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Evaluating the Teaching Perspectives of Engineering and Non-Engineering Graduate Students in a Shared Training Environment

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Abstract

This paper examines the responses of engineering and non-engineering students to the Teaching Perspectives Inventory (TPI) in a graduate-level interdisciplinary teacher training program. While preparing graduate students to be effective educators is a key aspect of their training, many programs lack discipline-specific pedagogical instruction and instead rely on broader resources, such as a university's Center for Teaching and Learning. These interdisciplinary environments raise critical questions: Do students' teaching perspectives vary across disciplines, and can a general training program support their development as educators? By exploring the teaching perspectives students bring to such programs, we can assess the degree to which disciplinary background shapes their approach to teaching and determine whether a generalized program can still align with their values and experiences.

Data were collected from 68 students in a graduate-level capstone teaching course provided through the Center for Teaching and Learning at a large, public, research-intensive institution in the southeastern United States. Of these students, 37 were in the College of Engineering, while 31 were from other disciplines. Students participated in a semester-long mentored teaching experience and completed the TPI around Week 3 of the semester. They were asked to write a reflection on their scores and develop teaching philosophy statements based on their beliefs about effective teaching.

The TPI measures five key teaching perspectives—Transmission, Apprenticeship, Developmental, Nurturing, and Social Reform—by assessing beliefs, intentions, and actions through a 45-item survey using Likert-style responses. The inventory provides insights into which teaching perspectives prevail and whether students exhibit tension between their abstract beliefs and the realities of teaching. The instrument has a robust history of validity evidence with multiple populations including graduate and undergraduate students. In this study, students' TPI scores were analyzed based on their enrolled program (engineering vs. non-engineering), teaching experience (Instructor of Record vs. guest lecturer), and gender presentation (as indicated by preferred pronouns).

Despite individual variability in TPI responses, no statistically significant differences were found between engineering and non-engineering students in terms of their dominant or recessive perspectives, as well as their perspective-specific beliefs, intentions, or actions. These results suggest that interdisciplinary, centralized teaching training programs, even when not discipline-specific, can be a valuable experience for graduate students. The study highlights the TPI's potential as a useful tool in teaching development and underscores the broader applicability of general pedagogical training across fields.

Introduction

Graduate training is an expectation of most faculty in the United States and abroad. However, the disciplinary training that earns most faculty their graduate degrees infrequently includes pedagogical preparation for serving as instructors in academia. Instead, the institutions primarily tasked with producing graduate-trained science, technology, engineering, and mathematics (STEM) professionals primarily focus heavily on scholarly output and research productivity. While such research endeavors are critical, the role of graduate students as educators cannot be ignored, particularly since many of those who complete their graduate training will secure faculty positions at institutions with different teaching and research expectations than the often research-centric institutions where they were trained [1, 2]. Instead, the graduate-students-turned-faculty will be expected to teach, but may not be prepared to do so well.

Most departments which offer some form of teaching exposure for graduate students do so by offering teaching assistantships. Graduate teaching assistants (GTAs) serve to support faculty members in many roles, primarily to amplify the faculty member's ability to teach larger courses and those with multiple sections [3-5]. While the roles may include grading assignments or holding recitation, duties may expand to include the graduate student being involved in assignment creation and holding class, and most institutions institute some form of training, which can expand from one-on-one consultation with the faculty member of their course, to pedagogy training courses, to full teacher preparation certificate programs [6] and pedagogy training [7], often run through Centers for Teaching and Learning (CTL) as centralized offices of expertise within universities. Such investments in graduate teaching have resulted in documented increases in student success, persistence, and engagement, particularly in STEM disciplines and for minoritized students [8-10], among many other benefits.

Although it is clear that training can be effective, the ability to offer training courses can be constrained by resource limitations. Faculty time may be constrained for such a course, and the resources required, both in expertise and scheduling, may prove difficult, especially in smaller departments. Recognizing this problem, universities have increasingly offered training across disciplines [11-13], where graduate students across programs come together for teaching training. Despite this, others have still strongly advocated for within-discipline teaching training [14], particularly as multi-discipline programs can struggle to provide sufficient discipline-specific preparation crucial for effective teaching [15, 16]. While one answer could be to combine formal programmatic training on pedagogy by experts outside of one's discipline with direct experiences and training within one's discipline, less is known on how one's perspectives on teaching, and therefore the teaching practices one is willing to adopt [17-19], are shaped by the discipline itself.

