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Modifications to a graduate pedagogy course to promote active learning and inclusive teaching

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Abstract

Graduate student instructors, also known as graduate teaching assistants, have an impactful role in the education of undergraduate and graduate students through their engagement in laboratories, discussion sections, and mentoring activities. It is essential to train graduate students in effective pedagogy, including teaching methods that promote student-centered learning, reflective teaching practices, and engagement of a broad diversity of students. This investment in graduate student training pays dividends in an enhanced learning environment for students now and in the future as graduate students go on to careers that often include teaching and mentoring as core skill sets.

This paper details an instructional improvement project targeting a pedagogy course for first-year graduate students in Chemical and Biomolecular Engineering at a large, public, research-intensive university. The course is offered each fall semester, and has traditionally presented topical material in theory and application of how people learn engineering, with modules on course design, teaching methods, assessing student learning, evaluating teaching effectiveness, mentoring, logistics of ABET data collection, and trouble-shooting difficult situations. Course modifications emphasized material in active learning and inclusive teaching, implemented through required readings, class discussions and activities, case studies, assignments, and supplemental resources. These materials were drawn from a broad base of education resources encompassing multiple disciplines.

To assess the impact of the course improvement project, a pre- and post-survey instrument measured student attitudes about active learning, inclusive teaching, and other aspects of teaching practice. The survey tool was developed using best practices, including literature review, construct validation, expert input, and pilot testing of the instrument. This paper reviews patterns in student comfort with using various active learning methods in their teaching, and attitudes towards creating an inclusive climate for learning within engineering. We use the insights gained from this work to develop suggestions for others looking to implement similar improvements in graduate pedagogy courses or seminars.

The implementation of this course project is situated within efforts of continuous improvement in diversity, equity, and inclusion at the large, public, research-intensive institution with a strong teaching mission. This project was informed by other efforts across campus, and the outcomes from this phase of the project will likewise inform further work in this area. Promoting effective

teaching that invites all students to enter into a safe space to take intellectual risks can have lasting impacts, as an engineering degree is a gateway into stable employment and meaningful work that advances the human condition for us all.

Introduction

Graduate student instructors (GSIs) have a substantial impact on the intellectual, professional, and personal development of their students. However, many GSIs lack adequate preparation to effectively teach due to limited training and feedback.[1] First-time GSIs often report low levels of confidence in a wide range of teaching skills, from facilitating group discussions to handling student cheating.[2,3] In light of these issues, it is crucial to establish effective programs to train and support new GSIs in developing both pedagogical knowledge and practical teaching skills.

There exists substantial evidence suggesting that semester- or year-long courses aimed toward training GSIs are effective in increasing GSI self-efficacy.[2,3,4] The benefits of these courses include improvements in GSI competency that persist years after the course is completed.[5] Numerous works have been published in recent years detailing best practices and recommendations for the development of these graduate student teaching courses, both for engineers in general[6,7,8,9,10] or focused on discipline-specific teaching.[11,12] While the majority of these courses focus on teaching skills within the academic realm, several courses have also emphasized skills transferable to non-academic careers such as leadership and communication.[12,13,14]

In this paper, we build upon this growing body of work to document an instructional improvement project for Chemical Engineering 375, Professional Preparation: Teaching Chemical Engineering, a 2-unit course for graduate students at the University of California, Berkeley. This course is typically taken during the first semester for PhD students, and it complements a set of three technical chemical engineering courses. During the same semester, students complete the selection process by which students become assigned to a research advisor. Most students are also appointed to their first GSI appointment, at 10 hours per week. This early engagement in teaching and instruction in pedagogy alongside technical coursework reflects the dual teaching and research mission embodied by the University. This course introduces new GSIs to the theory and practice of teaching and learning within the discipline of Chemical Engineering, to allow new teachers to integrate their experience with insights from cognitive and applied research in teaching and learning. The course also provides context for the expectations and practice of GSI-ship in the Chemical and Biomolecular Engineering Department at UC Berkeley. The course enrollment is usually around 25 students. While most students are PhD students in chemical engineering, there are sometimes a small number of MS or PhD students from allied disciplines in the course. Since 2012, the course has included modules on course design, teaching methods, assessment of student learning, evaluation of teaching effectiveness, ABET accreditation, facilitating groupwork, and preventing and reporting academic integrity violations.

