Training for Peer Teaching Assistants in Engineering Classrooms: A Review

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Abstract

This Complete Theory Paper focuses on the topic of Classroom Strategies. Specifically, it discusses a preliminary review of the current literature in engineering education to explore training programs for undergraduate, peer teaching assistants (peer-TAs or PTAs) working in engineering courses. The employment of PTAs has become more common in large enrollment engineering courses to increase student-to-instructor interactions. PTAs might be able to rely on their own experiences in the classroom, but learning experiences are not enough to translate to effective teaching. Therefore, it is essential to provide PTAs with training to guide and maximize their positive impact on students and their learning. This review addresses the research question *How are PTAs trained to work in engineering classrooms?* More discretely, (1) How are PTA training programs structured? (2) What skills or lessons are taught and prioritized? and (3) How is effective training and effective "PTA'ing" measured?

Introduction

The employment of undergraduate peer teaching assistants (PTAs) has become more common in large enrollment engineering courses to increase student-to-instructor interactions. Further, PTAs introduce near-peer teaching into these courses, which can be more relatable for students [1]. Although first catching on in math, physics, and chemistry, namely through the Learning Assistant (LA) model developed at the University of Colorado Boulder in 2001 [2], [3], PTAs have been slowly integrated into engineering classrooms. Environments common for PTAs include lab settings [4], [5], [6], first-year design courses [7], [8], [9], [10], [11], [12], [13], [14], and other active learning classrooms [1], [3]. More recently, PTAs have been integrated into large enrollment computer science courses as well [15], [16], [17]. Although employed in many environments, many PTAs are often hired with no prior teaching experience or training. Given their active role in teaching engineering students, sometimes in courses with particularly high DFW rates [1], it is essential to develop teaching training for PTAs.

This Complete Theory Paper focuses on the topic of Classroom Strategies. Specifically, it discusses a review of the current literature in engineering education to explore teaching training programs for PTAs working in engineering courses. The goal of this review is to establish a footing of where research focused on training PTAs currently lays.

Motivations for the Review and Institutional Context

A review of PTA training methods was undertaken to contribute broadly to the field and to inform the practices at the authors' institution.

Broad Motivations for the Review

Broadly speaking, there are reviews in the teaching assistant space outside of training PTAs working in engineering classrooms. Reviews on TAs in math education [18], medical education

[19], [20], [21], sociology education [22], and computer science education [23] have been conducted as scholarly work. Further, reviews focusing on a specific classroom environment have been conducted, including online learning environments [24] and primary school classrooms [25]. Reviews have also been conducted on certain outcomes expected of TAs, such as building and fostering inclusive classrooms [26] and managing behavior [27]. Acknowledging similar work that has been done, Sadera et.al. [28] recently published a scoping review on training and professional development of graduate teaching assistants (GTAs), TAs, and tutors. Further, Chen et.al. [29] recently published a systematic review on educator training in engineering higher education. We seek to build upon their work and all the work previously mentioned and look more granularly at the PTA training landscape in engineering education specifically.

Local Motivations for the Review and Institutional Context

There are multiple institutional contexts that would lead an organization to utilize PTAs. At our engineering college at a large, Midwest public university, the primary motivator for employing PTAs is to increase student-to-instructor interactions in a first-year engineering design course sequence. Another motivator at the authors' institution is cost. While the parameters of PTAs' employment will vary by institution, at our engineering college, PTAs are a cost-effective way to increase student-to-instructor and near-peer interactions. PTAs are employed as part-time hourly employees, opposed to stipend-based GTAs. This keeps interactions high while lowering institutional costs. As student enrollments in engineering courses increase, PTAs allow us to support larger enrollments without a decline in student in-class engagement. Indeed, efforts to better compensate PTAs are necessary and constant. Further, efforts to increase the number of knowledgeable and passionate instructors in engineering are also critical. For now, the reality is that PTAs support impactful learning moments and a positive classroom environment.

