Factors That Help and Hinder Teaching Assistants' Ability to Execute Their Responsibilities

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Abstract

Graduate and undergraduate teaching assistants (TAs) are key players in large universities' efforts to incorporate student-centered learning into science, technology, engineering, and mathematics (STEM) courses. This paper investigates, through interviews, the perspectives of eight TAs employed within a First-Year Engineering course with a significant focus on open-ended problem solving. The purpose of this study was to indentify factors that helped and hindered teaching assistants' execution of their responsibilities which included grading and helping students. Engaging TAs in the open-ended problems prior to implementing them in class, face-to-face discussions, and face-to-face lectures were helpful components of training, and training overall was the crucial factor for helping TAs' with their grading responsibilities. Prior knowledge, previous experiences, and intrinsic motivation were identified as helpful factors for TAs' responsibilities with regards to helping students and student teams. The hindering factors primarily consisted of struggles with the heavy workload, time commitment, understanding the open-ended nature of the problems, and understanding the students' solutions.

I. Introduction

Teaching assistants (TAs) have come to play a prominent role in undergraduate instruction. At larger research institutions, graduate teaching assistants (GTAs) serve to teach most of the laboratory and discussion sections.[1] There has also been a movement towards using undergraduate teaching assistants (UTAs) in an instructional capacity, specifically for introductory courses as they provide structure for courses with large numbers of students.[2-4] These TAs are in a unique position by serving as both students and teachers simultaneously.

A significant portion of research regarding TAs has focused on training and supporting TAs.[5-7] One of the problems is that many teaching assistants reported being assigned to undergraduate courses with no prior training.[8] In the case of GTAs, they are assumed to have the content knowledge, while pedagogical knowledge is not emphasized.[8] More recently, in an effort to address some of these concerns, more effort has been devoted to developing training programs that prepare TAs, specifically by providing them with the pedagogical tools necessary to be placed in a teaching role.[9] In an evaluation of these recent reforms, Luft et al. (2004) made two recommendations toward an effective learning environment for TAs.[9] The authors argue that faculty members must be involved in mentoring, supporting, and evaluating TAs throughout their experience. Further, TAs must be explicitly trained in educational practices; that is, they must learn about learning theory and how it informs their own practice.

These recommendations also apply to using undergraduates in TA positions. A significant difference between graduate and undergraduate TAs is what they take away from their teaching experiences. The emphasis placed on training GTAs has often sourced from the recognition that

they will serve as future college faculty.[8,9] For UTAs, teaching experiences are still treated as primarily learning experiences. They are viewed as "partners in learning".[3] Their training and support, then, should look slightly different than that supplied to GTAs. When using UTAs, it is important to understand what they will be taking from the experience. Specifically, they should not simply be used as "cheap labor".[3] In addition, faculty should make their role visible and explicit in the classroom. Finally, UTAs should be evaluated by students and should reflect on their experience.[3] Wallace (1974) adds to these claims by arguing that consistent and frequent training is necessary to ensuring the success of UTAs.[2]

TAs unique position as both student and instructor introduces the challenge of balancing teaching responsibilities with student responsibilities. The time and grading components of the teaching responsibilities can become overwhelming. This effect has been especially observed in classrooms where novel and experimental approaches are being used.[10] In response to calls for reform in engineering programs, the course being researched implemented the use of open-ended, client-driven, iterative, modeling problems, referred to as Model-Eliciting Activities (MEAs). The aim is to more closely model engineering practice with these types of problems and thus more effectively prepare engineers for the workforce.[11,12] The students' responses to MEAs are reviewed once by their peers and once by TAs before the final submission. Thus the TAs provide feedback and grade the students' solutions twice. A major challenge with grading these problems is their open-ended nature. Teaching the TAs to not look for the "right answer" as they grade has become a major focus in their training.[13]

II. Background

To further investigate how TAs perceive their responsibilities and to identify factors that influence their ability to execute their responsibilities, we interviewed several TAs in a large introductory engineering course. This course has introduced the use of intensive open-ended problems, in the form of mathematical modeling activities.[14] TAs are responsible for all feedback and grading associated with these problems. In this study, we seek to answer the following research questions:

1. What are TAs' perceptions of their responsibilities?
2. What are the factors that help or hinder their ability to execute their responsibilities?