In early 2019, the course instructor was awarded an Instructional Improvement Grant through the UC Berkeley Center for Teaching and Learning. The instructional improvement project, titled, "Inclusive Teaching and Active Learning Upgrades to Chemical Engineering Pedagogy Course," centered on general updates to the course reading materials, assignments, and in-class activities, with particular emphasis on active learning as well as inclusive teaching and mentoring strategies. Additionally, the grant provided funds for supporting a graduate student researcher to work on the course improvements, as well as funds for bringing in two guest speakers in the field of chemical engineering education.

This paper is organized as follows: We begin by describing the methodology undertaken for (1) designing the improved course materials and (2) evaluating the efficacy of the course changes. In the following section, we describe the content of the updated course, including assigned readings and activities. Next, we present results regarding the successes and limitations of the course based on student knowledge and attitudes towards a variety of aspects of teaching. Finally, we provide recommendations for others looking to develop similar courses at other universities.

Methods

Course Improvement Approach

Improvement of the pedagogy course was funded by an Instructional Improvement Grant and included phases of consultation with experts, literature review, course materials review, and development of refined lesson plans and course website.

The faculty instructor and graduate student researcher consulted with experts on active learning and inclusive teaching. Michael Prince, a professor and scholar in active learning within engineering education, provided a workshop on active learning for faculty, post-doctoral researchers, and graduate students in the Department in spring 2019. Prof. Prince provided insights into overcoming instructor doubts about implementing active learning and provided some updated materials on evidence for the impacts of active learning to enhance learning in the conceptual domain.

For inclusive teaching, the faculty instructor and graduate student researcher consulted with experts on campus during summer 2019, including Rita Conrad, Interim Director of Teaching and Learning Excellence; Khalid Khadir, Lecturer in Engineering, Global Economy, and Global Policy and Practice; and Fatima Alleyne, Director of Faculty Engagement for Equity and Inclusion in Engineering. This diverse group of experts was able to point to inclusive teaching resources and workshops on campus and at other campuses, to share titles of texts, authors, and articles in the area, and to share perspectives on justice, history, equity, and potential new directions within teaching in higher education.

This consultation with experts in active learning and inclusive teaching informed the literature review and course materials review during summer 2019. Literature review included traditional engineering education sources such as ASEE proceedings and JEE papers, but also included the review of websites of many university-level centers for teaching and learning. These included resources that broadened the scope of the literature to include education research and scholarship beyond the STEM domain, and were rich sources of information on teaching diverse groups of students.

These materials were integrated into the development of lesson plans for each week of a 14-week course, organized into six topical modules. The course website was developed on a Canvas learning management system platform, organized around the six modules. Each module included a statement of learning objectives, required and supplemental readings, and associated assignments.

Survey Development

Students were asked to complete a survey at the beginning and end of the course to assess their familiarity with various teaching ideas as well as their attitudes towards different aspects of teaching. Development of this survey generally followed the best practices outlined by Artino et al. for developing questionnaires for educational research.[15] Survey development began with a literature review of existing surveys with similar aims. This provided ideas for the survey structure and gave examples of the typical language used in the field. Based on this search, survey questions were developed by both drawing from the literature[16,17,18] and by creating original items more specific to the learning outcomes of our course.

While continuing to develop the survey items, a focus group was conducted with two graduate students at UC Berkeley. Neither had taken the previous version of Chemical Engineering 375, although both had taken similar pedagogy courses from other departments and had at least one semester of previous experience as a GSI. The purpose of this focus group was to ensure that the language of the survey was consistent with the language that the typical graduate student uses to describe teaching. The two focus group participants were asked very general questions such as "What makes good teaching?" and "How does a good teacher promote learning in a diverse classroom?". Based on this focus group, we did not identify any major discrepancies between how the students conceptualized teaching and the language used on our survey. However, we were able to identify some topics which were important to the two participants which were not originally included in the draft survey questions, such as the nuances of the complex relationships and power dynamics between GSIs, students, and professors.