Given that teaching is shaped by disciplinary ideas and perspectives on teaching, there is a need to understand how students' disciplinary backgrounds influence their teaching perspectives. *Do students' teaching perspectives vary across disciplines, and can a general training program support their development as educators?* By exploring the teaching perspectives students bring to such programs, we can assess the degree to which disciplinary background shapes their approach to teaching and determine whether a generalized program can still align with their values and experiences.

Below we will describe the methodology used to characterize and analyze graduate students' teaching perspectives, alongside the evidence of regarding differences (or lack thereof) in those teaching perspectives between engineering and non-engineering students. We will then conclude with the implications for designing effective teaching training programs across disciplines, given these results.

Methods

<u>*Teaching Perspectives as a Framework*</u>

Teaching Perspectives Inventory (TPI; available at teachingperspectives.com) is a 45-question instrument used to assess instructors' **beliefs, intentions, and actions** in teaching that shape their teaching perspective [20]. Beliefs describe one's beliefs about the teaching and learning, intentions are an instructor is trying to accomplish in their teaching, and actions describe the actions taken (what is done) when teaching. Each item is rated on a 1 to 5 Likert scale (never to always), with nine items corresponding to each of the five teaching perspectives: Transmission, Apprenticeship, Developmental, Nurturing, and Social Reform. Depending on the respondents' scores, a perspective might be characterized as dominant (more than one standard deviation above the individual mean score) or recessive (more than one standard deviation below the individual mean score). The TPI has been validated across various populations, including higher education and adult educators, graduate students, and graduate teaching assistants [20-22].

<u>*Study Context*</u>

This study concerned a population of graduate students (N=68) enrolled in a capstone teaching course developed through the Center for Teaching and Learning at a large, southeastern public research university between Summer 2023 and Fall 2024 (five total terms, including summers). In this time frame, this course attracted an average of 12 students per term from the Colleges of Engineering (*n*=37), Computing (*n*=1), Design (*n*=4), Liberal arts (*n*=9) and Sciences (*n*=17) from across the institute who wish to develop their teaching skills. The total number of students from colleges outside of engineering was 31 (hereafter, collectively the "non-engineering" group). This course can audited or taken for a grade (letter grade or pass/fail), at the students' discretion, and is evaluated based on completion of required observations, submission of lesson plans, and required written reflection assignments.

This course serves as a structured opportunity to gain hands-on teaching experience while engaging in reflective learning and professional development. Under the guidance of faculty teaching mentors in the classes they teach, and supported by course instructors with expertise in pedagogy, graduate students in this course plan and deliver lessons, design assessments, and receive constructive feedback from faculty, peers, and students. The practicum fosters a supportive learning community for graduate students to refine their teaching skills and critically evaluate their instructional practices; in short, they take theory and put it into practice. Throughout the course, participants will also explore various facets of academic careers, including faculty roles at different institutions and the academic job search process, and how teaching plays into faculty life.

As part of this course, students serve either as the Co-Instructor for a course, delivering at least two class periods independently, or as the Instructor of Record, the most involved role a graduate student may have. During the study, 44 students (65%) served Co-Instructors, while 24 (35%) were Instructors of Record. Gender demographics, as collected by their pronouns entered into the learning management system, included 31 men (46%), 35 women (51%), and 2 nonbinary individuals (3%).

The hands-on teaching experience entails the preparation and delivery of two teaching demonstrations. To prepare for these demonstrations, graduate students submit lesson plans which are critiqued in class by their pedagogy course instructors and graduate peers enrolled in the course. Revised lesson plans are then submitted ahead of teaching lessons, which are then observed, critiqued, and recorded by faculty members, a graduate teaching fellow (graduate students who have previously completed the program or similar training), and a peer in the course. Feedback from observers, video of the lesson, and feedback from students is provided to the graduate student who taught the class, and the graduate student is expected to complete a guided reflection on teaching and their teaching philosophy taking this evidence into account. Throughout the preparation, execution, and debriefing of these experiences, students are encouraged to reflect on the ways in which their personal beliefs about teaching affects their teaching practice. The TPI becomes a valuable tool to help students characterize and make explicit their beliefs.