Our program employs approximately 70-90 undergraduate peer-TAs per semester to achieve a 1-24 PTA-to-student ratio in the classroom. The program's current training includes a semester kickoff and weekly in-person meetings supplemented by online, asynchronous modules. The semester kickoff is centered around course philosophy (e.g., an introduction to learning theory, teaming, and professionalism), grading philosophy, and other administrative tasks (e.g., onboarding, timekeeping). Weekly in-person meetings facilitate peer-to-peer check-ins across sections and continue the pedagogical training started at the semester kickoff. Lessons covered in weekly meetings include collaborative learning facilitation, academic coaching, process-oriented teaching, and team conflict resolution. The online, asynchronous training modules often are recordings of meetings for PTAs that cannot attend in-person. Other modules also include topics such as FERPA and information security basics, bystander intervention, and public speaking. When there are special programs for the PTAs to facilitate, such as project demonstrations or exam grading, their training comes in a one-hour intensive orientation on cases of student experiences that they will expect to encounter. Overall, a PTA can be expected to spend approximately 30 hours per semester on formal training programs.

A unique institutional constraint of the current program is the mandatory co-op program in every engineering program's curriculum. This program extends an undergraduate's engineering time-to-degree to five years. The first-year course sequence runs from the fall to the spring semester,

with a smaller cohort enrolled in the summer semester. The typical cases for the timing of a PTA's employment are outlined in Table 1. The co-op program creates breaks in a PTA's teaching career that wouldn't otherwise be created in an engineering program, such as the calendar-year break from spring 2nd-year to spring 3rd-year in Case 1 and from spring 3rd-year to spring 4th-year in Case 2, as seen in Table 1. In typical cases, only once is a PTA employed in subsequent semesters: their 5th and final year. There are exceptions to these typical cases, but for the general PTA, they will have months-long breaks between every PTA experience before their 5th year. This impacts how much a PTA remembers from their original training as well as any scaffolding intended for PTAs returning to the position. Currently, this constraint is handled by encouraging PTAs to be employed with the program for multiple academic years, thus giving ample time and experience for reflection and improvement over the course of two to four years. Further, little to no advanced training is provided for a student that has been a PTA already. Finally, all PTAs are required to complete the training every semester, regardless of experience, to ensure that PTAs with long breaks between employment can remain current on pedagogical knowledge and best practices.

Table 1. Typical Cases for Timing of PTA Employment in a Co-op Required Engineering Degree

Student Case	Fall 2nd Year	Spring 2nd Year	Summer 2nd year	Fall 3rd Year	Spring 3rd Year	Summer 3rd Year	Fall 4th Year	Spring 4th Year	Summer 4th Year	Fall 5th Year	Spring 5th Year
Case 1 fall start date	PTA	Co-op	None	Co-op	PTA	Co-op	PTA	Co-op	Co-op	PTA	PTA
Case 2 spring start date	Co-op	PTA	Co-op	PTA	Co-op	None	Co-op	PTA	Co-op	PTA	PTA

Motivated by the discipline-specific need for scholarly literature and the institutional context that requires a more evidence-based approach to design future PTA training, we conducted a review of available literature to answer the overall research question: *How are PTAs trained to work in engineering classrooms?* More specifically, we aim to explore (1) How are PTA training programs structured? (2) What skills or lessons are taught and prioritized? and (3) How is effective training and effective "PTA'ing" measured?

Methods

On the recommendation of a Science-Engineering Global Services Librarian, the following databases were searched: *Scopus*, *ERIC*, *Education Full Text*, and *Education Research Complete*. Further, the following journals were also searched: *Journal of Engineering Education*, *European Journal of Engineering Education*, and *IEEE Transactions on Education*. The search string used to find relevant scholarly work was

("teaching assistant" OR "learning assistant") AND "engineering" AND "training".