After incorporating these additional topics into the survey, our next aim was in obtaining expert validation. We sent our survey to 53 experts in engineering education, receiving feedback from one expert. This feedback enabled further refinement of the language used in our survey items. The final step of survey development was pilot testing with two graduate students. These students were chosen to have backgrounds matching those of our incoming Chemical Engineering 375 students as closely as possible. Neither student had previous experience as a GSI and had not taken any prior courses in pedagogy. These students were asked to take the survey and identify any items which were unclear, irrelevant, or too leading. The edits stemming from this feedback yielded the final version of the survey given to the course students.

Course Content

The course was organized into six distinct modules, each covered by one to two class sessions. In this section, we describe the learning objectives and implementation of each of these modules. Aspects of the course which were newly introduced for this year's modified offering are *italicized*.

Module 1: Course Design

The first module of the course introduced students to student-centered, objectives-based approaches to course design. The module began with a whole-group discussion on the arguments in favor of student-centered, rather than teacher-centered paradigms and also included the topics of constructivism, student motivation, and student levels of development. This discussion was guided by the first assigned reading for the day by Bain.[19] The other assigned reading introduced students to the Understanding by Design framework, *with additional optional readings covering other frameworks such as the 5E model[20] and Universal Design for Learning.[21]* Following this discussion, the remainder of the class period focused on Bloom's Taxonomy.[22] The instructor presented example Bloom's style learning objectives for chemical engineering courses, then asked students to write several learning objectives for their own courses. Students then shared these objectives as a group.

Module 2: Teaching Methods

The first of two class periods on teaching methods centered around active learning strategies. The lesson began with a think-pair-share brainstorm of all the teaching methods that the students had heard of and experienced, after which the class discussed which of the methods could be classified as active learning. *This was followed by a whole-class discussion on the assigned reading, the meta-analysis by Freeman et al.[23] on the positive impacts of active learning on student performance in STEM*. The students discussed the main arguments for active learning as well as their skepticism. *Finally, to demonstrate how active learning can manifest in chemical engineering, the instructor performed three short demonstrations on active learning activities specific to the discipline. For each, students completed a handout with general observations as well as potential advantages and concerns about applying the technique in their own teaching.*

The second class period of the module focused on planning and executing effective lectures. A whole-class discussion on the assigned reading (McKeachie)[24] allowed students to share what they valued most in a lecture and how to structure lectures to help students learn most effectively. *The remainder of the class period consisted of an activity analyzing the language instructors use to establish the classroom climate, or Instructor Talk, as defined by Seidel et al.[25] Students worked in pairs to analyze a variety of quotes taken from the study by Harrison et al.,[26] which analyzed Instructor Talk in 69 college biology courses. In pairs, the students categorized each quote based on the Instructor Talk Framework established by Harrison et al.,[26] classifying Instructor Talk as either positively phrased (building the instructor/student relationship or establishing classroom culture, for example) or negatively phrased (such as compromising pedagogical choices or sharing personal judgment). The students then discussed the impact that each of the quotes would have on the students and reflected on how to be more mindful of their own language used while teaching.*

Module 3: Inclusive Teaching and Mentoring

The objectives of the module on inclusive teaching and mentoring were threefold: (1) understand important issues of diversity and inclusion in undergraduate education and their potential impact on student learning, (2) reflect on the inclusivity of one's current teaching practice and identify strategies for improvement, and (3) develop skills to be a formal and informal mentor to a diverse range of students. This module was split into two course periods. Note that while most of the other modules were built upon content covered in previous offerings of the course, the content on inclusive teaching was largely new this year.

The first day began with some ground rules to enable open and honest discussion of challenging issues, and a reflection of the assigned reading (Ambrose et al.),[27] to consider the impact that classroom climate can have on student learning and relate the evidence presented in the reading to students' own experiences as students and teachers. Students then split up into groups of four to analyze case studies in inclusive teaching, taken from Sellers et al.[28] These case studies centered on the experiences of hypothetical GSIs dealing with cultural differences amongst students, students with physical or mental disabilities, or challenging gender or race dynamics in the classroom. Each group received one case study and worked to dissect the issues at play, potential responses, and the consequences of these responses, which were then shared with the class.

Having established the importance of inclusive teaching and how it can manifest in STEM education, the second class period in this module began by introducing strategies for inclusive teaching. In addition to the general strategies outlined in the assigned reading by Saunders and Kardia,[29] students were each given a checklist of inclusive teaching practices (created by the University of Michigan Center for Research on Learning and Teaching)[30] and asked to reflect on which strategies they already use and which they would like to try the next time they teach. The course session concluded with a discussion of mentoring, including a debate on various mentoring models and strategies.

