Teaching in a Foreign Land: Experiences of International Teaching Assistants in U.S. Engineering Classrooms

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Abstract

In light of the pivotal role international teaching assistants (ITAs) play in undergraduate education at US universities, particularly engineering education, this study explores the experiences of engineering ITAs. When ITAs cross national boundaries to pursue graduate education at a US university, they may simultaneously experience significant differences in educational cultures. Teaching in this new educational culture offers challenges and rewards for both the ITAs and the students they teach. While prior work on ITAs highlights the rewards, challenges, and navigational strategies of the ITA experience overall, it generally does not take disciplinary differences into account. By better understanding ITAs' experiences in disciplinary contexts, departments can more effectively provide the needed resources and support. Toward that end, we ask the following question: How do ITAs describe the experiences of teaching engineering classes at US universities?

To explore this question, we adopted a multi-case study approach and collected data from seven engineering ITAs with each ITA representing a case. Data were collected in the form of weekly reflections and in-person interviews at the beginning, middle, and end of the semester. Participants were diverse in terms of their home countries, genders, and engineering discipline. Using thematic coding, we are analyzing the data using both *a priori* codes drawn from the literature and inductive codes emerging from the data, with particular attention to engineering-specific and ITA-specific experiences.

Preliminary findings suggest that three of the four general categories developed by prior researchers are relevant to the experiences of engineering ITAs. At the same time, the data allow us to operationalize these experiences in the context of engineering classrooms, including both lecture and laboratory courses, and identify nuances in each category that are unique to the field. Additionally, preparing for teaching responsibility and management of teaching workload with research and other responsibilities emerged as two new categories of experiences for engineering ITAs. The preliminary results suggest potential areas where colleges, departments, and course instructors may focus efforts and/or develop discipline-specific materials to better support and engage ITAs.

Keywords: International Teaching Assistants, Teaching Experiences, US Engineering Classrooms

1. Introduction

International graduate students form a significant portion of the graduate student population at US universities, especially in engineering disciplines. During Fall 2015, 54.5% of the 157,457 graduate students enrolled in engineering and 55.5% of 105,033 graduate students enrolled in mathematics and computer science were international students [1]. Moreover, the number of international students, both at graduate and undergraduate levels, has been increasing annually since 1950 with few exceptions [2].

Besides contributing to the ongoing research and development work at the universities, adding to the cultural diversity on campuses, and contributing to university's finances through tuition and other fees, international graduate students play an important role in the undergraduate education at US universities by serving as teaching assistants (TAs), especially in STEM disciplines [3]. These international teaching assistants (ITAs) serve as laboratory assistants, graders for assignments, and recitation leaders. They may design exams and assignments, proctor tests, and work closely with undergraduate students by answering their course and project related queries. They are also sometimes assigned the responsibility of teaching a course as an "Instructor of Record," which may require them to design syllabi and assignments, grade student work, hold office hours, and assign a final grade to students at the end of the semester [4].

Given the important role played by ITAs in undergraduate education, especially engineering education, it becomes important to understand their experiences so that effective steps can be taken to support, engage with, and leverage the skills brought by them. To this end, this paper explores the experiences of ITAs in engineering classes.

2. Background: Prior Research on Experiences of ITAs

ITAs cross national and cultural boundaries when they come to the US, and what is considered effective teaching is situated in a cultural context [5]. Thus, ITAs face and have to navigate cross-cultural issues while teaching at US universities. Teaching in a different academic culture leads to both challenges and rewards for the ITAs.

2.1 Challenges faced by ITAs

In identifying challenges faced by ITAs across disciplines, we draw on the work of Kuo [3], who grouped the challenges into four categories: linguistic, cultural, instructional, and classroom management.

Linguistic challenges. The first category described by Kuo is linguistic. Many ITAs do not have English as their first language, which may lead to challenges in presenting instructional materials or interacting with students in English. If ITAs do not have a strong command of English or have a strong accent, miscommunication with students may occur [6]. Clayton [7] notes several instances in which undergraduate students find it difficult to communicate with the ITA. Often, ITAs feel concerned about their ability to communicate with students in English [8]. This leads to frustration and further lowers their confidence as a communicator and a teacher.

