Board 16: Work in Progress: Designing a course to equip Bioengineering graduate students with effective and equitable teaching skills

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Alexis Seymour (she/her/hers) recently completed her Ph.D. in Bioengineering at Stanford University. She believes that clear and effective teaching through communication is integral to our professional and personal lives and that teaching is not truly effective unless it is also equitable. While completing her doctorate, Alexis worked to create opportunities for graduate students to learn these essential communication skills through her work as a TA Mentor, a Leadership in Inclusive Teaching Fellow, a co-coordinator of the Bioengineering TA program, and an instructor for a TA-focused pedagogy training course at Stanford.

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Andrew Perley (he/him/his) is a 4th-year PhD candidate in the Bioengineering department at Stanford University. He has always had a passion for helping others learn from a young age and continues to strive to learn new ways to provide equitable opportunity for all learners. Andrew strongly believes that it is our job as educators to help students find confidence in their ability to learn and build community with others. In pursuit of building more inclusive and equitable systems in education, he strives to learn new ways to affect how we implement education at the department and school level. Andrew serves as a co-coordinator for the Bioengineering TA program and is a Leadership in Inclusive Teaching Fellow at Stanford University.

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An Electrical Engineer by training, Ross built and applied new types of MRI hardware for interventional and device-related uses during graduate school. Following a Biodesign Innovation fellowship, Ross helped to start the MRI safety program at Boston Scientific Neuromodulation, where he has worked for over a decade across the MRI safety community to create and improve international standards and to enable safe MRI access for patients with implanted medical devices.

At Stanford, Ross primarily leads undergraduate lab courses. He also supports a variety of courses and runs hands-on workshops on prototyping and systems engineering.

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Introduction: Addressing a critical training gap

Graduate Teaching Assistants (TAs) are often fundamental to the function of many academic departments. Whether serving as course aides, graders, or primary instructors, graduate TAs play a vital role in teaching and building a community of belonging in the classroom [1]–[4]. Well-prepared graduate TAs with strong pedagogical training have the potential to ease the burden on teaching faculty and may even see improvements in their own development as scientists [5], [6]. Many studies have illustrated the benefits of graduate TA training for increasing graduate TA understanding of pedagogical techniques and self-efficacy as educators [1], [7]–[9]. However, graduate TA preparation varies widely across schools and often focuses on policies over pedagogy [10], [11]. For example, our Bioengineering department previously offered just two opportunities for graduate TA training: a 1.5-hour departmental orientation and a 4-hour schoolwide TA training. In total, these orientations dedicated less than 2 hours to learning pedagogical strategies. Similar training is seen in other engineering departments and institutions, leaving graduate TAs with limited access to sufficient training on pedagogical skills and strategies [7], [12].

To address this need, we designed a seminar course, "Promoting Effective and Equitable Teaching in Bioengineering," to help graduate students confidently develop their teaching and communication skills. We hypothesized that course participants would develop practical pedagogical expertise and build self-efficacy as educators, empowering them to contribute more effectively to learning environments. We have offered the course in the Spring quarters of 2021, 2022, and 2023. In each iteration, we sought to actively demonstrate evidence-based inclusive pedagogical techniques through our course design and instruction. In the future, we plan to 1) evaluate the effectiveness of our course design on participant accomplishment of learning goals, and 2) examine the impact of course participants as TAs on the broader bioengineering community.

Course Design: Enabling effective learning of pedagogical skills

Course Learning Goals: We designed a course to address a critical need in the training of graduate TAs by allowing them to build pedagogical skills before their first TAship. We employed student-centered course design to create course ***learning goals that were meaningful and attainable*** through a weekly seminar course [13]. Specifically, through this course, graduate TAs would be able to: **(1)** build practical skills for defining and accomplishing course or communication objectives; **(2)** implement actionable inclusive strategies to foster belonging and equity within the (classroom) community; and **(3)** develop a tangible plan for applying effective teaching and communication skills to achieve personal and professional goals. The selection of module topics (**Appendix A1**) and the structure of each course module (**Appendix A2**) was rooted in the course learning goals.

Course Topics: We selected course topics to teach graduate TAs the ***why*** (*i.e.*, theoretical knowledge) and the ***how*** (*i.e.*, actionable strategies and skills) of equitable pedagogy, such as designing learning objectives and rubrics or discussing critical pedagogy and culturally responsive teaching. See **Appendix A1** for an overview of weekly topics and learning objectives.