TPI Data and Analysis

Early in the course (week 3), students are asked to complete the TPI and reflect on the results they see. They are to describe 3-4 primary teaching philosophies/goals, using the TPI as a launching point, by describing each philosophy/goal and why it is important to them and their students. The expectation is that these ideas are documented and revisited across the term as each of the graduate students gains experience as an instructor.

The data from these early TPIs was collected from this assignment and coded alongside the department and college a graduate student is home to, as well as teaching role (Co-Instructor versus Instructor of Record) and gender. **Table 1** summarizes the distribution of these characteristics, with women and non-binary students collapsed into a single category to protect student privacy (although we acknowledge differences in the lived experiences of these groups, both compared to each other and as gender minorities). The students' majors were also recorded, representing 23 different programs. For the following analysis, student discipline was further collapsed into “engineering” and "non-engineering" categories to enhance robustness and facilitate comparisons between engineering graduate students and their peers in other disciplines. Of the N=68, the sample contained 37 engineering students (those enrolled in the College of

Engineering) and 31 non-engineering students (those enrolled in the Colleges of Computing, Design, Liberal Arts, and Sciences; see Table 1).

Table 1. Student Characteristics. A total of 68 graduate students are reflected.

		Instructor Type		
Gender	**College**	**Co-Instructor**	**Instructor of Record**	**Gender Subtotal**
Men	Engineering	10	12	31
	Computing	0	0	
	Design	0	1	
	Liberal Arts	3	2	
	Sciences	2	1	
Women & Non-binary Individuals	Engineering	9	6	37
	Computing	1	0	
	Design	3	0	
	Liberal Arts	3	1	
	Sciences	13	1	

Composite TPI results were created independently of the quantitative analysis to visually represent the output of the TPI for an audience unfamiliar with the instrument. These composites display the average score for each perspective, with different colored columns representing each perspective (Transmission, Apprenticeship, Developmental, Nurturing, and Social Reform). A dominant perspective is indicated by a higher score compared to the other perspectives, while a recessive perspective is shown by a lower score. Within each perspective, the left-most bar represents the respondent's belief subscore, the middle bar represents their intention subscore, and the right-most bar represents their action subscore. A perspective score is the sum of the three subscores.

The data was then analyzed and visualized in R [23] using the packages "car" [24], "dplyr" [25], "tidyr" [26], "ggplot2" [27], "scales" [28], "ggthemes" [29], and "formatR" [30]. Linear regression models assessed potential differences in teaching perspective in terms of student characteristics in terms of (1) overall perspective score (i.e., the aggregate of beliefs, intentions, and actions for each perspective), (2) perspective-specific beliefs, intentions, and actions, and (3) the dominance or recessiveness of perspectives. In each model, the set of predictors were the same: gender (0 = men, 1 = women or nonbinary individuals), teaching role (0 = Co-Instructor, 1 = Instructor of Record), and discipline (0 = non-engineering, 1 = engineering). To account for the number of comparisons, a Bonferroni corrected significance threshold was conservatively set to 0.00056. In aggregate, the predictive value of "engineering" vs "non-engineering" represents the contribution of discipline when gender and teaching role have been accounted for. Model assumptions were confirmed prior to analyses to determine appropriateness of the methods. Data were collected, anonymized, and processed under IRB protocol H18227.

Results

The distribution of student characteristics presented in Table 1 highlights several contextual factors that may influence the model predictions, emphasizing the importance of incorporating multiple characteristics. Specifically, 70% of the men in the course during the study were from engineering disciplines, and students in engineering programs were more likely to serve as Instructors of Record compared to their peers in other colleges. These patterns may reflect disciplinary or programmatic norms. At the institution-level, two-thirds of engineering students are men, and many engineering schools have established roles for graduate students to serve as Instructors of Record, especially for non-major service courses.

