumed intelligence to be an intrinsic quality. The work in this area seems to have connected with the students. In my most recent student evaluations at the end of the Winter 2021/2022 term, I received a mean score of 2.8 out of 3.0 (meaning *Very Much*) in response to the prompt, 'Did you feel safe, respected, and like you belonged in the course?' I also received a mean score of 5.8 out of 6.0, meaning *Completely Agree*, in response to the prompt, 'My instructor modeled and promoted inclusivity.' This score is more than two standard deviations above the university-wide and department-wide means of 5.6. From these evaluations it seems that my efforts made a positive impact on the class.

In addition to the historical context of mathematics, I am also concerned with the current social setting in which students are attending my courses. A confluence of worldwide events has created an incredibly difficult setting for students to succeed. As such, I prioritized discussions of mental health in my most recent course and emphasized that learning and academic achievement is only a small piece of what makes us human. I included prominent language in the syllabus expressing that my support of the students was not limited their success in this course, but applied more generally to their happiness in life. I wanted to emphasize that college in general, and this course in particular, are only a small piece of a

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[2] M.R.S. Domingo et al. "Replicating Meyerhoff for inclusive excellence in STEM". in: *Science* 364.6438 (2019), pp. 335–337.

[3] B. Hofstra et al. "The Diversity–Innovation Paradox in Science". In: *Proc. National Academy of Sciences* 117.17 (2020), pp. 9284–9291.

[4] Theodore Kim. "Confronting Euro-Centrism and Erasure In Discrete Math". self-published. 2021. URL: www.tkim.graphics/ERASURE/.

[5] American Anthropological Association et al. "Statement on race". In: *American Anthropologist* 100.3 (1998), pp. 712–713.

[6] National Human Genome Research Institute. "Fact Sheet - Eugenics and Scientific Racism". self-published. 2022. URL: www.genome.gov/about-genomics/fact-sheets/Eugenics-and-Scientific-Racism.

person's life. The stakes are not as high as they might sometimes seem, and we have a common goal of learning and trying to be in a better place physically, intellectually, and emotionally than when we start. If we end up in a worse place, then this course was not worth it. I want to establish myself as a person who will advocate for students regardless of reason or need. I don't want students to think that they only deserve support if they fit some narrow definition of struggling or that their struggles are going to be measured, belittled, or criticized.

I backed this language up by creating flexible deadlines and remote participation options, as well as requiring no justification for accommodations. On top of these structural supports, I offered the students weekly check-in surveys, which feature prominently in the the third and fourth pillars as well. These surveys, which were given at the start of the lecture period and collected during our mid-lecture break, casually asked about the course, students' lives, their ideas about learning and studying, and a plethora of other topics. They were voluntary, ungraded, and anonymous, although many students chose to include their name. Participation in the surveys was very high, even students that did not attend the in-person lectures would send survey responses by email. The check-ins allowed them to provide feedback about the current difficulty of the course or topics that seemed obtuse. It allowed them to decompress and discuss stress levels outside of the class that were impacting their work. I asked for music recommendations and about the coolest things they were learning in other classes. I asked them to grade the exams that I created on how well they represented the material we had covered. I asked them discuss their preparation strategies for tests and to anticipate what kind of questions would be included based on their intuition about the importance of the topics. Some of the questions were meant to get assessments from the students so I could adjust the course. Some questions were meant to get the students thinking about their own efforts. Other questions were to remind them that the world still exists outside of the classroom, and they are worthy of respect even if they struggle with one subject or another. Each week after class, I spent an hour reading the surveys, emailing responses to students when it seemed prudent, and taking notes on how I could improve or address the students' needs. The evidence of the success of these check-ins is abundant. Throughout the course 14 students (out of 51) told me specific stories about external issues that were impacting their ability to focus on school, 1 student confided about abuse in their family that was an omnipresent burden for them, 1 student confided that they had made an attempt on their life, and 2 students asked for help finding and accessing mental health resources. Zero students tried to use these issues to avoid work or get a shortcut to a good grade. I believe that because I carefully designed the course to remove as many bottlenecks and barriers as possible, and because no justification was ever needed in requesting accommodation, the disclosures were truly just asking for emotional support. These surveys also played a prominent role in the comments that I received in the student evaluations, with overwhelming support.

