Perspectives on a Mentored Engineering Graduate Student Teaching Practicum for Faculty Teaching Preparation

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Abstract

The Graduate Certificate in Engineering Education is designed to prepare graduate students considering academic career paths for teaching undergraduate engineering courses. It consists of two courses in active learning and curriculum design, an education elective course, a teaching practicum, and teaching portfolio preparation. The semester –long teaching practicum is an opportunity for graduate students ("student-teachers") to gain experience designing instructional activities and implementing them in the classroom under the mentorship of a supervising faculty member and with support from the practicum course instructor and other student-teacher peers. Student-teachers are encouraged to try new teaching methods and active learning activities to increase confidence and decide what tools they may use in their future teaching. The supervising faculty member agrees to include the student-teacher in course planning before the semester begins, to provide guidance in preparing and teaching a major portion of at least five classes, and to support participation in grading and responding to student work. The student-teacher participates in all aspects of course planning, lesson planning, and student assessments with opportunities for reflective self-assessment and structured feedback from faculty and student-teacher peers from lesson observations. This presentation will provide perspectives on the teaching practicum experience of a student-teacher, supervising faculty mentor, and students in a sophomore-level computational fundamentals of biomedical engineering design laboratory course. The student-teacher and supervising faculty member provided feedback on the benefits and challenges of the practicum course. The students in the course provided feedback on their satisfaction with the student-teacher's lesson designs through a classroom feedback application.

Introduction

Pedagogical instruction is still lacking in many graduate engineering programs[1,2]. While graduate students undertake teaching assistant assignments, the experience is highly variable and not usually structured to provide graduate students with insight of evidence-based teaching theory and practice. High quality teaching assistant experiences require large time and effort demands of faculty and graduate students, who may lack support from peers and administrators for channeling time away from research activities[3,4]. Universities are continuing to incorporate teaching certificate programs as they recognize the benefits to their graduate students' preparation for future academic positions as well as to undergraduate engineering education[5,6]. Many programs are designed to occur concurrently with TA assignments[7–9], while others provide more extensive instruction and teaching experiences[10,11]. Overall, graduate students and faculty mentors report positive experiences through these programs. The purpose of this article is to provide multiple perspectives of a teaching practicum course that serves as the capstone to the Graduate Certificate in Engineering Education at The University of Texas at Austin. Perspectives from the supervising practicum professor, graduate student-teacher, faculty mentor, and undergraduate students provide a narrative for how graduate teaching certificate programs can impact all levels of engineering education.

Methods

UT Austin Graduate Certificate in Engineering Education

The UT Austin Graduate Certificate in Engineering Education consists of 16 credit hours of coursework and practical experience to prepare graduate students interested in pursuing academic positions for faculty teaching responsibilities. The coursework consists of two engineering education courses, one education elective, a teaching practicum, and a teaching portfolio seminar. The two engineering education courses are Teaching Engineering and Curriculum Design & Assessment. Teaching Engineering reviews evidence-based teaching theory that applies to teaching practice, such as scaffolding, feedback, and Bloom's taxonomy, as well as challenges students to lead class discussions and activities. The final product of Curriculum Design & Assessment is a suite of learning objectives, assessment tools, and class activities for a one- to two- week course topic using backward design methods. After students have completed coursework, they can complete the teaching practicum.

The practicum course provides graduate students an opportunity to implement the teaching methods they learned previously in the graduate certificate in engineering education program. Throughout the semester, the graduate students enrolled in the practicum course, which in this particular semester included three students, and the practicum class instructor, met weekly to discuss aspects of the students' teaching. This group served as a learning community, with all members aiming to become better teachers and supporting each other in the process. Some meetings included discussions of general teaching topics of interest to the graduate students, such as questioning and grading techniques, while other meetings focused on the students' preparations for and reflections on the specific classes they were teaching. Before each student got in front of the class, they prepared learning objectives for the topics they were to cover, and discussed those learning objectives and associated classroom activities with the group. The group provided feedback, including suggestions for promoting student engagement in classroom activities, editing content to ensure timely delivery of information most pertinent to the learning objectives, and encouraging student-teachers to step out of their comfort zones to grow. These discussions resulted in many ideas for in-class activities.