Final Project: A final project allowed course participants to tie their conceptual understanding to practice [1]. Each participant chose a personally meaningful pedagogical project, such as mentoring a summer undergraduate student or preparing to instruct a future class and designed a plan for effectively and equitably carrying out their role utilizing skills learned in the course. See **Appendix A3** for more details about the final project.

Course Leadership: The leadership team consisted of three primary graduate student instructors and two faculty sponsors. Uniquely, the course was designed and facilitated entirely by the graduate student instructors, while the faculty sponsors engaged with the course as participants.

Evaluating Efficacy of Course Design on Participant Learning

We will gather survey data from participants before and after taking the course to evaluate achievement of course learning goals and self-perceived readiness as instructors. We will measure participant learning by gathering anonymous student feedback before, during, and after course participation. We will collect all measurements from survey data on a Likert scale ranging from 1 to 3 (Low to High, respectively) or 1 to 5 ("Not Well at All" to "Extremely Well," respectively). Further, we will account for previous teaching experience by asking participants to self-evaluate their experience on the 1 to 5 Likert scale.

(1) Evaluation of participant accomplishment of the course learning goals. To evaluate the first learning goal, to "build practical skills for defining and accomplishing course or communication objectives," weekly feedback will be collected where participants indicate their confidence with each course topic before and after the corresponding course module. For the second learning goal, to "implement actionable inclusive strategies to foster belonging and equity within the (classroom) community," participants will indicate whether they feel that the course prepared them to promote diversity, equity, and inclusion within their communities or classrooms in the future. For the third learning goal, to "develop a tangible plan for applying effective teaching and communication skills to achieve personal and professional goals," participants will report whether the final project enabled them to successfully describe a vision for their future teaching or communication practices using course concepts and develop a tangible plan to achieve that vision. Finally, we will evaluate whether the course effectively modeled inclusive and effective teaching strategies. At the end of the course, participants will be asked to evaluate the extent to which class sessions were engaging, whether they felt a sense of belonging within the classroom, and whether the instructors effectively demonstrated the inclusive teaching practices discussed in the course.

(2) Evaluation of participant confidence and self-efficacy as educators. As a metric of participant self-efficacy as educators, we plan to evaluate participant self-perceived readiness and comfort level as TAs before and after taking the course. Moreover, we plan to evaluate participants' intention to use the techniques learned through this course in the future in their roles

as TAs or mentors.. We hypothesize that through completion of our course, participants will experience an increase in comfort and self-perceived readiness for the role of graduate TA, which may correspond with greater self-efficacy as educators and mentors.

Evaluating Impacts of Trained Participants on the Bioengineering Community

While we hypothesize that our course empowers participants to accomplish the learning goals and develop greater self-efficacy as educators while taking the class, we aim to further evaluate the longer-term impacts of our course participants within the bioengineering department community by measuring their effectiveness as TAs. We will design our data collection along three key dimensions: **(1)** Sampling a greater proportion of graduate students in Bioengineering including non-course participants as a control, **(2)** Evaluating content mastery of pedagogical knowledge covered in the course *via* written and/or oral assessment, and **(3)** implementing longitudinal surveys to determine the long-term impact of expanded pedagogical training on TA effectiveness.

Specifically, after their first TAship, course alums will report whether they implemented pedagogical skills built through the course and describe how these skills influenced their effectiveness as educators. Additionally, we will use mid-quarter and post-course student evaluations of teaching to investigate the effectiveness of course alums compared to non-participant TAs. This will allow us to determine whether our course represents a significant improvement over existing training. **Appendix A4** contains more detailed plans for future data collection.

Conclusion

In this work, we created a course centered around equitable pedagogical practices and generalizable communication skills that would properly equip graduate TAs for success in the classroom and their future careers. The course filled an urgent need in the Bioengineering graduate curriculum while the design and content of this course empowered participants to achieve the course learning objectives. Through this course, participants developed an increased mastery of pedagogical theory and practices, including active learning, inclusive teaching, and more. Further, through the final project, participants solidified their knowledge by applying course content to their own areas of interest.

In the future, we plan to evaluate both the efficacy of the course and the longer-term impacts of course participants as graduate TAs within the broader bioengineering community. We hope that this work in progress will catalyze the implementation of similar training-based courses to improve the pedagogical preparation of graduate TAs.

References

[1] G. E. Gardner and M. G. Jones, “Pedagogical Preparation of the Science Graduate Teaching Assistant: Challenges and Implications,” *Sci. Educ.*, vol. 20, no. 2, pp. 31–41, 2011.

[2] E. M. Alford, “Training TAs to help students learn engineering discourse,” in *Proceedings Frontiers in Education 1997 27th Annual Conference. Teaching and Learning in an Era of Change*, 1997, vol. 3, pp. 1543–1548 vol.3, doi: 10.1109/FIE.1997.632748.