An area for improvement under the second pillar: *more relevant practical examples*. One piece of feedback that I received in the weekly check-ins and in my student evaluations is that the examples I provided in class were not direct applications to electrical engineering. In truth this is because my training and expertise comes from mathematics (and academia), so such applications are outside of my experience. Relevant engineering examples fit under this pillar as well, because many of my students intend to work in industry. Building this connections to their life after university is just as important as the connections that I developed to history. In an attempt to make progress towards this goal, I surveyed upper-division electrical engineering students who had recently completed their internships. As a result, I gathered a small collection of practical examples that are well-aligned with the topics we discussed that I can incorporate into future versions of the course. It is my hope that with intention and effort this portfolio of practical examples will continue to grow and include the industries of students I will teach in future courses.

3 Multiple paths to demonstrate understanding

I intentionally have a very non-punitive policy on grading. I would do away with grading completely if I had the time and resources to give students as many opportunities as they like to demonstrate understanding of the course material. Since I have not yet reached that level of experience, I have tried to create a policy that is direct enough that most students will follow it, but flexible enough that no one will be hurt by creating their own personal schedule if they do it with intention. Additionally, the policy is discussed with my teaching assistants (TAs) and graders ahead of time to ensure that I am not unduly putting extra burden on them. The motivation for the policy is that work loads vary from student to student, and throughout the term. I want students to have the ability to manage their own time in a way most suited to them, but I want to set a clear standard or example of what I think the easiest path to success will be, while not overburdening my graduate TA. I feel that this policy reinforces my philosophy of holistic student-centered teaching. In particular it supports the statements made about viewing students as complete people and considering the context of the world outside this course.

In the most recent term, zero students took advantage of the lax policy in a malicious way, I think in part because there would have been little to nothing to be gained from it.

The specific structure of my policy is that homework is released every Friday night and due on the following Friday night. The grader then has until Wednesday to complete the grading. Homework that is turned in before Wednesday requires no explanation, but is graded with the following week's batch of homework to not put extra burden on the TA. On Wednesday I release the solutions to the homework. If anyone knows ahead of time that they will not meet the extended "deadline," they can email me and tell me when they want their own personal deadline to be. As long as I am notified before the extended deadline, I ask no questions about why, and simply update the deadline for them individually. Ostensibly they will have access to the solutions before they submit their work and could just copy them, but that has not happened. Some students asked for a deadline extension for every single homework assignment, but the number was very low. After the fourth extension request, I email the student to see if things are going okay or if they are falling behind.

I try to not say any version of "you can do whatever you want and I will allow it" even though that is kind of what I mean, because I want students to use the resources that were already available to them first. Some students have asked to redo a homework set if they got a low grade. After exams I let students correct the problems that they got wrong and receive 1/4 of a point back for every question that they successfully corrected. Without creating extra credit, anytime someone is willing to do work themselves to improve their understanding, I agree. The result of this policy is that students feel very in control of their own success. I received overwhelmingly positive student evaluations, including from the students who did not get high marks. I have received numerous comments that the flexibility and lack of judgment allowed students to succeed not only in my courses, but in their other courses as well.

An area for improvement under the third pillar: *reducing test anxiety*. One area where I would like to improve is in testing. I would like to remove time-limits for exams in all my courses. I do not see the value solving problems as quickly as possible when the goal is to develop intuition, deep understanding, and critical thinking skills. I also believe that the anxiety created by time limits yields even worse results for some students than they would otherwise be able to achieve. As a junior faculty member in my academic positions thus far, I have not been able to create my own structure for evaluations. Thus, to reduce the test anxiety induced by time limits I have attempted to create exams short enough so that time was not a critical factor. From the weekly check-ins I can see a marked improvement between my first mid-term exam and the subsequent exams during the last term. With practice, I will continue to improve, and hopefully in future positions I will have the freedom to evaluate students based on the best effort they are willing to contribute.