The linguistic challenges are not limited to oral communication, but extend to written communication in terms of grading students' work and giving feedback. As many ITAs are non-native speakers of English, they may not be aware of the appropriate conventions about verb, sentence structure, or word choice as used in academic English. In such cases, ITAs may not be best suited to grade students' written work [8].

Cultural challenges. The second category Kuo identifies is cultural, which includes several issues. The first is the instructional style adopted in classrooms. Many ITAs come from academic cultures characterized by minimal interaction between teacher and students. On the other hand, classrooms in the US may be interactive with active participation from students [8]. In such cases, ITAs may feel uncomfortable with students wanting to express their opinions or

interrupting the lecture to ask questions [9]. Second, writing practices vary across cultures, which can directly affect ITAs' abilities to evaluate student work and give appropriate feedback. For example, cultures differ on reader-versus-writer responsibility for understanding the meaning of written text, with many Asian cultures putting more responsibility on the reader to understand a piece of writing [10]. Similarly, in many cultures, it is not considered a serious offense to directly copy texts from other sources. For example, in a study conducted by Hayes and Introna [11], many Asians did not consider copying a few sentences word by word from a different source as serious cheating. A third area of cultural difference involves diversity. US classrooms have students from diverse backgrounds including race, gender, age, religion, and sexuality. ITAs may not be aware of how this diversity affects US classrooms [12]. As a result, they may not be aware of the presence of and ways to address racism, sexism, homophobia, and other forms of discrimination in their classes.

Instructional challenges. The third group of challenges Kuo describes is instructional. ITAs may lack knowledge about their own roles and responsibilities, academic level or students, or testing and grading systems used in the US universities. Bauer [8] notes that the practice of employing teaching assistants is typical of US universities and hence, ITAs may not be aware of what this role entails as they may not have encountered a teaching assistant during undergraduate studies. Hence, they may face challenges in supporting students they teach. Also, given they have done their K-12 education and undergraduate degrees outside the US, they may be unaware of the testing and grading systems used here [13] and the academic knowledge that students have at US universities at various levels of their education [14]. This may further hinder their ability to effectively help students.

Classroom management challenges. The fourth category identified by Kuo relates to managing student behavior in class meetings, lab sessions, and office hours. Teaching assistants (both domestic and international) often cite student behaviors such as late arrival to and early departure from the class, not paying attention in the class, and use of profanity [9]. Besides expressing frustration with student behavior in classroom, ITAs in a study done by Arshavskaya [14] noted that undergraduate students would come unprepared to the class, and at times, use disrespectful language toward ITAs. This kind of behavior not only disturbs the flow of the classes but also increases ITAs' workload in managing the class.

2.2 Rewards of the ITA experience

While teaching in a new academic culture poses multiple challenges, this experience also provides numerous opportunities for growth and learning in terms of enhanced pedagogical skills and cross-cultural competence. For example, participants in the study conducted by Trebig [13] noted that employing pedagogical practices such as group work, classroom discussion, relating concepts to real life, and using student feedback helped them improve their own teaching. Similarly, participants in the study done by Arshavskaya [14] indicated that using technology in classrooms helped them organize their own teaching.

Besides improving their pedagogical practices, the experience of serving as teaching assistants also helps international students become more inclusive teachers through exposure to diverse ways of teaching and learning and through engagement in the cultural adjustment process. For example, Zong [15] notes how as an international graduate student, she was able to

interact with students from various cultural and ethnic backgrounds and engage in conversations about issues such as racism, power, globalization and environmental pollution, and how these issues shape educational curricula and practices. This experience motivated her to make cross-cultural experience an important component of her teaching.

2.3 Gap in literature on ITA experiences

While the prior work on ITAs highlights rewards and challenges, it does not take disciplinary differences into account and tends to generalize ITA experiences across all the disciplines in the university. However, multiple studies [16]–[18] suggest that there are disciplinary differences in teaching and learning in higher education that, we posit, also nuance ITA experiences in the classroom. For example, Becher [16] suggests that academic disciplines can be seen as tribes with each having its own set of intellectual values and cognitive domains. These distinct intellectual values and cognitive domains lead to a unique disciplinary culture, which shapes the behaviors of individuals in the discipline. These differences give rise to differences in teaching and learning practices, and assessment of students' learning. For example, Donald [18] notes that engineering instructors emphasize problem-solving skills given the applied nature of the discipline. However, they also tend to adopt lecture-based teaching methods typical of disciplines such as physics, chemistry, and math from which engineering derives its roots [17].