Table 2 shows the overall mean and standard deviation for the perspectives and subscores (Beliefs, Intentions, and Actions). Possible perspective scores range from a minimum of 9 to a maximum of 45, with 45 representing a response of "always" on the 5-point scale for all nine items (three per subscore). In this study, the observed scores ranged from 11 to 45, with a lower bound of 22 for perspectives besides Social Reform. The mean scores for the Transmission, Apprenticeship, Developmental, and Nurturing perspectives cluster around 34, with standard deviations of approximately 4. Thes descriptive statistics indicate that most scores fall between 30 and 38, reflecting a moderate degree of dispersion. This variability points to the diversity in individual participants' teaching beliefs and practices, which is less apparent in the aggregated data.

The composite TPI results for engineers and non-engineers are displayed in **Figures 1 and 2**. While these composites show some visual differences, they do not capture the variance within each perspective and are intended for illustrative purposes only. A common feature in both composites is the contrast between the Social Reform perspective and all other perspectives. Specifically, Social Reform was a recessive perspective for 59 out of 68 students (87%). Individual students also exhibited dominant perspectives; however, which perspective was dominant varied across students. This variability resulted in an average score where four of the perspectives are relative closely aligned in the composite images. In fact, 56 students (82%) had at least one dominant perspective, defined as a score at least one standard deviation above their individual mean score. Descriptively, the composite images also suggest variation within the perspectives. For instance, both engineering and non-engineering students showed higher action subscores than intention subscores in the Transmission perspective.

Table 2. Mean and Standard Deviation for TPI Values. The range of values for a total is from 9 (lowest) to 45 (highest agreement with a perspective. Each total is comprised of subscores for Beliefs, Intentions, and Actions, each of which have a max of 15.

Perspective	Totals and Sub-Scores	Mean	Standard Deviation
Transmission	*Total*	33.4	3.8
	Beliefs	11.3	1.8
	Intentions	9.7	1.8
	Actions	12.3	1.5
Apprenticeship	*Total*	34.6	4.2
	Beliefs	11.0	1.9
	Intentions	12.0	2.0
	Actions	11.6	1.5
Developmental	*Total*	34.7	4.4
	Beliefs	10.8	2.1
	Intentions	12.6	1.9
	Actions	11.3	2.0
Nurturing	*Total*	34.4	4.8
	Beliefs	11.9	1.6
	Intentions	12.2	1.9
	Actions	10.4	2.2
Social Reform	*Total*	25.6	6.1
	Beliefs	9.0	2.0
	Intentions	8.5	2.3
	Actions	8.2	2.6