4 Ongoing self-assessment and continuing education

The final pillar of my philosophy for student-centered teaching is ongoing self-assessment and continuing education. It should be clear from the previous pillars that I use intentional introspection regularly to evaluate my teaching, and my role in society. The weekly check-ins that I have already discussed, began during my time as a graduate teaching assistant. The original goal was to identify students whose study habits and learning strategies were not setting them up for success, before it was too late for them to adjust. However, I quickly realize that this was also an opportunity for me to adjust. In particular, students are often not willing to share constructive feedback out loud in class, and I am not always in the best position to receive feedback when I am on display. Allowing the surveys to be completed in-class means that the student responses are more specific than they would be otherwise, and asking for them every week means that I can implement changes before it is too late. I refer to these surveys as 360° feedback, because they allow the students to evaluate the instructor and the course itself. This leads to a feeling of community – an investment in our collective progress, and it helps to diminish the power imbalance between those who are giving grades and the students who are being graded. Far and away, the surveys and the adaptability of my courses were the most praised aspects of my teaching in student evaluations. The students felt that they were part of a discussion rather than on the receiving end of a top-down edict, and because I often discussed my thoughts about the check-ins during the next class period, students knew that their voice was heard even if I didn't adopt every change they suggested.

Feedback from students is essential, but because they only have experience on one side of the classroom, I believe that it is important to seek out coaching from peers and mentors as well. During graduate school, I was invited to be the TA mentor for the incoming graduate students. In addition to leading the teaching training workshops, I independently organized peer observation sessions, where TAs would trade off watching and recording each other during lectures. We would then re-watch the lectures and discuss ways to improve. I have continued this practice of requesting coaching and observation, in particular when teaching new courses. In the fall of 2021 I guest lectured during a graduate level non-convex optimization course. I used the opportunity to have my postdoc supervisor provide feedback on my lecturing, and received so useful feedback on how to motivate and structure lectures for more advanced students. Even the most elite professional athletes still need coaches, it seems only natural to me that our performance as teachers should be observed and critiqued if we hope to improve.

Outside of the classroom, I frequently attend workshops to improve my teaching. At Oregon State University I participated in the College of Engineering "Inclusive Teaching Workshop," as well as a workshop on "Engaging Students through effective questioning: Strategies and tips" hosted by the Center for Teaching and Learning. During the time that I was living in Europe, I participated virtually in the Mathematical Sciences Research Institute's "Workshop on Mathematics and Racial Justice," and the American Mathematical Society's "Workshop on Advocating for Students of Color: There's More You Can Do." At Colorado State University I was a regular participant in both the "Front Range Mathematics Education Seminar," and the reading group on the history of mathematics. These professional development experiences have laid the groundwork for me to interrogate my own teaching practices, identify weaknesses, and gain exposure to new research in education. The results are intertwined in my philosophy for holistic student-centered teaching, and evident in my classrooms and policies. I have many great teachers and mentors to thank for that development.

An area for improvement under the fourth pillar: *classroom equity self-assessment.* One area that stands out as a weakness with respect to my self-assessments and continuing education is that the results are always interpreted qualitatively, often by me. There is value in such analysis, but I am aware of the difficulty of inverting my own lens. In addition to the previously described methods, I also intend to use evidence-based methods to assess and reduce bias in my classrooms, such as the EQUIP App created by Reinholz and Shah[7]. The assessment seeks to quantify classroom equity as measured by the type and amount of student participation in class. Such a tool could provide insight that remains unseen while I am lecturing, and can track my patterns over time. I attempted to implement this assessment in my most recent course, but could not get university approval in time for the start of the term. It would be particularly straightforward to implement this tool in a course that was being recorded, because the assessment could happen offline.

5 Summary

John Conway wrote, "It is a paradoxical truth that to teach mathematics well, one must also know how to misunderstand it at least to the extent one's students do![8]" I think the truth in this statement goes beyond the teacher's ability to put themselves in their students' shoes with respect to understanding mathematics, but also with respect to understanding the context in which the student is trying to learn. The philosophy for holistic student-centered teaching that I have described in this document, is my attempt to treat students with dignity, both in the classroom and in the world at large. If I can create an environment where students can learn through discovery, engagement, and critical thinking, where the course material goes hand-in-hand with social context and cultural relevance, where students have multiple paths to demonstrate understanding, and where I as the instructor engage in ongoing self-assessment and continuing education, then I think my students will have a genuine opportunity to learn and grow. From my experiences and the student feedback that I have received thus far, the effort has been largely successful, but of course my growth is far from complete.

[7]D. Reinholz and N. Shah. "Equity analytics: A methodological approach for quantifying participation patterns in mathematics classroom discourse". In: *Journal for Research in Mathematics Education* 49.2 (2018), pp. 140–177.

[8]G. Polya. *How to solve it: A new aspect of mathematical method.* Vol. 85. Princeton university press, 2004.