As suggested by the above studies, the experiences of ITAs from different disciplines may not hold true for engineering as faculty adopt different teaching methods in different disciplines. Also, students hold different expectations of their instructors and teaching assistants across different disciplines. Hence, there is need for research that captures the experiences of ITAs in engineering. To this end, our study addresses the following research question: **How do ITAs describe the experiences of teaching engineering classes at US universities?**

3. Research methods

3.1 Participants for the study

To address the research question, we adopted a multi-case study approach suggested by Yin [19] with each ITA representing a case. We collected data from seven ITAs over the course of an entire semester at a large public university classified as an R1 university (Highest Research Activity) according to the Carnegie classification [20]. The participants for the study were teaching classes in various engineering disciplines including Aerospace Engineering, Computer Science, Electrical Engineering, Civil Engineering, and Industrial and Systems Engineering. Participants were also diverse in terms of their gender, nationality, and prior teaching experiences. Participant selection allowed for both literal and theoretical replications. Literal replication is achieved through selection of cases that are predicted to give similar results [19]. Selecting participants from a single university allowed for literal replication as it can be argued that selecting participants from a single R1 university would lead to similar experiences for participants because of high research expectations and the same institutional advantages or constraints for each ITA. Literal replication was also achieved with two or more participants with the same nationality or gender or similar prior teaching experiences, who were anticipated to have similar experiences. Theoretical replication is achieved through selecting cases that are

expected to give different results but due to predictable reasons [19]. In this study, sampling of participants with different nationalities and prior teaching experiences allowed for theoretical replication as it is anticipated that participants would have different experiences due to variation in these factors. Yin notes that sampling cases for literal and theoretical replication adds to the trustworthiness of the findings. A summary of participant demographics is presented in Table 1. Participants were assigned IDs from P1 through P7.

Table 1: Participant demographic information

Country of Origin	Number of male participants	Number of female participants	Total
China	1	1	2
Egypt	1	0	1
India	3	0	3
Iran	0	1	1
All	**5**	**2**	**7**

Participants were recruited through a combination of electronic advertisement, in-person recruitment, use of flyers, and snowball sampling. The following approaches were used to advertise the study and recruit participants:

- The study was advertised to the potential participants (ITAs) through the weekly emails sent to all graduate students through the Graduate School at the university. We also asked the engineering departments at the university to advertise the study among all the TAs hired by them. Additionally, we asked several student groups and campus resource centers catering to international students to advertise the study among international graduate students.

- One of the research team members (Author 1) also visited various training sessions for TAs at the university. We also asked the instructors of various courses taken by TAs to advertise the study to their classes.

- We put flyers at various locations on the university campus to advertise the study.

- We used the snowball sampling method [21] in that we asked our acquaintances to participate in the study if they met the eligibility requirements for the study. We also asked the acquaintances to further advertise the study to other potential participants.

3.2 Data Collection

We collected data using three face-to-face interviews and weekly reflections during the Fall 2017 semester. The interview protocols and weekly reflection prompts were designed by Author 1, and further modified after discussions with Authors 2 and 3. Subsequent interviews built on the previous interviews and weekly reflections completed by each participant. Figure 1 presents the data collection timeline along with the purpose of each aspect of data collection.