In addition to providing a supportive community of peer teachers, this practicum course also focused on the value of teaching assessments with the goal of developing valuable skills in self-assessment. Each student-teacher was assessed by the practicum instructor, their graduate student peers, the mentoring faculty member in their subject area, and themselves. Assessments were done using an instrument asking the assessors for specific observations related to the value of the classroom activities and content, presentation (e.g. articulation, visual aids, etc.), pacing, and student interaction. The observers were asked to provide examples of strengths and areas for improvement for the student-teacher. These assessments were given to the student-teacher to arm them with specific examples of what worked well and what required additional refinement as they prepared for their future classes. Additionally, the student-teacher completed journals before and after each class they taught. The journal entries prior to the class included documentation of the learning objectives, planned classroom activities, and anticipated challenges for their upcoming class. After each class, the student-teacher reflected on what worked well, what didn't, and lessons learned that will influence future teaching. The reflection journals allow student-teachers opportunities to practice the valuable skill of self-assessment. Practicing the art of self-assessment as a graduate student will better prepare students as they become faculty members, to regularly reflect on their own strengths and areas for improvement as a means of becoming a better teacher.

Teaching Practicum in BME 214L

BME 214L, Computational Fundamentals of Biomedical Engineering Design, is hands-on, project-centered course that is second in a series of 4 "design" courses that all UT Austin BME undergraduates are required to take during their freshmen through junior year. It consists of two 50-minute lectures per week and one 3-hour lab section per week. Typical fall semester enrollment is 100 students with approximately 20 students in each of 5 lab sections. Lectures prepare students for lab by connecting theoretical concepts to lab activities. The final three and a half weeks of lecture are centered around a programming project to introduce students to the area of biomedical informatics, which is not covered in lab. There are two major themes in lab: (1) computer-aided engineering and (2) circuit design leading to an instrumentation device. The major projects in the lab portion of 214L corresponding to the topics are (1) use of SOLIDWORKS to simulate blood flow through a bifurcated artery with obstructions and (2) design and construction of an electrocardiogram (ECG) device.

The student-teacher took responsibility for one instrumentation/circuits lecture, two biomedical informatics lectures, and a design thinking laboratory section lesson related to the students' ECG projects. The learning objectives for the lectures were outlined by the faculty mentor, and the student-teacher was able to refine the lectures and develop course activities.

The learning objectives for the instrumentation lecture were for students to be able to describe the purpose of operational amplifiers in active filters, describe the expected output of different filters, and design an operational amplifier filter for signal conditioning. The student-teacher adapted slides and created an original in-class worksheet for the students to take notes on and individually complete practice problems throughout the lesson. The worksheet could be used as a reference for completing the instrumentation and circuits laboratory project. In-class interaction with the worksheet was varied across students, with some attempting the problems during the work time and others waiting for the group review. Verbal feedback from students suggested some did reference the worksheet when completing the laboratory activity. At the end of the lesson, the student-teacher presented a demonstration of an online tool to create and test breadboard circuits. Figure 1 shows the completed in-class worksheet and breadboard circuit model.