<u>Module 4: Evaluating Teaching Effectiveness</u>

The module on evaluating teaching effectiveness took place near the midpoint of the semester, around the time when the students who were currently GSIs would be conducting midterm evaluations. In addition to discussing the protocols for course evaluations at UC Berkeley, the instructor provided resources for students to design their midterm evaluation questions. *The main component of this course period, however, consisted of a debate centered around the two assigned readings of the module: Stark and Freishtat,[31] who use a statistical perspective to argue that course evaluations do not measure teaching effectiveness, and Benton and Cashin,[32] who present evidence towards the validity and overall lack of bias in student evaluations. Students were assigned a position on debate topics such as the role evaluations should play in tenure or promotion decisions and the extent to which factors such as gender or age affect ratings.* This ultimately culminated in a broader class discussion on how we should use and interpret course evaluations in our own teaching.

In addition to discussing student evaluations, this module also included other ways to evaluate teaching effectiveness, such as student test results, video recordings, or feedback from an outside observer. Focusing on self-evaluation, the students were introduced to Weimar's[33] five spheres of effectiveness: preparation and organization, clarity, knowledge of content, enthusiasm, and ability to stimulate thought and interest. The students were asked to reflect on which of these spheres comes across most strongly in their own teaching and on how the different spheres interact.

<u>Module 5: Assessing Student Learning</u>

The module on assessing student learning focused on summative assessments such as exams rather than formative assessment. *The main emphasis of the in-class activity of the first class period of this module was to allow students to practice analyzing the strengths and weaknesses of various exam questions. Initially, all of the students were presented with two similar exams which could be offered in an undergraduate transport class for chemical engineers. Both exams dealt* *with the same system, but one emphasized the mathematical aspects of solving the problem while the other focused on more qualitative skills such as physical intuition and contextualization. We then asked students to pair up and identify the Bloom's style learning objectives tested by each exam and discuss the relative merits of each approach. After this discussion, students performed this same analysis using an exam of their own, either from a class they have taken or taught. Students were asked to reflect on what changes could be made to their exams to make the questions better align with the learning objectives of the course.* This class period also included a discussion of the assigned reading (Felder),[34] in which students shared their opinions on other aspects of designing exams such as minimizing speed as a factor and providing detailed study guides.

This module included a second class period as well, which covered design of rubrics. Students analyzed the key features of example rubrics for various types of assignments such as lab reports and presentations. This class period also introduced students to the ABET accreditation program, including their responsibilities as GSIs in preparing examples of student work demonstrating the course outcomes.

Module 6: Troubleshooting

The final course module focused on troubleshooting general issues that might be faced by a GSI. *Students were presented with several hypothetical scenarios related to academic dishonesty, inappropriate or unruly student behavior, issues with group work, and student-teacher relationship boundaries, then used the think-pair-share approach to discuss how they would respond in this situation.* The instructor also introduced several of the resources available to GSIs from the university, for example to report cheating or respond to student distress. The assigned reading focused on student attitudes towards cheating.[35]

Assignments

In addition to assigned readings and in-class exercises, students were required to complete five assignments. Each was designed to be grounded in a course of the student's choosing from the undergraduate chemical engineering curriculum which they were either currently teaching or would like to teach in the future.

1. Design of a lesson plan for a discussion section: Students were required to identify the desired learning outcomes of the lesson (based on the Bloom's taxonomy structure) and describe the content, activities, and time allocations of each component of their lesson. *Furthermore, students were required to incorporate at least two active learning techniques into their lesson, drawn from the list of strategies outlined by Faust and Paulson.*[36]

2. Critique essay: This assignment encouraged students to critically read and analyze literature in the engineering pedagogy field. Students chose one of the module topics described above and were asked to choose at least three readings on this topic out of a list provided by the instructors. The essay prompt required students to challenge the perspectives and assumptions of the readings' authors in order to develop their own opinions on the topic.

3. Peer observation and reflection: Students observed and were observed teaching by a peer from the class. Observers were asked to provide constructive feedback on strengths and

areas for growth, after which the observed student would write a reflection on the process and how they can improve their teaching.