[3] L. B. Wheeler, J. L. Maeng, J. L. Chiu, and R. L. Bell, “Do teaching assistants matter? Investigating relationships between teaching assistants and student outcomes in undergraduate science laboratory classes,” *J. Res. Sci. Teach.*, vol. 54, no. 4, pp. 463–492, Apr. 2017, doi: https://doi.org/10.1002/tea.21373.

[4] C. Kepple and K. Coble, “Investigating potential influences of graduate teaching assistants on students’ sense of belonging in introductory physics labs,” *PERC Proc.*, pp. 282–287, 2019.

[5] S. M. Love Stowell *et al.*, “Transforming Graduate Training in STEM Education,” *Bull. Ecol. Soc. Am.*, vol. 96, no. 2, pp. 317–323, Apr. 2015, doi: https://doi.org/10.1890/0012-9623-96.2.317.

[6] N. M. Trautmann and M. E. Krasny, “Integrating Teaching and Research: A New Model for Graduate Education?,” *Bioscience*, vol. 56, no. 2, pp. 159–165, Feb. 2006, doi: 10.1641/0006-3568(2006)056[0159:ITARAN]2.0.CO;2.

[7] S. E. DeChenne, K. Lesseig, S. M. Anderson, S. L. Li, N. L. Staus, and C. Barthel, “Toward a Measure of Professional Development for Graduate Student Teaching Assistants,” *J. Eff. Teach.*, vol. 12, no. 1, pp. 4–19, 2012.

[8] K. A. Richards, J. D. Velasquez, and L. B. Payne, “The Influence of a College Teaching Workshop Series on Teaching Assistant Perceptions of Preparedness and Self-efficacy.” ASEE Conferences, San Antonio, Texas, doi: 10.18260/1-2--22072.

[9] S. L. Young and A. M. Bippus, “Assessment of Graduate Teaching Assistant (GTA) Training: A Case Study of a Training Program and Its Impact on GTAs,” *Commun. Teach.*, vol. 22, no. 4, pp. 116–129, Oct. 2008, doi: 10.1080/17404620802382680.

[10] J. Gilmore, M. A. Maher, D. F. Feldon, and B. Timmerman, “Exploration of factors related to the development of science, technology, engineering, and mathematics graduate teaching assistants’ teaching orientations,” *Stud. High. Educ.*, vol. 39, no. 10, pp. 1910–1928, Nov. 2014, doi: 10.1080/03075079.2013.806459.

[11] M. Di Benedetti, S. Plumb, and S. B. M. Beck, “Effective use of peer teaching and self-reflection for the pedagogical training of graduate teaching assistants in engineering,” *Eur. J. Eng. Educ.*, pp. 1–16, Apr. 2022, doi: 10.1080/03043797.2022.2054313.

[12] J. Agarwal, G. Bucks, and T. J. Murphy, “A Literature Synthesis of Professional Development Programs Providing Pedagogical Training to STEM Graduate

Students," in *2020 IEEE Frontiers in Education Conference (FIE)*, 2020, pp. 1–5, doi: 10.1109/FIE44824.2020.9274036.

[13] G. P. Wiggins and J. McTighe, *Understanding by Design*. 2005. ISBN-13: 978-1416600350

Appendix

A1. Summary of Course Topics and Learning Objectives

Table 1. Overview of the weekly module topics and associated learning objectives.

Week	Topic	Learning Objectives
1	**Promoting Effective and Equitable Teaching in Bioengineering: Course Values & Learning Goals**	● **Define** BIOE 296 community values, norms, and learning objectives. ● **Understand** course structure, content, and participant and instructor expectations. ● **Reflect** on personal goals for the course and specific skills you would like to develop.
2	**Engaging Teaching as Inclusive Teaching: Promoting Equity through Student Empowerment**	● **Reflect** on what makes a classroom or learning experience exciting, engaging, and empowering. ● **Explore** the ways in which exciting instruction is an inclusive teaching practice. ● **Identify** concrete strategies to promote inclusion and equity through active learning techniques.
3	**Leveraging Cultural Experiences to Enrich Learning**	● **Describe** the Culturally Responsive Teaching (CRT) framework and build vocabulary to discuss cultural biases in the classroom. ● **Identify** key strategies and competencies to incorporate cultural responsiveness into a course or other teaching setting.
4	**Defining and Working Toward Course Goals**	● **Understand** the use of learning goals. ● **Articulate** the elements of classroom success that support effective learning. ● **Apply** two strategies to create attainable milestones (SMARTER, CLEAR).
5	**Equitable Assessments and Rubrics, by Design**	● **Examine** the relationship between learning goals, assessments, and rubrics. ● **Describe** the benefits of rubrics as an equitable

		teaching and learning tool. ● **Implement** knowledge to design a rubric based on a set of learning objectives.