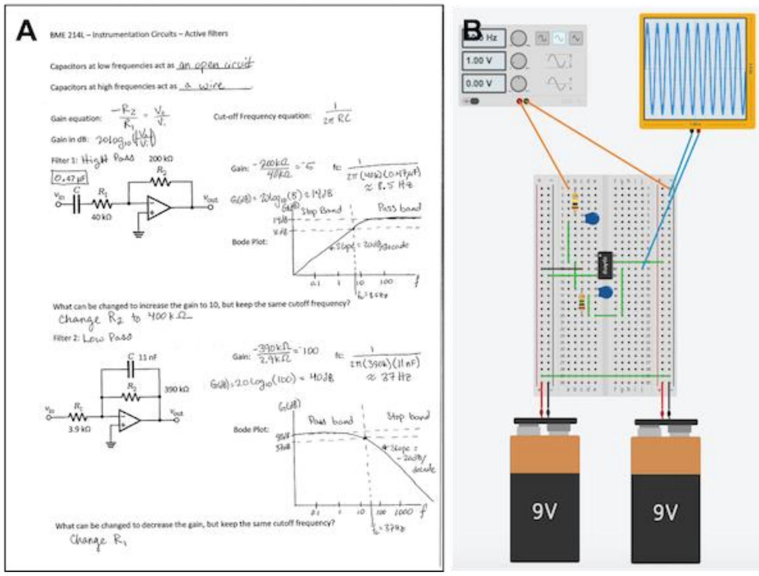

Figure 1: Instrumentation Active Learning Activities. A) The worksheet was developed by the student-teacher with fields for students to take notes of important concepts and equations throughout the class as well as practice problems that were first completed individually, then reviewed as a class. B) The student-teacher also demonstrated constructing a bandpass filter on a circuit board using the online TinkerCad (Autodesk, San Rafael, CA, tinkercad.com) platform.

The overall goal of the biomedical informatics unit is to introduce students to the field of biomedical informatics and provide an opportunity for students to develop programming skills while completing an informatics project. The first lecture consisted of an information delivery presentation of an introduction to biomedical informatics and classifier evaluation methods, as well as a preview of the second lecture's in-class activity. The second lecture began with a Kahoot quiz to review the information from the first lecture, leading to a group activity to practice the key calculations and plotting required for the individual informatics project (collecting and analyzing observer data for a signal-noise classification problem). Poster boards with blank charts were posted around the classroom. Within groups of 10, each individual student was responsible for the specificity and sensitivity calculations to create one data point, which could be plotted on the groups' chart to construct a Receiver-Operating Characteristic curve. Figure 2 provides examples of the students' work at the end of the activity. The student-teacher floated between groups to answer questions and provide guidance. The students participated well in this activity and engaged the student-teacher in more questions than during the lectures. The student-teacher and mentoring faculty identified improvements to the instructions and timing that could be implemented for a future activity, which would help students in conducting the calculations and have more time to compare the groups' results. In addition, the student-teacher created a graphic organizer of key concepts that could be used as a future in-class or out-of-class activity (Figure 3).

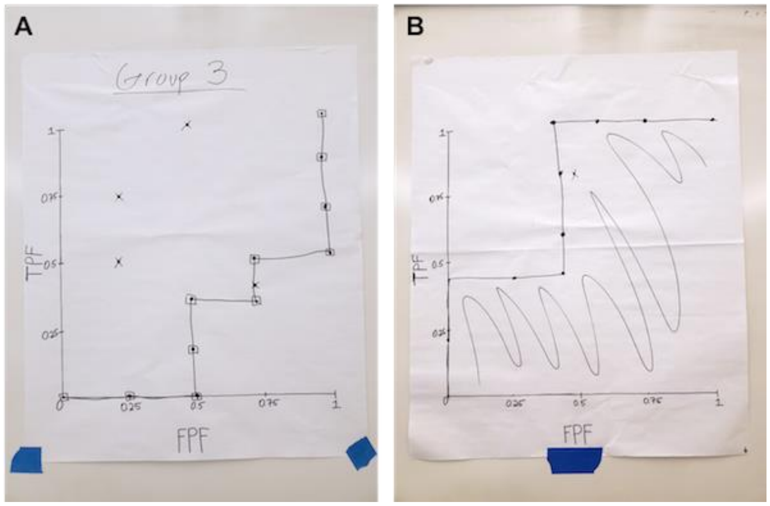

Figure 2: Two examples of student work after completing the Biomedical Informatics group activity. Within groups of 10, the students individually calculated and plotted the sensitivity and specificity corresponding to a decision variable value within a set of classification data to construct a Receiver-Operating Characteristic (ROC) curve. The student-teacher rotated amongst groups to answer questions and observe the students' level of understanding. The groups had unique data sets and were able to visually compare the classification performances by the Area Under the Curve (AUC).