Covidence was used to aid de-duplication and the screening of articles, firstly at a title and abstract level and then a full-text level. Articles that included discussion of some training

program specifically for PTAs working in engineering or computer science classrooms were included. Articles were excluded if (1) they did not mention training; (2) they discussed training only for graduate teaching assistants (GTAs) (note: studies were included if the target audience of the training was both PTAs and GTAs); (3) the research took place outside of the United States; and (4) the research did not take place in a higher education engineering program environment (e.g., the research took place in a P-12 environment).

Reasoning for inclusion and exclusion criteria were based on the need to explore training programs for a specific population: undergraduate students working as teaching assistants in engineering courses. Marbouti et al. [14] and Moon et al. [30] find that different factors motivate undergraduate students to become and remain PTAs than those factors that motivate graduate students. Further, each population's motivations to excel in a teaching assistant position may differ as well. Our aim is to explore the specifics of PTA training to explore what resonates with undergraduate students, whether similar or different from their graduate counterparts. Moreover, the culture surrounding education may differ from country to country. Because we aim to relate our findings to actionable change at a large, Midwest public university, we excluded studies that are conducted outside the United States. For similar reasons, we also excluded studies conducted outside of the higher education engineering program environment. We acknowledge that there is knowledge to be gained from these excluded domains, and we aim to include these domains in a larger, more systematic review in the future.

Results and Discussion

A total of 479 articles were retrieved from the original search. A systematic review process was used to select studies that qualified for the review. These results were loaded into Covidence, and 94 were removed by Covidence's duplication detectors, leaving 385 titles and abstracts for screening. Using the inclusion and exclusion criteria outlined in the Methods section, 311 articles were excluded from the review based on title and abstract review, moving 74 articles onto full-text screening. Seven articles' full text could not be retrieved. Using the same criteria on the remaining 67 articles, 31 of the 479 articles found in the initial search were ultimately included in the review. A PRISMA flow diagram is shown below in Figure 1. The review first investigates the structure of PTA training programs as well as the content covered. Then, the review discusses the outcomes measured by training programs to evaluate a program's success. Papers included in the review have been marked with an asterisk in the references.

Themes in Topics Covered by PTA Training Programs

PTA responsibilities are highly contextualized around the course PTAs are working and other aspects of instructional culture. However, the major themes of the most contemporary PTA teaching training programs as seen in scholarly literature are generally consistent: (1) course content knowledge, (2) grading, and (3) classroom facilitation through simulation and role playing.