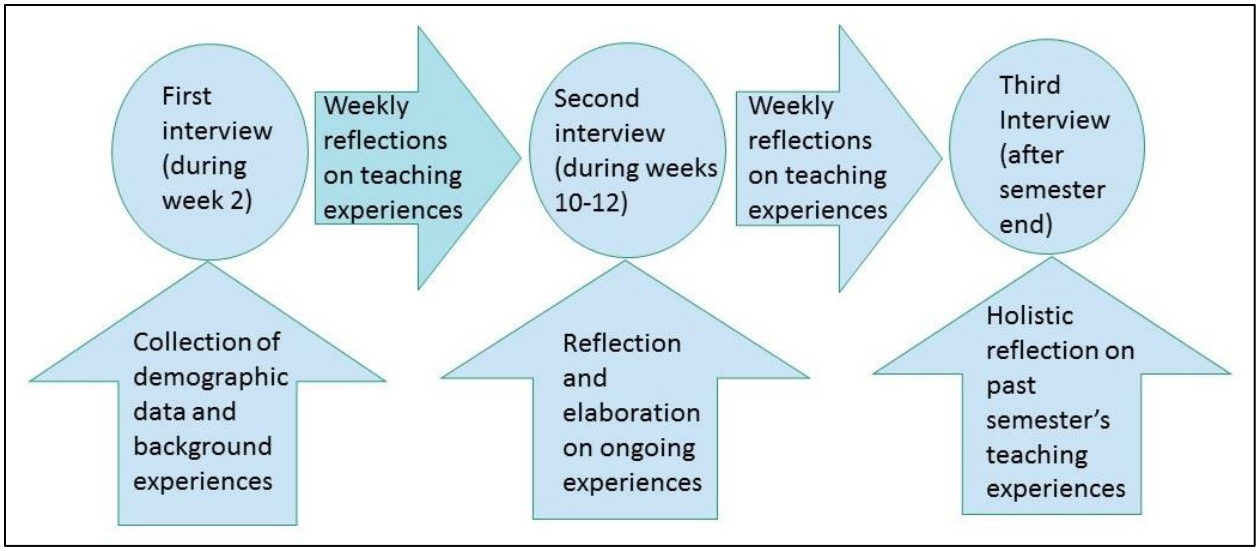

Figure 1: Overview of the data collection process

Interviews were conducted at three critical junctures – one at the beginning of the semester, one in the middle of the semester and one after the end of the semester. Each interview served a unique purpose. The first interview was conducted during the second week of the semester. This interview involved collecting participants' demographic data and background experiences. This included gathering information about participant's English proficiency, family status, prior teaching and work experiences, duration of stay in the US, and future plans after graduation. During this interview, we also asked participants about their teaching assignment including nature and level of class, their role in the class, prior experiences of teaching or taking the class, anticipated rewards and challenges as a teaching assistant, and support provided by the university or the engineering department or the course instructor to help the participant better handle their TA responsibilities.

The second interview was conducted in the last third of the semester (10^{th} - 12^{th} week). The aim of this interview was to give an opportunity for participants to reflect and elaborate on the on-going experiences while they were still fresh in their memories and for the researchers to triangulate the data collected from the weekly reflections. During this interview, we asked participants about their experiences and the strategies they adopted to navigate those experiences, and factors that led to those experiences.

The third and final interview was done at the beginning of Spring 2018 semester. This interview was aimed at helping the participants holistically reflect upon their teaching experiences during the past semester and further elaborate on any significant experiences from the second half of the semester. During this interview, they were asked about their overall teaching experience, navigational strategies, rewards and challenges they faced during the semester, differences in teaching between their home countries and the US, suggestions for the university or the department or the course instructor to help them do their job better, and recommendations for future ITAs.

We also collected data using weekly reflections. Weekly reflection prompts were emailed to participants each week and asked them to reflect on either the most significant experience or the biggest achievement or the biggest challenge they had during the week. These reflections helped gather participants' experiences on a regular basis during the semester. Also, they helped in developing prompts and probes for the second and the third interviews.

3.3 Data Analysis

After the data were collected, audio-recorded interviews were transcribed verbatim by professional services, and weekly reflections from each participants were collated together. The transcribed interviews were reviewed by a member of the research team to check for accuracy. As our participant pool comprised non-native English speakers, we did not rectify the grammatical errors in interview transcripts and weekly reflections to represent participants' spoken words rather than standard academic English. Interviews and weekly reflections were then coded using both *a priori* and inductive coding methods. In this exploratory study, we focus on analysis of the second interview and the first ten weekly reflections (i.e. those prior to that interview).

A priori codes were drawn from the four categories of challenges described by Kuo [3]: linguistic, cultural, instructional, and classroom management. While Kuo's analysis focused on challenges, we used these categories to explore both challenges and rewards since the literature also highlights multiple possible benefits for ITAs. An initial codebook was developed using the existing literature, then modified and expanded based on the emerging data. The resulting codebook is presented in the Appendix A.

To increase the reliability of the coding process, we used inter-coder agreement. After coding three interviews and three sets of weekly reflections, a graduate student from the department was asked to read through the codebook and verify if she agreed with the current definitions and categorization of codes. The graduate student and Author 1 also separately coded some data. After that, they met to discuss any discrepancies in code definitions, categorization, and coding results. The differences were resolved through discussion resulting in a modification of the codebook.