Biomedical Informatics Evaluation Measures

Measure	Definition	Confusion Matrix Calculation	Conditional Probability Definition	Depends on Prevalence?
Accuracy	AKA Percent correct. Number of diseased and non-diseased samples we classified correctly divided by total number of samples.	Truth: D, $\bar{D}$; Prediction +: 965, 973; Prediction -: 17, 303	$\Pr(+\|D) \times \Pr(D) + \Pr(-\|\bar{D}) \times \Pr(\bar{D})$	Yes
Prevalence	How often the disease occurs in the population. Total number of diseased samples divided by total number of samples.	Truth: D, $\bar{D}$; Prediction +: 965, 973; Prediction -: 17, 303	$\Pr(D)$	N/A
Sensitivity	AKA True Positive Fraction (TPF). Number of diseased samples classified as disease divided by the total number of diseased samples.	Truth: D, $\bar{D}$; Prediction +: 965, 973; Prediction -: 17, 303	$\Pr(+\|D) = \frac{Pr(D \cap +)}{Pr(D)}$	No

Figure 3: The first page of a completed graphic organizer designed by the student-teacher for students to organize the different definitions of the Biomedical Informatics terminology.

The laboratory lesson was designed as a whiteboard presentation about two tools used in empathetic design thinking: a journey map and a feedback capture matrix. A journey map is an interviewing technique that aims to provide insight into a current process and opportunities for improvement by having the user verbalize or reenact their current routine. The student-teacher led the students through the process of a journey map to generate ideas about what functions would be useful for a doctor using their ECG devices. Afterwards, there was a discussion about how to implement some of their ideas in their design. The student-teacher demonstrated how to use a feedback capture matrix to organize feedback and new ideas when evaluating a project and encouraged the students to try this method when giving feedback about their laboratory project presentations. The journey map concept could have been better reinforced by recruiting a medical professional, even a student EMT, that the students could interview. In addition, including the feedback matrix as part of a course assignment would elicit better participation.

Survey of undergraduate students

In order to measure the undergraduate students' satisfaction with the student-teacher's lecture activities, an anonymous Kahoot survey was given during a lecture in which the student-teacher was not present. Kahoot is used throughout the semester in BME 214L as a student response system so students had been familiar with the process. For the student-teacher feedback survey, Kahoot was used with automatically generated nicknames to help maintain anonymity. The first question of the Kahoot survey was used to confirm positive consent to use survey data for this paper. Students were then asked questions about their view of graduate student-teacher training in general and their specific rating of the student-teacher and the activities used to engage students in active learning.

Results and Discussion

Experiences from the student-teaching practicum course are discussed from perspectives of key stakeholders, including those of the supervising instructor of the practicum course, the graduate student-teacher, the mentoring faculty member (e.g. the instructor of record for the BME 214L course), and the undergraduate students enrolled in the BME 214L course. These perspectives aim to present the benefits and challenges of a graduate student-teaching practicum course.

Practicum class supervising professor perspective

As a faculty member myself, I did not receive any training on how to be an effective teacher as a graduate student. As a new assistant professor, I had to figure out my own teaching style only based on experiences I had a student. I viewed end-of-course student evaluations and annual teaching evaluations from senior faculty as the only means to get feedback on your teaching, and the threat of low evaluation scores was enough to scare me from trying any "novel" techniques that might enhance student learning. Only after attending several teaching workshops and finding a community of faculty interested in innovative teaching methods did I gain the confidence and skills to effectively evaluate my own teaching and to try new teaching methods in my courses. My goal in this practicum course is to streamline the process for students to gain these skills and experiences prior to becoming faculty members. In this practicum course, I was impressed with how willing student-teachers were to try new things in class and step outside their comfort zones. The discussions amongst the student-teachers about ideas for active learning techniques and the feedback they were providing about each other's teaching far exceeded what I expected from graduate students, and was on par with what I might expect from seasoned faculty members who have dedicated years to the art of teaching.