*(**Table 1.**, Continued)*

Week	Topic	Learning Objectives
6	**Exploring and Applying Universal Design for Learning (UDL)**	● **Outline** the guiding principles of Universal Design for Learning (UDL). ● **Apply** UDL to assessments in order to promote student inclusion and classroom equity.
7	**Individualized Formative Feedback to Promote Student Growth and Learning**	● **Explain** the difference between summative and formative feedback. ● **Contrast** the utility and implications of convergent versus divergent formative feedback. ● **Describe** how the language of feedback and a culture of growth mindset impact student learning. ● **Plan** how you can apply these concepts in your own teaching experience.
8	**Building a Culture of Trust and Wellness in the Classroom**	● **Describe** the impact of instructor-learner trust on feedback efficacy. ● **List** strategies for building trust in a teaching or mentoring setting. ● **Implement** feedback knowledge — including the Pendleton feedback model — to provide peer feedback. ● **Categorize** wellness practices to establish a conceptual framework of holistic wellness. ● **Discuss** strategies to promote wellness for both students and teaching teams
9	**Project Showcase & Course Summary**	● **Implement** communication skills developed

		throughout the quarter in a Lightning Talk format. ● **Practice** providing feedback and asking insightful questions about an academic talk. ● **Build** a community of educators via discussion of teaching, mentoring, and communication-related interests. ● **Reflect** on your learning experience this quarter and **recommend** next steps for the future of this course.

A2. Daily Course Structure

Table 2. An outline of the daily course structure, including a description of each module phase.

No.	Phase	Description
1	**Welcome Check-In** (5 min)	Each session included a **check-in question** as participants joined. Participants were invited to discuss with others at their table or quietly reflect. This helped build classroom community.
2	**Agenda** (5 min)	When we were ready, we began with the **agenda** for the day and introduced that day's **learning objectives**.
3	**Recall** (5 min)	We then **recalled** the topics covered the week prior. Here, we paused to address lingering questions or new comments. We would **address feedback** submitted via Exit Ticket during this time.
4	**Reflect** (10 min)	We transitioned to a **reflection** that used the participants' own experiences to link the topic covered the week before to the topic for that day, followed by a **group discussion**. This helped to link past and future knowledge and promoted participation.
5	**Content Knowledge** (15 min)	Once we set the stage, we moved to **knowledge building**. We clarified key concepts or terms, described their use, and introduced data from the literature to motivate its utility. We used reflections or short practice exercises to break up content-heavy sections.
6	**Activity** (25 min)	After providing the necessary information, we would engage the students in a **longer activity** that would allow them to synthesize and deepen their understanding of the topic. Examples include a modified **jigsaw activity** for a guided exploration of resources; **small group work** on a practice exercise, followed by a **gallery walk**; and a **think-pair-share**. Activities often concluded with a **group discussion**, though we encouraged varied participation methods. This sharing was essential for helping students identify actionable strategies to implement in their teaching practice.
7	**Final Project Work Time** (10 min)	To help participants review and apply concepts covered during the course session, we set aside time at the end of class for students to **work on their projects**, either individually or in small groups.
8	**Summary** (5 min)	When wrapping up the class session, we would **revisit the learning objectives** for the day, with additional **visual cue**s for each concept.
9	**Exit Ticket** (5 min)	We'd then share a QR code that directed the students to a **feedback form** for that class session.

A3. Final Project Description

Project Overview

The final project provides a structured way for participants of BIOE 296 to **draw connections between course topics** and make a concrete **plan** for applying learned skills in the future. You are encouraged to choose a communication-related situation or role that: **(1)** is **reliant upon or improved by** effective communication and **(2)** will be **meaningful and useful** to you. See the "**Example Project Topics**" section below for ideas!

The project is broken into **weekly modules**, allowing BIOE 296 participants to make progress on the project each week to reduce the burden on students during weeks 8-10 without reducing the impact of the exercise. For more information on project deliverables and deadlines, please refer to the "**Weekly Building Blocks**" table at the end of this document.

Lastly, the **scope of the project** and **means of presentation** are personalizable, guided by the following learning goals.