4. Results and discussion

Based on our analysis of the in-person interviews and weekly reflections, we found participants' experiences were resonant with some of the categories identified by Kuo [3]. However, there were two major categories of experiences described by ITAs that did not fall within existing categories: course preparation and workload management. In this section, we discuss the salient aspects of ITAs' experiences within each category with example quotes representing the experience. It should be noted that the example quotes were taken verbatim from interview transcripts and weekly reflections and hence reflect the spoken words of the participants rather than standard academic English.

4.1 English competency experiences

The first category of experiences described by ITAs is related to their competency in English. Kuo calls this category "linguistic". We changed the nomenclature to separate the

language-related experiences that participants had in English with the ones they had in their native language (as the latter fit the category of sociocultural experiences better, as discussed in the next section). Experiences related to English competency include expressing concerns about or facing difficulties in effectively communicating with students and experiencing improvement in English language and communication abilities. As discussed earlier, many ITAs do not have English as their first language, and therefore face challenges when communicating with students in English. For example, an ITA talked about the difficulty they faced in listening and speaking.

> *I think there are two aspects in the communication part. One is the language barrier for international GTAs. Sometimes I can get only 80% or 90% and I have to ask the students to repeat their questions again. As for the second aspects, at first, we just assumed that students understand everything we give them, but it turns out that sometimes they do not understand. [P1, Interview 2]*

However, teaching undergraduate students and interacting with them also helped ITAs improve their own communication skills, which some thought will help them in their future careers. For example, an ITA noted:

> *I did not anticipate [in the beginning of my teaching assignment], but I wanted it to be that way, that I learn through these labs how to interact with a group of people. [P6, Interview 2]*

As reflected in the quote, the TA experience improved the participant's ability to present and explain the course content to a large group of students.

4.2 Sociocultural experiences

The second category is sociocultural experiences. Kuo calls this category "cultural". We renamed it as sociocultural as some of the experiences in this category pertain to ITAs' social setting (such as use of native language). Participants' sociocultural experiences related to differences in the educational practices and use of native language. Participants noted experiencing differences in educational practices in terms of instructional approaches. Coming from different educational cultures, the study participants did not have a complete understanding of the instructional approaches adopted in US classrooms. As a participant recounted:

> *The first semester that I was here, I did not know the American education system. I attended first few lectures along with the undergrads to get the feeling like how the instructors teach. [P5, Interview 2]*

In this quote the participant notes how during their first semester of teaching, they used to go to undergraduate classes to observe the instructional approaches taken by professors in those classes so that they could learn the teaching methods used at US universities.

Sociocultural experiences also relate to ITAs' use of their native language while interacting with students. Regarding interaction with students in their native language, one ITA noted that they found it unprofessional for them or their students to use their native language during office hours:

> *They just came to the office and started talk <native language>. I tried to answer them in English, because my friend told me that it is not something professional to just speak in different language with other student … from your own country in your own language. [P7, Interview 2]*

Hence, the ITA asked the students not to speak in the native language during office hours.

4.3 Course preparation experiences

The third category of experiences is related to course preparation. This category of experiences emerged from the data and was not identified by Kuo. Course preparation relates to ITAs' knowledge of content (learning/relearning of course material) and logistics of effectively delivering the content.

Many participants described preparing for courses they taught as one of the most significant parts of their teaching assistantship. One aspect of course preparation involved learning/relearning of the course content. If an ITA was teaching a course that was different from their own expertise, they had to spend a significant amount of time learning the content. For example, a participant noted how it took a lot of time to learn the course content as it was different from their own research area:

> *The first few weeks, because I do not familiar with the electronics because my research area is about power electronics and most of them are related to power, and it's basically the analog circuit parts, but my research does not cover that topic, so I need to spend several hours to read the textbooks to figure out what is BJT amplifier, what is MOS amplifier, and so it takes more than 10 hours each week in the previous week. [P1, Interview 2]*

On the other hand, going over the course content to help students sometimes enhanced ITAs' own learning. As a participant recounted:

> *That's something actually in the course … like how they calculate this 18-month [to pay off the debt on credit cards by paying the minimum amount] is something that we discussed with the students in the course. I'm just becoming more aware that those things are real, and I see them in real life. [P4, Interview 2]*

In this instance, the participant describes how teaching a course that involved calculating the payback period for credit card statements made them more aware of their own credit card dues and provided insights into how to avoid accumulating a lot of debt.