Student-teacher perspective

My goal for completing the teaching practicum with BME 214L was to gain more experience combining active learning lessons that students find helpful and engaging with necessary information delivery lectures. While I completed three TA assignments, my classroom teaching was limited to discussion sections, and the course was not a technical course. I wanted an opportunity to challenge myself to develop lesson plans for a technical course. After completing the practicum, there are three areas in which I believe graduate students will benefit most: developing course materials, in-classroom experience, and receiving feedback. For developing course materials, I found meeting with my faculty mentor before the semester began to discuss the syllabus and course evolution was helpful for seeing how past experience can be used to continuously improve a course. Meetings with our supervising professor and graduate student peers were opportunities to brainstorm and refine my ideas for in-class activities. Also as a result of our meetings and reflective writing, I was able to ensure that each activity could be mapped to the learning objectives. For example, the in-class worksheet for my instrumentation lecture was a tool for students to practice doing calculations individually and to stay more engaged with the lecture. My previous courses in the certificate program were extremely helpful in developing my own instructional activities, especially in areas of scaffolding, in-class active learning and assessment tools, and inclusive teaching.

Another benefit of the practicum is to be able to teach in front of all of the enrolled students versus being in discussion or laboratory sections with only a subset of students at a time. I learned that knowing the students' names is even more valuable in the larger setting in order to conduct meaningful questioning and eliciting student engagement. Meaningful questioning is an area I can still improve in as well as being comfortable in front of a large number of people, but through the certificate program, I know the resources available to support my future teaching work. I also endeavored to attend as many lectures as possible to observe my faculty mentor as he used different strategies and engaged students. Attending lectures is often not required for teaching assistants, so one may not take advantage of the opportunity to gain insight from how others teach. When teaching the biomedical informatics unit, I feel I could have been more successful with the group activity, had I known that I could have spent more time after the activity to review properly versus having to move on to another topic that we planned to cover that day. More communication beforehand with my mentoring faculty about "what if" scenarios could have allowed me to feel like I could change the plan during the lecture time.

Receiving structured feedback from multiple perspectives is a unique aspect of the teaching practicum and is essential for having a positive experience through the semester. Teaching assistants may not receive any feedback on their teaching besides end of semester evaluations from students. The structured feedback and discussions after each teaching experience allowed me to use the feedback for the next teaching experience to improve over the whole semester. In addition, it can be uncomfortable to have others evaluate you, and through the practicum, I am more comfortable seeking out feedback to know how I can continue to develop my teaching style. A possible improvement to the practicum course is to include a requirement for prompting mid-semester or periodic feedback from the undergraduate students. The students exceeded my expectations in their willingness to engage with the activities, but I would have appreciated more detailed opinions than the Kahoot survey we conducted at the end of the semester. Overall, I would encourage other graduate students to seek out opportunities such as the teaching practicum if they are interested in pursuing a faculty position. I gained more confidence in my teaching, awareness of my strengths and weaknesses, and support from other faculty and peers who are interested in engineering education practice.

Mentoring faculty member perspective

This is the second opportunity that I have mentored a graduate student-teacher in BME 214L through the UT Austin graduate certificate in engineering education program. The first time was my second semester teaching the course and I had major revisions to make after inheriting the course from a previous instructor and therefore was open to radical changes suggested by the student-teacher. In contrast, this past semester was my seventh iteration teaching BME 214L and I had become comfortable in the course and material and had a history of positive feedback from students. While I was happy to accommodate a student-teacher learning experience in my class, BME 214L had become a 'mature' class and therefore some of the course was off-limits to making changes. However, there were a couple of areas which I was open to allowing the student-teacher to redesign the lecture. Overall, I was very impressed by the thoughtfulness and creativity of the resultant lectures and active learning opportunities that the student-teacher designed. I plan to use all of the lecture materials and learning activities as I continue to teach 214L in the future. The quality of work was on par with what I would demand from myself and this experience resulted in a better class moving forward. The mentorship opportunity also allowed me to personally demonstrate and highlight one of the most important learning objectives that I set for students in BME 214L: working with other people. After administering the Kahoot survey about the effectiveness of the student-teacher, I told students that although I am a professor and the student-teacher is a graduate student just learning to teach, I learned from what she did and I am going to use her work in my classes so that they improve in the future. The teaching practicum gave me the unique ability to model positive teamwork and demonstrate why I make them work in teams.