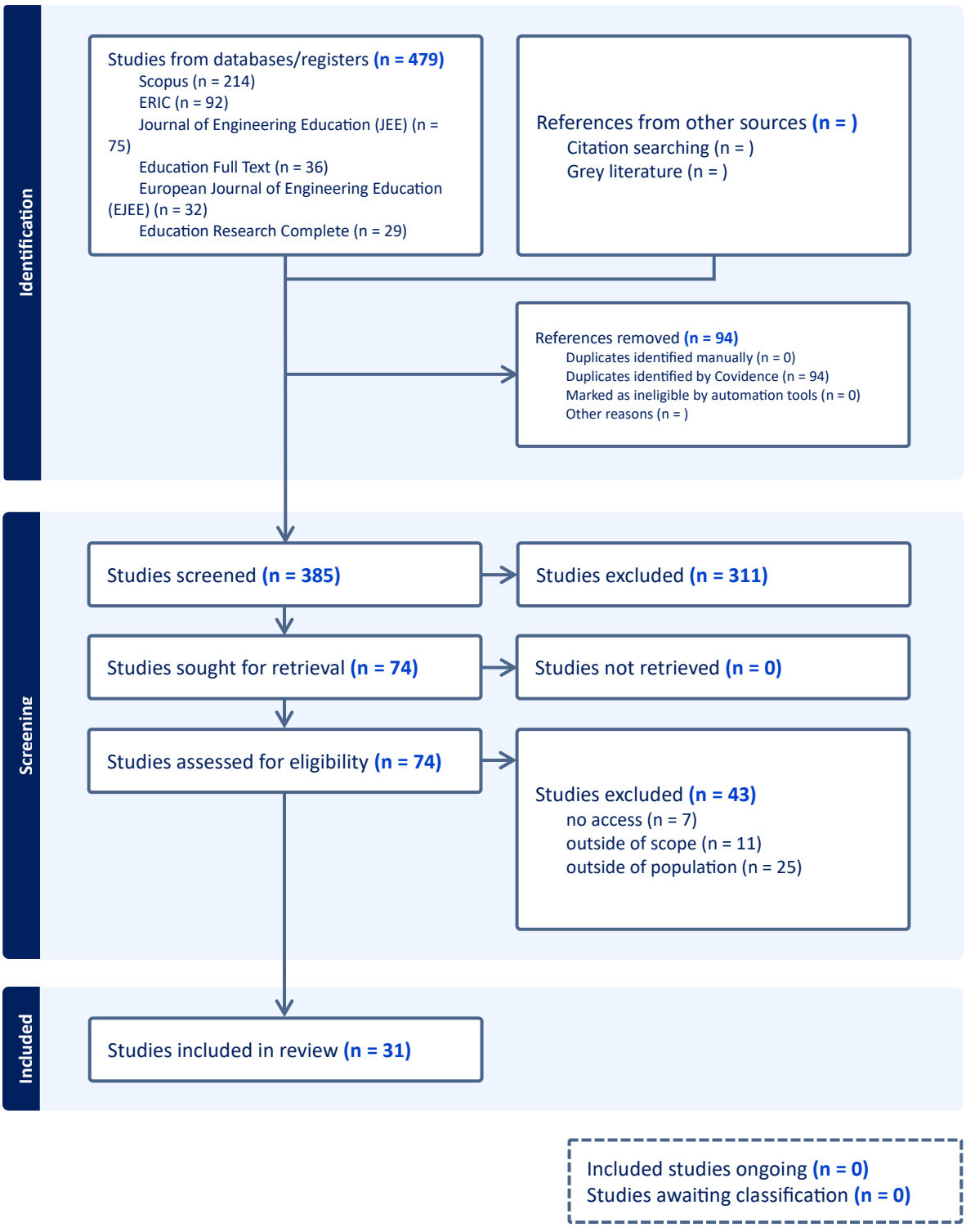

Figure 1. PRISMA Flow Diagram from Covidence

Theme 1: Course Content Knowledge

Enhancing or ensuring the PTAs' content knowledge has been important from the beginning [11]. Many training programs have weekly meetings or some regular touchpoint throughout the semester/quarter to focus on content knowledge for the week ahead [1], [3], [29], [31], [32], [33], [34], [35]. Other programs utilize a pre-semester kickoff to get through all of the content knowledge for the semester [29], [36]. When content knowledge training is not included in a PTA teaching training, it is requested by the PTAs as a means of improving the program overall [8], [9]. Most training programs are run by a faculty or a professional staff member, but a 2015 ASEE Student Chapter report called for more impact on TA training by ASEE student chapters [37]. Discussed by Rios & Lutz, this request could be because PTAs (or LAs, in this case) have a more absolute idea of knowledge: that it is something that is passed from someone who has it to someone who did not [1]. This PTA epistemology could lead to much of their confidence being reliant on if they can provide students with answers to their questions. As the authors recommend, more studies exploring PTA epistemology and their reliance on content knowledge are needed.

Theme 2: Grading

Training in effective grading and feedback-providing is essential to those PTAs with grading responsibilities. Although recognized as a key responsibility by PTAs [30], grading can be a subject of trepidation or fear for them [38]. This could be due to their near-peer position: PTAs want to grade effectively so that students learn, but PTAs also may feel bad awarding students lower scores. More work is necessary to affirm that claim. To quell worries and to ensure effective assessment of students, many programs include grading training as a part of their training program [7], [14], [15], [34], [36]. Much of grading-training happens just-in-time or at weekly meetings. Some training programs are developed around one specific form of grading, such as technical writing grading and feedback-providing. Examples of these training programs touch on pedagogical skills and ideas such as rhetorical commenting and the concept of writing-to-learn [4], [5], [7], [39], [40]. Grading trainings mentioned utilizing sample submissions to get a feel for rubrics, critiquing rubrics, and guidance on feedback. If not situated in any theory, effective grading could be very context-driven, so finding the best practices may be challenging. Finally, PTA programs utilizing the LA model will not have grading training, because the LA model specifies that LAs do not grade [1], [3], [33], [41].