4. Development of an assignment: Students created a sample homework assignment, including learning objectives based on Bloom's taxonomy. Course time was allocated for students to give and receive feedback on the effectiveness of their assignment.
5. Teaching philosophy evolution essay: At the end of the semester, each student wrote an essay on how their teaching philosophy changed or evolved during the semester. Students reflected on which of the readings and class activities were most impactful in shaping their views on teaching.

Results and Discussion

The fall 2019 course offering was taken by 24 students, the majority of which were first-year PhD students in the Chemical and Biomolecular Engineering department. Our survey instrument to assess the course improvements (described in the Methods section) was administered before the first week and after the last week of instruction. Participation was optional, with a total of 18 student responses (75%) in the pre-survey and 16 responses (67%) in the post-survey. The first question of the survey asked students to describe their previous teaching experience; a very wide range of experiences, from none to several semesters as undergraduate teaching assistants, were reported. Half of the survey respondents in both the pre- and post-surveys were concurrently working as first-time GSIs that semester.

The survey items were split into two sections. The first asked students to evaluate their familiarity with a range of teaching concepts and strategies, most of which pertained to active learning. These items are given in Table 1. The second section evaluated student attitudes on a broad range of teaching ideas, including active learning, inclusive teaching, and general self-efficacy as a GSI (Table 2).

Table 1: Options and results for Part 1 of the survey instrument. Each question asked students, "Which of the following techniques would you feel comfortable using in your teaching?" (Yes; No; I do not know a lot about this technique). Data for the fraction of students choosing each option is shown.

Technique	Pre-Survey			Post-Survey		
	Yes	No	Do Not Know	Yes	No	Do Not Know
Active Learning	0.68	0	0.32	0.94	0	0.06
Cooperative Learning	0.41	0	0.59	0.75	0	0.25
Problem-Based Learning	0.95	0	0.05	0.94	0.06	0
Clarification Pauses	0.82	0.09	0.14	0.94	0	0.06
One-minute Paper	0.09	0.27	0.64	0.31	0.63	0.06
Clicker Questions	0.50	0.32	0.18	0.56	0.38	0.06
Group Discussions	0.86	0.09	0.05	1.00	0	0
Think-Pair Share	0.45	0.05	0.50	0.88	0.13	0
Note Comparison/Sharing	0.36	0.18	0.45	0.81	0.19	0

Table 1 continued from previous page

Technique	Pre-Survey			Post-Survey		
	Yes	No	Do Not Know	Yes	No	Do Not Know
Peer Evaluation	0.50	0.32	0.18	0.75	0.25	0
Concept Mapping	0.41	0.05	0.55	0.75	0.25	0
Debates	0.32	0.50	0.18	0.50	0.50	0
Jigsaw Group Projects	0.14	0.14	0.73	0.25	0.44	0.31
Case Studies	0.64	0.18	0.18	0.81	0.19	0
Bloom's Taxonomy	0.14	0.09	0.77	0.56	0.44	0

The first portion of the survey demonstrated that the course was generally effective in increasing students' comfort with the teaching techniques emphasized in the course. As shown in Figure 1, the average fraction of students who reported that they do not know a lot about a technique decreased substantially after taking the course, from 37% to 5.4%. This change was correspondingly accompanied by an increase in the average fraction of students who would be comfortable using a technique in their teaching, from 48% to 72%.

Among the specific changes captured by Part 1 of the survey, we are particularly encouraged by the fraction of students who would be comfortable using active learning in general, which increased from 68% to 94%. We believe this is due to a combination of discussion of active learning techniques in the assigned readings, modeling of the techniques during the class itself, and the opportunity to try active learning themselves in the assignments. Students' change in attitudes towards active learning were captured more completely in Part 2 of the survey. As given in Table 2, the first nine elements of this portion of the survey addressed ideas surrounding active learning. This data shows several promising changes, for example an increased fraction of students who believe that student participation is an important part of every class session and a decreased fraction of students who think that active learning requires a significant amount of preparatory time and thought. Only one of these active learning questions yielded a statistically-significant change (p-value < 0.05): "I feel comfortable using active learning strategies in my teaching." This question had a post-survey mean of 4.69 out of 5. Based on this data, it is clear that these graduate students feel ready to use active learning techniques in their teaching.