Undergraduate student perspective

Fifty-one students out of the eighty-five enrolled in the course participated in the survey and gave positive consent to use their responses for this paper. Students indicated an overall favorable attitude toward allowing graduate students to learn how to teach through a practicum experience (Figure 4). Students were then polled on the two specific topics taught in lecture and their corresponding active learning activities. Figures 5A and 6A show that students thought that the student-teacher was above average in teaching both the circuits class and the two biomedical informatics classes. By assigning a score of 4 to great, 3 to good, 2 to average, and 1 for poor, the resultant average score is 2.68 for the circuits lecture and 2.66 for the biomedical informatics lectures. Therefore, the generalized consensus was essentially the same for both set of lectures. The students also responded positively to the active learning exercises in both classes (Figures 5B and 6B). However, they responded more favorably to the handout given during the circuits lecture

(Figure 5B) than the group activity used for biomedical informatics (Figure 6B). Because the activities are very different (individual versus group activity for example), making a strong comparison between these two activities isn't necessarily valid, but the student responses help the instructor understand where improved guidance is needed in the future when incorporating these activities.

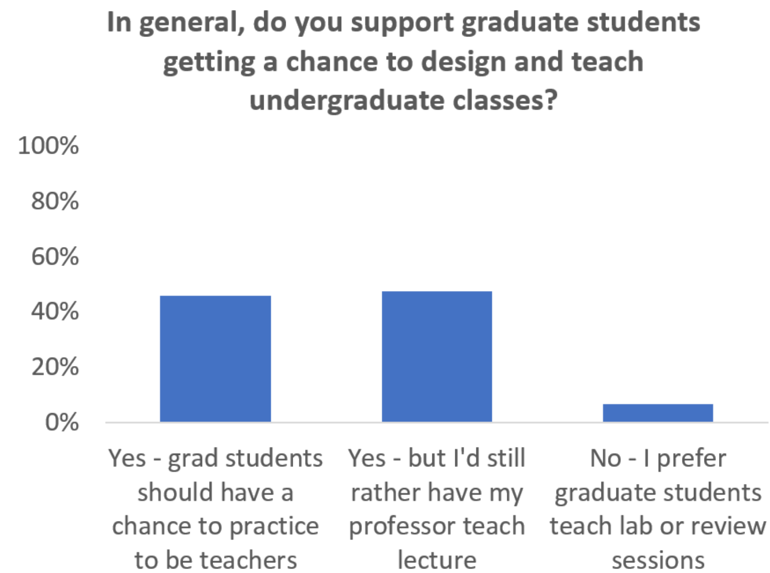

Figure 4: Kahoot survey demonstrates general positive student attitude graduate student teaching in an undergraduate class