The nature of content preparation depended on participants' TA responsibilities. For those leading lab sessions, content preparation involved doing the lab experiments beforehand so that they could learn about the correct experimental procedures and potential issues that students may face while doing the same experiments. For those ITAs who were required to hold office hours, preparation involved going through the homework and other course assignments and their solutions before the scheduled office hours.

Sometimes, preparation for the course did not involve learning or relearning of the course content. Rather, it entailed handling the logistics of delivering the content, which included designing and/or modifying class slides, exams, rubrics, and solution manuals. Additionally, formulating plans and strategies to successfully deliver the course materials and implement testing and grading schemes also constituted a part of logistical experiences. One such experience constituted successfully resolving issues that came up during proctoring of tests. For example, one ITA noted encountering mistakes in the test questions and addressing them during proctoring.

> *During the proctoring of the second midterm, there were two questions with some mistakes… [W]e had to figure out a way around it quickly. [P6, Weekly Reflection 10]*

Another example was to ensure consistency in grading student work, especially if the same assignment was graded by multiple TAs. As a participant noted:

> *I tend to grade everything in one session so that everything stays in my head how I graded the first one and the last one. So basically, it's more or less constant in me. [P5, Interview 2]*

As reflected in the above example, the participant graded all the assignments in one sitting to ensure consistency in awarding points to students.

4.4 Instructional experiences

The fourth category of experiences described by ITAs in this study relates to carrying out their instructional responsibilities. These responsibilities include supporting student learning, managing instructional time when multiple students need help, and managing student behavior. This category combines two of Kuo's categories - "instructional" and "classroom management". We combined these categories because ITAs' experiences in both categories involve interaction with students and require some managerial skills on their part to navigate.

Like course preparation, supporting student constituted a major part of participants' teaching experiences. They noted helping students understand difficult concepts during class sessions, perform experimental work during lab meetings, and understand and solve assignment problems during office hours and through emails. Given the technical knowledge of engineering courses, helping students often involved teaching complex concepts using real world examples.

At times, helping students also involved providing additional support to low-performing students in the class. This included sending reminders to students to submit their homework or handling late assignments from them. One participant also talked about motivating students who got low grades in exams and assignments to do better in future.

However, the process of helping students was dynamic and involved multiple complexities. ITAs needed to be aware of students' prior knowledge so that they could provide the required scaffolding to them. They learned about students' prior understanding of the course content while interacting with them or grading their work. For example:

While grading different students on the homework, it was evident that each of them had different levels of knowledge on the prerequisites. [P3, Weekly Reflection 1]

Another aspect of managing instructional responsibility and supporting students included managing and providing support to many students simultaneously during labs or office hours. Participants noted getting a rush of students, especially before a test or a major assignment. For example, a participant reflected on their experience during a week:

This week I had a relatively larger number of students during my office hours (because they had a quiz on Wednesday). A lot of students were asking at the same time and some of them were sometimes cutting each other questions off. [P4, Weekly Reflection 5]

In this example, the ITA describes how they had a lot of students visiting during the office hours before a quiz. This required them to manage the office hour time in a way that helped all the students and prevented one student from taking up most of the office hour time.

In addition to helping and supporting students, participants also noted experiencing and managing both positive and negative student behavior in classroom or during office hours. Positive behavior included students paying attention in class and engaging in the class. Student behaviors that ITAs viewed negatively comprised students being distracted in class, showing up to ITAs' offices without appointment to seek help, or sending queries related to an assignment a few hours before the submission deadline. Some ITAs also noted the discomfort they felt when students tried to get the solutions of homework problems from them without trying it on their own. As an ITA noted:

Sometimes the students hopes you to teach them step-by-step and they want me to give them the solution directly. So, this is some kind of embarrassing for me in the office hour time. I do not like to give the solution to the students. [P2, Interview 2]

In this example, the ITA recounts the difficult situation they face when students ask for assignment solutions. On one hand, the ITA doesn't want to refuse help to students, and on the other, they want students to make effort to solve the assignment problems.