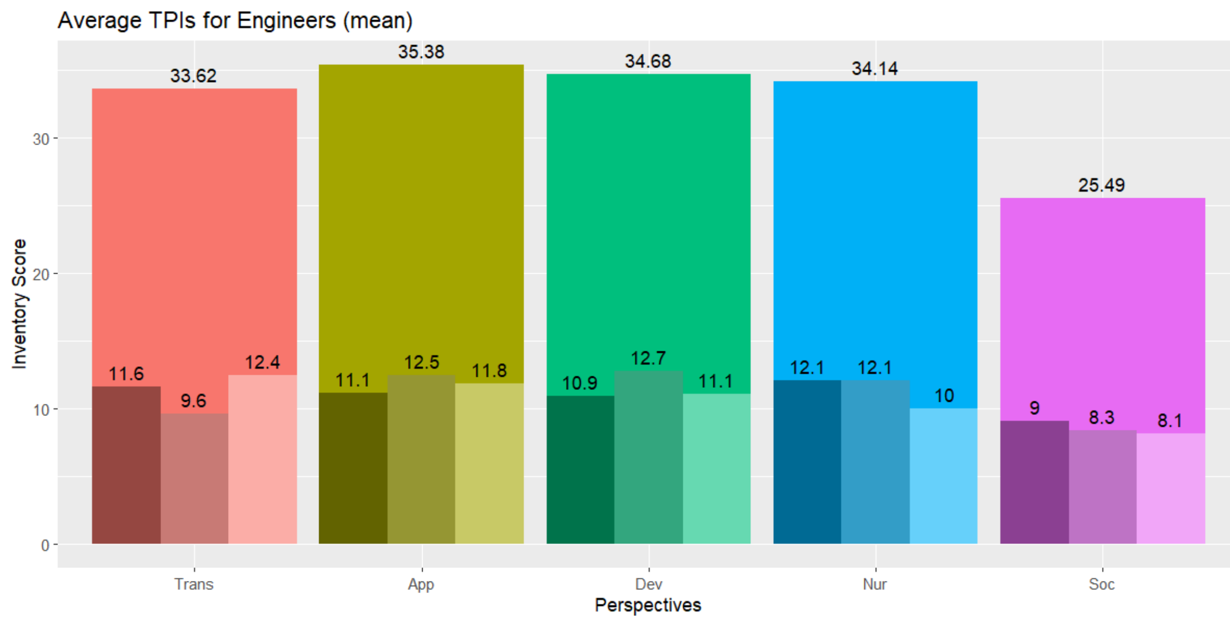

Figure 1. A composite TPI score for engineering graduate students. Trans = Transmission, App = Apprenticeship, Dev = Developmental, Nur = Nurturing, and Soc = Social Reform. Within each perspective, the left column represents beliefs, the middle column represents intentions, and the right column represents actions. Numbers above the bars represent averages.

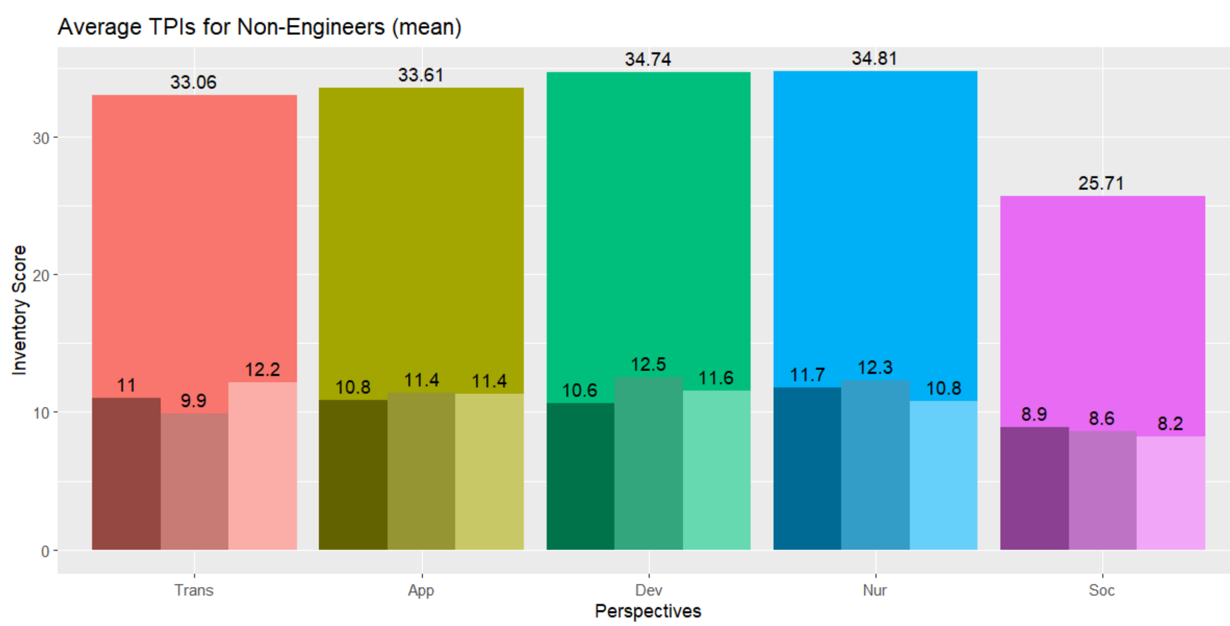

Figure 2. A composite TPI score for non-engineering graduate students. Trans = Transmission, App = Apprenticeship, Dev = Developmental, Nur = Nurturing, and Soc = Social Reform. Within each perspective, the left column represents beliefs, the middle column represents intentions, and the right column represents actions. Numbers above the bars represent averages.