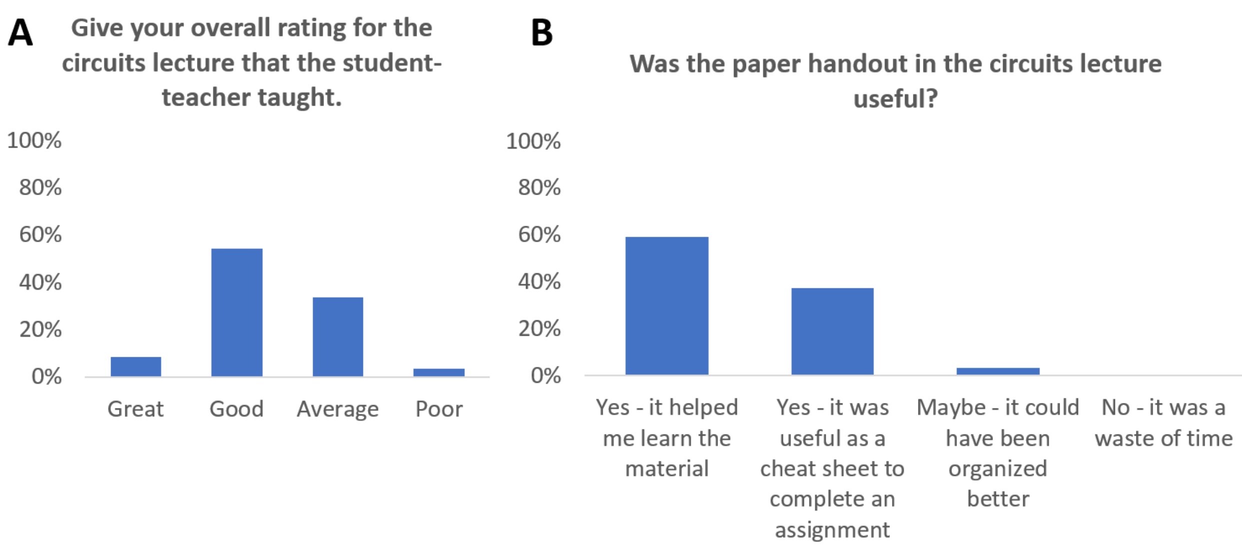

Figure 5: Undergraduate students rated student-teacher (A) above average and (B) appreciated the active-learning handout for the BME 214L circuits lecture.

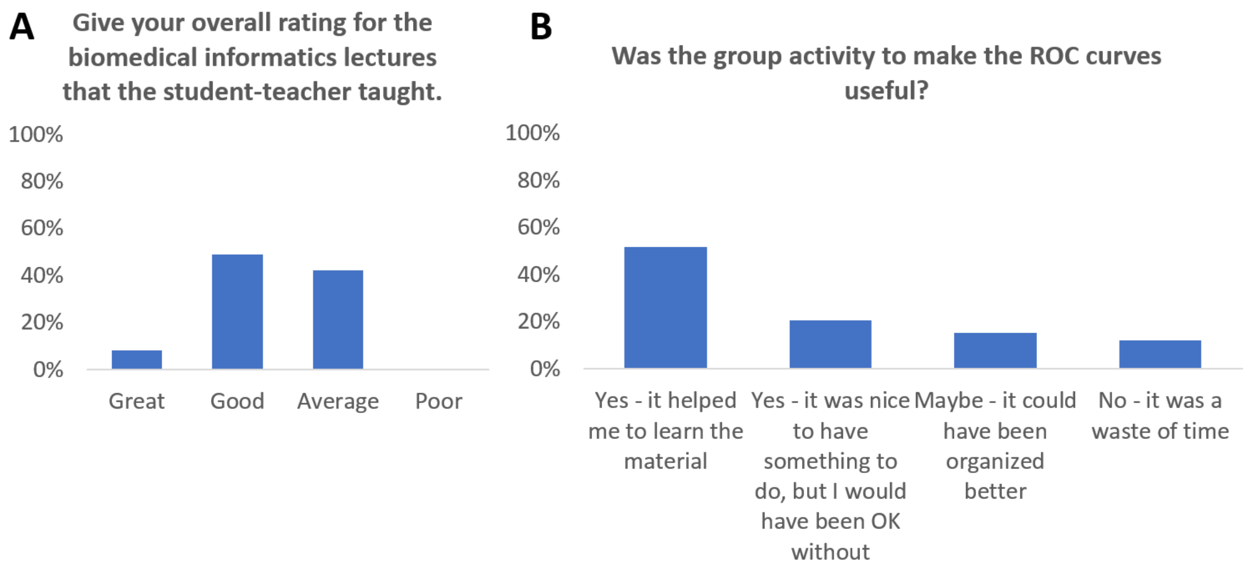

Figure 6: Undergraduate students rated student-teacher (A) above average and also shared (B) mostly positive feelings toward the active-learning group activity for the BME 214L bioinformatics lecture.