4.5 Workload management experiences

The fifth category represented in the data involves ITAs managing their TA workload along with their own coursework, research, and personal commitments. This category emerged from the data and was not identified by Kuo. Several participants noted the large amount of time their TA responsibilities took. While some participants had expected their TA work to be time-consuming, for others, it came as a surprise. As a participant who was taken by surprise by the amount of time their TA work took noted:

The large number of submissions to grade is time-consuming. Thus, sometimes the grading process take longer than I expected (from last year experience I had). [P7, Weekly Reflection 2]

Not only the TA work took a lot of time, sometimes they had to complete it in a relatively short time period, which put additional pressure on them. For example, a participant noted:

As we get closer to the first midterm exam, students tend to ask more question and come to the office hour more often…. The significant experience of this week was dealing with this situation and try to answer their question one by one. Also, I had to be somehow "on call" for the discussion forum since students expect to be responded as soon as possible. [P7, Weekly Reflection 6]

In this example, the ITA reflects that they had to be very prompt in responding to student questions during the exam time so that students could get the maximum help in preparing for their exams.

In addition to meeting their TA responsibilities, which were at times time consuming, participants also had to give their attention to their own coursework, research, and other personal commitments. This required participants to sometimes work for their TA responsibility (such as grading) during conference trips or family visits. Sometimes, they had to make up for the missed work prior to or after their travels, which also significantly increased their workload.

4.6 Salient aspects of engineering ITAs' experiences

Our preliminary analysis of the data collected for this study suggests that the categories of experiences identified by Kuo are relevant to ITAs' experiences. Additionally, our analysis led to the emergence of two new categories to describe ITAs' teaching experiences—course preparation and workload management experiences.

Our analysis also points to important nuances that are relevant for all TAs in engineering or STEM disciplines. For example, pedagogies that help students understand complex and abstract concepts by giving real-world examples are common in engineering, given a high level of technical and mathematical content in engineering courses [17]. Also, preparing for teaching a lab session by doing the experiments beforehand or solving homework problems to prepare for office hours is typical of engineering, which has many laboratory-based courses and assignments that require numerical problem solving [22], [23]. Similarly, students trying to get the solutions of homework problems and rushing to office hours before tests and quizzes is characteristic of engineering, and STEM disciplines in general, in which solutions to assignment problems can generally be categorized as right or wrong [18] and tests are a prevalent way of assessing student learning [23].

Besides pointing to nuances that are specific to TAs in engineering or STEM disciplines, our data also highlight certain complexities that are ITA-specific. For example, ITAs noted facing communication challenges due to their non-native-English-speaker status. Their difficulties with English communication are also reflected in the grammatical mistakes they made during the interviews, as evidenced by the excerpts presented in the paper. Also, given the large number of international students in engineering at US universities [24], it is possible that some students taught by an ITA are from the same country as the ITA and hence have the same native language. This may lead to a dilemma for the ITA whether they should communicate with these students in their native language if it leads to an ease in explaining the course material to them. Additionally, a lack of knowledge about the American education system and the additional efforts required to learn about the instructional methods prevalent in US higher education are also ITA-specific experiences.

5. Conclusion and implications

The purpose of this study was to explore the experiences of ITAs in US engineering classrooms. We adopted a multi-case study approach with each participant representing a case and collected data in the form of in-person interviews and weekly reflections about their teaching experiences. Participants in this study were recruited from a single university and represented a variety in terms of nationality, gender, and prior teaching experiences, which allowed for both literal and theoretical replications. Data were analyzed using Kuo's [3] categorization of challenges faced by ITAs as an analytic framework. Based on our initial data analysis, we found that three of the four categories are relevant to ITAs' experiences. Additionally, we identified two new categories of experiences emerging from our data. We also highlighted nuances in participants' experiences that are specific to TAs in engineering and international TAs.

While the analysis presented in this paper only covers a portion of the data collected for this study, it still points to some potential areas in which ITAs can be supported by the university, engineering departments, and course instructors to better engage them in undergraduate engineering education. At university and department levels, workshops and seminars can be organized for ITAs to discuss ways to improve English communication and time management skills. Engineering departments can also organize sessions to discuss nuanced differences in teaching and learning of engineering across countries. Course instructors can discuss with ITAs the appropriate level of guidance that should be given to students without completely revealing answers to homework problems. They can also help ITAs identify relevant real-world examples to be used while teaching abstract and complex concepts. Moreover, they can incorporate more flexibility into ITAs' teaching schedules so that they can pay adequate attention to their research work and other personal commitments. Finally, while many of these issues prominently arise in ITA experiences, these methods of support could be beneficial for all graduate students learning to teach in engineering.