Project Learning Goals

Through completion of this project, participants will…

- **Internalize** the value of equity-centered teaching practices for improving communication efficacy.
- **Identify** an area of life or specific role in which effective communication (or, more specifically, effective teaching) will help them achieve their personal or professional goals.
- **Describe** their vision of effective and equitable communication/teaching in that area of life or role (their communication/teaching/mentoring philosophy).
- **Design** a communication/teaching/mentoring artifact that uses course concepts to realize their vision.

Final Project Checklist (Rubric)

All projects, regardless of the topic and means of presentation, should include the following:

- **Project Topic:** A clear description of the selected project topic.
- **Motivation:** Explanation of why you chose this topic and means of creation.
- **Course Topics:** Synthesis and application of at least three (3) course topics and justification for why you selected these course topics to use for your project.
- **Support:** At least three (3) primary sources that present evidence-based best practices and aid you in creating your project. Look to Canvas for a starting point!
- **Project Deliverable:** The bulk of your project! The topic-specific aspect of your project. See "Means of Presentation" for examples of forms this might take.

- **Self-Reflection:** A reflection exploring what you learned through completing this project. How did this project help you gain a deeper understanding of teaching and communication? What would you do differently next time

Example Project Topics

Example ideas for this project include (and are certainly not limited to):

- **Teaching:** Design a lesson plan for a discussion section, final review, or office hour you might lead as a TA. How will you engage students? How will you divide your time equitably between predefined and student-requested topics? How will you apply feedback to guide students?
- **Teaching:** Imagine that you are asked to consult on course re-design for a class that you took but did not love. Write a proposal that outlines the current class structure, identifies strengths and weaknesses based upon student data, and makes actionable suggestions for improving one (or more) metrics of class success. Be sure to support your suggestions with evidence and references from the literature (e.g., resources used in BIOE 296 slides).
- **Mentoring:** Design a 10-week plan for mentoring a rotating graduate student or summer undergraduate student in your lab. How could you apply feedback strategies to help them achieve their goals? How will you ensure that you set -- and revisit -- reasonable and actionable goals? How will you communicate with them and teach them the ins and outs of your field?
- **Mentoring:** Imagine that you are a manager who is informally mentoring a recruit at work. How might you help the mentee set goals and devise a plan to achieve those goals? How might you help them to feel included in the workplace community? How might you apply ideas around rubrics and expectancy to a workplace setting?
- **Leadership:** Imagine that you are the chair of an engineering department at a research-focused university. What steps might you take to work towards equity and inclusion within your department (could be focused on admissions, curriculum design, or community-building)? Consider how you might formulate and define a plan, delegate roles/responsibilities, and provide feedback to your team.

A4. Further Discussion of Future Work

In the future, we plan to evaluate the effect of the course on graduate TA preparedness by gathering more data. As discussed, we will implement data collection along three key dimensions: **(1)** Sampling a greater proportion of graduate students in Bioengineering (including non-course participants as a control), **(2)** evaluating content mastery of pedagogical knowledge and skills covered in the course via written and oral assessment, and **(3)** implementing longitudinal surveys to determine the long-term impact of expanded pedagogical training on TA effectiveness.

For **(1)**, in the Spring of 2023, we will implement this course with a new cohort of graduate students; this will provide a greater sample size of course participants. We also plan on surveying graduate TAs in the department that do not take our course to serve as comparative controls to demonstrate the course's effect. Given that all course participants self-selected to take the course (*i.e.*, the course is not a departmental requirement), there may be bias introduced in the self-reporting.

For **(2)**, we believe that evaluating content mastery of pedagogical knowledge and skills covered in the course beyond self-reported levels of comfort utilizing alternate forms of assessment will increase the rigor of our tests. By comparing mastery of pedagogical content and skills between course participants and non-participants, we will be able to more effectively assess the impact of our course in comparison with the baseline graduate TA training requirements. This quantification of graduate student expertise in pedagogical practice, a skill set that is essential for students pursuing faculty careers, may also be a useful metric for graduate training more broadly.

In the initial design of the course, we chose to move away from traditional assignments and assessments (such as quizzes and tests) to maximize the accessibility of the course. Given that our course participants are graduate students with research responsibilities, reducing the time burden for this course was a top priority. Still, we believe that utilizing a limited number of ungraded assessments will increase opportunities for active recall and spaced repetition without a significant increase in participant time burden.

For **(3)**, one of the driving motivators in the inception of the course was creating more opportunities for graduate students to develop professional skills relevant to their future careers. Thus, we will employ longitudinal surveys to track course participants not just after their first TAship, but also after their experiences as mentors and leaders through and beyond graduate school in academia, industry, or elsewhere.