The survey also included a variety of items around inclusive teaching. Despite devoting two course sessions to the inclusive teaching module, none of the pre-/post-survey changes in this section were statistically significant (Table 2). On the one hand, many of the inclusive teaching survey items were scored very high in the pre-survey, leaving little room for improvement in the post-survey. These items suggest that students were already convinced of the importance of inclusive teaching and were already making an effort to promote positive classroom culture. On the other hand, some survey items were scored low (<4) in both the pre- and post-survey. Based on these items, it is apparent that the course could have been more effective in helping students learn how to identify their own cultural, racial, and gender biases and to address them in their teaching. This suggests that the course modules should have had more emphasis on helping each student become more self-aware of their biases and equipping then with a wider array of inclusive teaching techniques. It may be possible in the future to bring in an outside organization to run a

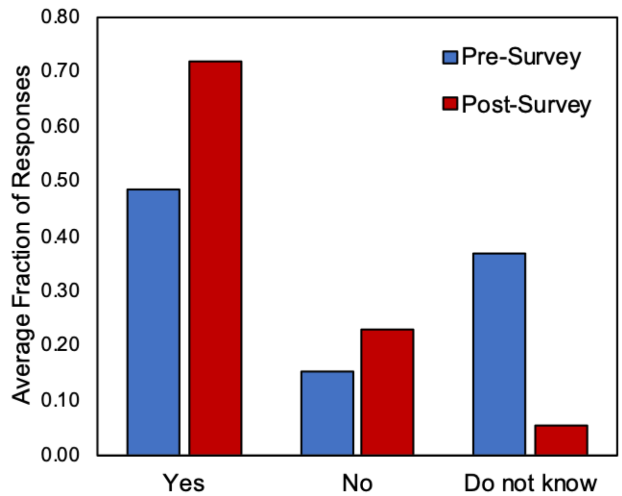

Figure 1: Summary of the response data for Part 1 of the survey instrument. The average fraction of “Yes”, “No”, and “I do not know a lot about this technique” responses is given for both the pre- and post-survey.

workshop on the subject.

The final portion of the survey addressed general attitudes towards teaching, wherein we observed three statistically significant changes: students are better equipped to evaluate their teaching effectiveness, understand the resources available to them as GSIs, and overall feel prepared to be effective GSIs.

Table 2: Questions and results for Part 2 of the survey instrument. Each question asked students, “Indicate your agreement with the following statements (1 Strongly Disagree; 2 Somewhat Disagree; 3 Neither Agree nor Disagree; 4 Somewhat Agree; 5 Strongly Agree; Unsure). Items with a p-value < 0.05 are in bold.

	Pre-Survey		Post-Survey		p-value
	Mean	S.D.	Mean	S.D.	
Active Learning					
The most important characteristic of good teaching is to have complete and accurate lecture notes.	3.77	0.97	3.69	1.14	0.81
Learning in large classes reduces learning effectiveness.	3.23	1.02	3.31	1.14	0.81
Student participation should be an important component of every class session.	3.95	1.17	4.44	0.73	0.13
Students can, during peer discussions, learn new scientific knowledge.	4.52	0.75	4.50	0.63	0.92
Discussions between students related to course materials are vital for a deeper understanding of the course material.	4.41	0.85	4.69	0.48	0.21