The initial linear regression models assessed the five perspective scores, with no significant predictor effects found (gender, instructional role, and engineering vs non-engineering disciplines). An example model is shown in **Table 3**. Subsequent analyses focused on perspective-specific subscores for beliefs, intentions, and actions. Similarly, none of the predictors were significantly associated with the subscores. The final set of models evaluated whether a perspective was dominant or recessive for each respondent, and again, no significant effects were observed. Despite individual variability in TPI responses, no statistically significant differences were found between engineering and non-engineering students in terms of their dominant or recessive perspectives, as well as their perspective-specific beliefs, intentions, or actions, when accounting for gender and instructional role.

Table 3. Linear Regression Model Predicting Transmission Total Score. Gender was coded as a binary variable indicating men (0) vs women and non-binary individuals (1). Instructor Type was coded as a binary variable indicating Co-Instructors (0) and Instructors of Record (1). Discipline was coded as a binary variable indicating non-engineering home departments (0) and engineering home departments (1).

	Estimate	Standard Error	p-value
Intercept	33.22	1.07	<0.001
Gender	-.20	1.03	0.85
Instructor Type	-.09	1.03	0.93
Discipline	.52	1.03	0.61

Discussion

The descriptive and visual TPI results offer implications for graduate programs who wish to support their students. For students in this study, a general trend was that the Social Reform score was the lowest perspective of the five. This finding aligns with TPI development, which notes that this perspective reflects “a small, but important group” of educators [31]. In terms of graduate students who are currently building their identities as instructors, this pattern may also reflect the challenges of integrating broader societal change into teaching practices when needing to prioritize more immediate classroom concerns. Further, the differences identified between participants’ beliefs, intentions, and actions underscore the importance of providing structured teacher training. Such training can play a critical role in helping graduate students navigate the dissonance and conflicts they experience as they reconcile their evolving teaching philosophies with practical classroom implementation [32]

In a diverse classroom with graduate student instructors of various disciplinary backgrounds, we found more diversity in teaching perspectives within disciplines than between them. Specifically, when comparing engineering and non-engineering students, we found no statistically significant differences in dominant, nor recessive, perspectives, as well as their perspective-specific beliefs, intentions, or actions. While this may be an artifact of this sample and a single institution, it does provide evidence that discipline does not necessarily determine an instructor's teaching perspective.

Interdisciplinary teaching training programs can leverage the diversity within, and lack of diversity between, graduate instructor perspectives on teaching. Specifically, because students can be pooled together across departments, it may be possible to offer courses more often and to more departments by pooling resources as well as students. This may have the added advantage of acculturating graduate students to interacting with academics across disciplines, as they would be more expected to do in a faculty role than they may have training or experience to do as a graduate student. Additionally, because perspectives vary, but not primarily by whether engineering or not, strategic programming can be designed to address specific perspectives and associated pedagogical approaches and draw upon increased demand felt when open to graduate students across programs.

Teaching perspectives not being predicted by disciplinary background suggests that other factors may shape how students approach teaching. Teaching experiences in the past may be more similar based on shared common curricula or standards (e.g. ABET), but the exact methods used and their outcomes are variable. Similarly, graduate programs are not typically derived from students solely from the same institutions; rather, they draw graduates of many undergraduate programs, each of which may impart various lessons on 'how to teach' to their students through their experiences being on the receiving end of instruction. Not without mentioning, mentoring experiences, cultural backgrounds, and other factors may also shape how instructors approach teaching in ways that far outweigh discipline. Thus, among all of the factors that could shape teaching perspectives, these other factors deserve attention for the relatively larger role they could be playing in education compared to discipline alone.

Based on our data, universities can safely combine graduate students in engineering and non-engineering disciplines for practical teaching coursework. Graduate students are not entering these programs with wildly different notions of teaching and may benefit from the advantages of more frequent and intellectually diverse learning environments afforded by a multidisciplinary group. Reflection over the term, especially when combined with instruments such as the TPI, could be leveraged to assess perspective changes, and for whom, following professional training (e.g. [22], for a recent example). Strategically assessing and incorporating student perspectives in the development of graduate instructor training remains an open area for both research and in creating inclusive, effective, and adaptable teaching environments.

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