Acknowledgements

The authors would like to thank Amy Hermundstad Nave for her support in conducting the inter-coder check during data analysis. The authors would also like to acknowledge the funding from the Graduate Research Development Program (GRDP) at Virginia Tech to compensate participants in this study. However, any opinions, findings, conclusions or recommendations presented in this paper represent the views of the authors only.

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Appendix A: Codebook to categorize ITAs' teaching experiences

Category of Experience	Codes	Code Definition
English competency experiences	Concerns about communication	ITA describes potential problems they may face while communicating with students
	Improvement in communication skills	ITA talks about improvement in their communication skills
	Confidence about linguistic ability	ITA expresses confidence about their linguistic ability
	Communication problems due to lack of linguistic proficiency	ITA describes communication problems they face or faced in the past due to their linguistic abilities
	Problems due to using different English dialects	ITA describes problems they face or faced in the past due to difference in ways of speaking English
	Use of different English dialects as a benefit	ITA describes using their different way of speaking English as pedagogical tool
Sociocultural experiences	Appropriate instructional style	ITA describes an experience depicting their lack of knowledge about appropriate instructional style or implementing appropriate instructional style in their class in the given sociocultural context or learning about the pedagogical system
	Diversity present in a US engineering class	ITA describes an experience concerning their knowledge about diversity (about race, class, gender, and other similar social factors) present in their class or lack thereof, and the associated positive and negative teaching experiences
	Academic integrity	ITA describes an experience concerning academic integrity
	Appropriate behavior for themselves	ITA describes an experience concerning appropriate behavior (or lack thereof) in the given sociocultural context for themselves
	Appropriate student behavior	ITA describes an experience concerning appropriate student behavior (or lack thereof) in the given sociocultural context
	Use of native language	ITA describes experiences related to the use of native language with students in an academic setting
Course preparation experiences	Knowledge of course content	ITA describes experiences their knowledge of the course topics lack thereof, and related positive or negative teaching experiences

	Learning/relearning of course content	ITA describes an experiences related to learning/relearning of the course content (includes doing experiments to learn about them, going through assignment solutions, reading books etc.)
	Design course materials	ITA describes an experience of designing class slides, HW sheets, rubric, solution manual, exams etc.
	Modifying course materials	ITA describes an experience about modifying already existing course materials for their instructional responsibility (preparing/modifying slides, editing course handouts) (Differs from making instructional material as in this ITA uses the pre-existing material to prepare)
	Testing and grading strategies	ITA describes an experience about successfully implementing tests for students and finishing grading work in an appropriate manner (does not include making/modifying tests or rubrics or solution manuals) – this may refer to ensuring consistency in grading or addressing student concerns during tests
Instructional experiences	Help or support provided to students	ITA describes an experience of helping students or inability to do so (includes helping students in-class, through emails, during office hours)
	Students' prior knowledge	ITA describes their knowledge of students' prior knowledge or lack thereof, and related teaching experiences (includes learning about their prior knowledge)
	Provide support to low performing students	ITA talks about supporting low performing (eg not submitting HW or getting poor grades) students either through having conversation with them or alerting them through emails
	Multiple students seeking help	ITA talks about an experience of managing multiple students seeking help during class or office hours
	Students trying to get answers/solutions from ITAs	ITA describes an experience of students trying to get solutions from ITAs instead of solving problems themselves
	Students paying attention in class and/or diligently doing their work	ITA describes an experience about students paying attention in class and doing their work
	Students not paying attention in class	ITA describes a behavior about students not paying attention in class

	Students showing up to office without appointment	ITA describes an experience of students showing up to their office without scheduling
Workload management experiences	TA responsibility taking a lot of time	ITA talks about the TA responsibility taking a lot of their time
	Management of TA work with other responsibilities	ITA talks about managing multiple responsibilities including TA work, research, travel, and personal commitments
	Completion of TA work in a short time period	ITA describes an experience where they had relatively short period of time to fulfil their TA responsibility