Table 2 continued from previous page

	Pre-Survey		Post-Survey		p-value
	Mean	S.D.	Mean	S.D.	
Active learning activities require a significant amount of preparatory time and thought.	4.11	0.94	3.56	1.26	0.17
Incorporating active learning activities makes it harder to cover all the topics on the syllabus.	2.88	1.20	3.00	1.20	0.77
The efficacy of active learning is supported by quantitative research.	4.13	0.64	4.44	0.73	0.23
I feel comfortable using active learning strategies in my teaching.	**3.39**	**0.98**	**4.69**	**0.60**	**5.7e-5**
Inclusive Teaching					
The social and emotional climate of a classroom impact student learning.	4.77	0.53	4.88	0.34	0.47
Diversity in the classroom promotes student learning.	4.40	0.88	4.31	0.87	0.77
I am well-versed of the effects of race and gender bias and stereotyping on students.	3.36	1.22	3.60	0.74	0.47
I am able to identify cultural biases in my own instruction.	3.52	0.87	3.40	0.83	0.67
I am able to identify racial biases in my own instruction.	3.57	0.87	3.27	0.80	0.29
I am able to identify gender biases in my own instruction.	3.57	0.87	3.53	0.74	0.89
I attempt to overcome cultural, racial, and gender biases in myself and in my students.	4.29	0.78	4.38	0.62	0.70
I listen with an open mind to students and faculty members of diverse cultural groups, even if their communications are initially disturbing or divergent from my own thinking.	4.55	0.80	4.63	0.62	0.73
A GSI has significant control in creating an inclusive classroom environment, regardless of the attitudes of the faculty instructor.	4.73	0.46	4.56	0.89	0.51
It is important for an instructor to get to know their students individually.	4.09	0.92	4.13	0.72	0.90
It is important for instructors to highlight the contributions of scientists and engineers from diverse backgrounds to the course's field of study.	4.05	0.95	4.50	0.63	0.09
The instructor should make every effort to identify and address students' learning difficulties.	4.38	0.80	4.25	0.86	0.64
I try to prevent prejudiced or stereotyped thinking from unfairly influencing my evaluation of students.	4.59	0.59	4.69	0.48	0.58

Table 2 continued from previous page

	Pre-Survey		Post-Survey		p-value
	Mean	S.D.	Mean	S.D.	
As a GSI, I am comfortable confronting statements made by faculty and other students that are racially, culturally, or gender biased or prejudiced.	3.65	1.39	3.87	0.99	0.59
I understand how to define appropriate boundaries in student-teacher relationships	4.18	1.01	4.38	0.62	0.47
I have techniques to handle emotionally intense discussions in my class.	3.36	1.43	3.69	0.95	0.41
I have the training required to work with students from diverse cultural backgrounds.	3.57	1.21	4.00	0.63	0.17
I feel comfortable teaching students with backgrounds similar to mine.	4.45	0.74	4.75	0.45	0.14
I feel comfortable teaching students with backgrounds different from mine.	4.09	0.68	4.40	0.51	0.12
General					
Giving tests that only the top students have time to complete sorts students effectively according to their understanding of the material.	2.14	0.96	2.25	1.29	0.78
Teachers should give students detailed study guides for tests.	3.09	1.38	3.31	1.20	0.60
Most students have a clear understanding of what does and does not constitute cheating.	3.45	1.14	2.94	1.39	0.23
I understand what steps to take if I suspect that one of my students is cheating.	3.15	1.31	3.69	1.14	0.20
Student evaluations are a useful tool for helping instructors become more effective teachers.	4.48	0.68	4.69	0.48	0.28
I am aware of techniques to evaluate my own teaching effectiveness.	**3.19**	**1.17**	**4.44**	**0.63**	**2.2e-4**
I am aware of the resources available to me to help me overcome any issues I might have as a GSI.	**3.10**	**1.25**	**3.94**	**0.93**	**0.03**
I feel prepared to be an effective GSI.	**3.77**	**0.87**	**4.50**	**0.63**	**5.1e-3**

Conclusions and Recommendations

A graduate pedagogy course is a valuable opportunity to communicate ways of thinking about teaching and learning, to model effective teaching, and to share values associated with teaching and learning. Given the documented effectiveness of active learning, and the critical need to engage talented people from diverse backgrounds in the engineering workforce, we focused on active learning and inclusive teaching in this course improvement project. Where resources are available, we highly recommend a course or mentoring experience such as this to intentionally educate graduate students in pedagogy.

Our survey results suggest that this offering of the Chemical Engineering 375 pedagogy course was largely successful in increasing students' teaching skills and self-efficacy. However, several aspects of future work will enable further improvement of the class and more complete assessment of the effectiveness of the course. In addition to the analysis presented herein to quantitatively evaluate the effectiveness of the course, future work will also incorporate more qualitative analysis based on student assignments and evaluations. Furthermore, we plan to assess how well the students perform as GSIs in the classroom after taking this course through analysis of course evaluations in the coming semesters. This will be compared to representative evaluation scores and comments from those who took the original version of the course. Furthermore, to extend the reach of these efforts beyond the students enrolled in the course, efforts are currently underway to develop a public, online version of the course. Through this additional work and further iterations of the course, we can more effectively train graduate student instructors to help educate the next generation of engineers.

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