Theme 3: Classroom Facilitation Through Simulation and Role Playing

Classroom facilitation through simulation and role playing typically were included in the same articles [3], [6], [15], [30], [31], [32], [34], [41], because the simulation can add a nuanced active learning exercise to classroom facilitation scenarios. By playing out scenarios before going to teach, the PTAs have an idea and an experience that will inform their teaching that day. Further, classroom facilitation skills are valuable professional skills to set PTAs apart. Outside of role play, lecture-style instruction is used, typically supplemented by roundtable conversation [10], [12], [13], [34], [38]. A number of programs have moved to online distribution of this portion of training [5], [6], [30], possibly pointing towards another need to scale. Skills and deliverables that have been requested to be added to their respective classroom facilitation and simulation

sessions include collaborative teaching, teaching portfolios, classroom professionality, inclusive language, and other pedagogical units [3], [5], [7], [10], [12], [13], [15], [31], [38].

Measured Outcomes of Training Programs

The outcomes measured after PTA teaching training were inconsistent across different training programs. Some earlier programs used student evaluations as a measurement of success [31], [32], [39], [40]. While student satisfaction is important, effective teaching is more important, and an effective teacher does not always equate to high student satisfaction [42]. In recent years, different metrics have been used such as PTA reflections on various prompts, PTA stories told in interviews, and PTA confidence or self-efficacy in their ability to do their job [17], [33], [43]. Teaching portfolios were also used as a form of self-reflection [35]. While these measurements may well measure confidence and enhance their learning through reflection, these instruments still do not completely measure teaching effectiveness: outside observation is limited. Melvin's paper on undergraduate coaches in a lab course mentioned observations, and they were used in training and continuous improvement [6]. D'Angelo and Rajarathinam analyze recordings of TA's interventions with students to provide performance feedback [44]. The LA model requires teaching observation [3]. If they had any centralized tool or rubric, a program could do top down (by a professional faculty or staff) and/or horizontal teaching observations (fellow PTAs).

Conclusion and Future Directions for Scholarship

Several models for teaching training of PTAs are presented, and all likely work within their own institutional context. The two main structures, pre-semester orientation and weekly meetings, seem to work best when used together (e.g., the LA model). However, the bandwidth to host this amount of training takes a dedication to infrastructure that may be hard to come by depending on the institution. Further, more innovation is necessary in the evaluation of training effectiveness and teaching effectiveness of PTAs. Self-reflection through surveys is good, but there is a likely opportunity for other qualitative and quantitative measurements, such as teaching evaluations by teaching experts or audio and video recording assessment. Finally, there is no cited research that investigates the retention of teaching skills of PTAs. Given the institutional context described in the Motivation section of this paper, a measure of teaching skills over time, semester-to-semester, may be of interest for program evaluation and improvement. Undergraduate PTAs will likely continue to be a path forward for creating more student-to-instructor interactions and near-peer learning opportunities. Therefore, work to assess effective training and effective teaching of these PTAs will be essential to the learning of our undergraduate engineering students.

In this preliminary review, we focused on the results generated by and full texts available through the databases listed in the Methods section. Future work will focus on expanding this search to a targeted review of work published at conferences such as Proceedings of the ASEE Annual Conference and Exposition. Further, effective pedagogical training of PTAs should also align with the learning outcomes of the course in which the PTAs are working. Engineering PTAs often work in first-year engineering design courses, and common learning outcomes in these courses include teamwork, conflict resolution, metacognition, and systems and critical thinking skills. [34], [45], [46], [47]. Future work also includes analyzing the content of the training programs and measuring their alignment with these learning outcomes.

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