Conclusions

Overall the teaching practicum was a positive experience for the supervising faculty for the practicum class, the student-teacher, and the mentor faculty member. Mentored teaching experiences such as a teaching practicum benefit the mentor faculty members and the graduate student-teachers involved. Graduate student-teachers gain confidence and practical experience that is not available through traditional TA assignments. The opportunity to receive low-stakes feedback from multiple sources and participate self-reflection allows for improvement as an instructor and a basis for application and interview for a future faculty position. Mentoring faculty can use the practicum opportunity to enhance their own teaching as the student-teachers generate new ideas for learning activities. Even in a relatively mature course, the student-teacher can identify opportunities and offer creative options to improve learning experiences for students. Finally, undergraduate students benefit from the positive model of teamwork and experiential learning. Undergraduate students were open to the student-teacher trying something new in class and the perspectives from undergraduate students can provide insight into the cycle of improving engineering education. Our suggestions for future iterations of the teaching practicum course include proactively planning for eliciting undergraduate student feedback more often. In addition, the active learning materials developed by the student-teachers may benefit by having students complete out-of-class work or assigning completion grades to the work. When possible, identifying these opportunities early allows them to be incorporated into the syllabus, so students have pre-knowledge of their required work. The broader impacts of this work include inspiring other undergraduate educators and graduate students to engage with mentored teaching opportunities by demonstrating the benefits to faculty, graduate students, and undergraduate students.

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References

1. Bok, D. We Must Prepare Ph.D. Students for the Complicated Art of Teaching - The Chronicle of Higher Education. *The Chronicle of Higher Education* https://www.chronicle.com/article/We-Must-Prepare-PhD-Students/142893 (2011).
2. Visco, D. & Schaefer, D. Training Engineering Faculty to be Educators: History, Motivations and a Comparison of US and International Systems. in *122nd ASEE Annual Conference and Exposition* (American Society for Engineering Education, 2015).
3. Ciston, S., Cerretani, C. & Went, M. S. Teaching with graduate teaching assistants: Tips for promoting high performance instructional teams. in *ASEE Annual Conference and Exposition, Conference Proceedings* vols 2016-June (2016).
4. Behrouzi, A. Developing a robust teaching portfolio as a doctoral student in a research-intensive engineering program. in *ASEE Annual Conference and Exposition, Conference Proceedings* vols 2017-June (2017).
5. Connolly, M. R., Lee, Y.-G. ; & & Savoy, J. N. *The Effects of Doctoral Teaching Development on Early Career STEM Scholars' College-teaching Self-efficacy*. http://www.wcer.wisc.edu/publications/workingPapers/papers.php (2015).
6. Flaherty, C. Online conversation shines a spotlight on graduate programs that teach students how to teach. *Inside Higher Ed* https://www.insidehighered.com/news/2019/12/13/online-conversation-shines-spotlight-graduate-programs-teach-students-how-teach (2019).
7. Kusano, S. M. *et al.* Preparing future engineering educators through round-table practicum course discussions. in *ASEE Annual Conference and Exposition, Conference Proceedings* (2014).
8. Pinder-Grover, T. A. Active learning in engineering: Perspectives from graduate student instructors. in *ASEE Annual Conference and Exposition, Conference Proceedings* (2013).
9. Nicklow, J. W., Marikunte, S. S. & Chevalier, L. R. Balancing Pedagogical and Professional Practice Skills in the Training of Graduate Teaching Assistants. *Journal of Professional Issues in Engineering Education and Practice* **133**, 89–93 (2007).
10. Crede, E. & Borrego, M. Preparing graduate engineering students for academia: Assessment of a teaching fellowship. in *ASEE Annual Conference and Exposition, Conference Proceedings* (2009).
11. Linsenmeier, R. A. & Woods, L. Educating biomedical engineering graduate students about teaching (work in progress). in *ASEE Annual Conference and Exposition, Conference Proceedings* vols 2017-June (2017).

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