Answering these research questions will help remove any inconsistencies between instructors' expectations of TAs and TAs' perceptions of what is expected of them. By removing any disparities, researchers and instructors will be better able to shape a course and teaching environment that supports its TAs, consequently improving the overall course. These improvements should be easily modifiable for other large introductory courses.

III. Research Context

A. Setting and Participants

The graduate and undergraduate teaching assistants (G/UTAs) for two sequential first year engineering (FYE) courses from Fall 2012 were asked to participate in this study. The courses are required for all FYE students (~2000 per year) and each is a 2-credit hour course (with 4

hours of face-to-face class time per week). There are approximately 90 G/UTAs involved in these two courses each semester, with a 1:8 ratio of GTAs to UTAs. The undergraduates range from sophomores that just completed the FYE course to second-year seniors completing their fifth year of college. Out of the 30 G/UTAs who volunteered to participate in the study, four graduate and four undergraduate students were randomly selected. Each participant worked as a FYE TA in the Fall 2012 semester. Their previous experience as FYE G/UTAs ranged from the fall being their first semester working for the department to up to working as a FYE TA for six consecutive semesters. All UTAs and two of the GTAs were previously students in the FYE course. Both UTAs and GTAs receive support from faculty while GTAs mostly manage UGTAs. Some of their common responsibilities include preparing for class, helping with in-class activities, facilitating good teaming behaviors, grading MEAs, and answering students' questions.

TAs participated in a training session before starting the semester. The purpose of this training was to review the course materials, responsibilities, policies, and other course related activities. During the semester and before implementing an MEA in class, TAs participated in MEA specific training in three phases. First, TAs solve the MEA individually and applied the rubrics to their solution. Second, in a face-to-face training session, they reviewed the rubrics and applied it to sample students' responses. Third and last, they graded students' responses and compared their grade and feedback to of an expert (i.e. a calibration process).

B. Data Collection

Participants participated in a semi-structured interview ranging from 45 to 90 minutes. Since the purpose of the interviews was to understand the G/UTAs' perspectives of the FYE program and their TA position, the questions covered a wide range of position related topics. The interview questions were divided into seven categories: background information, hiring process, overall experience, thoughts on MEAs, training, expectations and responsibilities, and support and mentoring (See Appendix A). The interview categories were developed based on analysis of findings regarding the key components for a successful program utilizing UTAs,[15] changes to the implementation and grading of the mathematical modeling activities in the FYE program[16,17] including the design of assessment rubrics,[18,19] nature of TA feedback,[20] and modifications to the FYE program TA training.[21]

C. Data Analysis

Interviews were audio recorded and transcribed verbatim. The coding scheme included key TA responsibilities of the course based on the 2012 Fall *Instructional Team Manual*. This coding scheme was divided into six main categories with 18 subcategories. Table 1 shows the categories, subcategories, and coding examples. The different segments of the interview were determined either to be relevant to their responsibilities or not. If they were relevant, they were coded based on the TAs' perspectives as either factors that helped or hindered them to execute their responsibilities or general perceptions about the topic (positive, neutral, or negative). After deciding on the coding scheme, one interview was coded by four individual researchers. The discussion of coding process resulted in small changes in the coding scheme including some clarification. Another interview was coded by two dyads (the same four researchers paired off to

work as two teams). After changing the coding scheme based on the consensus of two teams, the dyads continued to code the remaining interviews using the agreed upon coding scheme; each dyad coded two UTAs' and two GTAs' interviews. Of all the subcategories, certain categories emerged as central themes. These themes will be discussed in the results. Once all eight interviews were coded, the frequency of examples from each subcategory was counted. Rather than reporting all the 18 subcategories, we focus on a few categories that were discussed most frequently by the U/GTAs in our result section.

Table 1. Coding Scheme

Categories	Subcategories	Coding Examples
General	Know course layout	"I did training I didn't know what to expect but I feel like I was ready for it. A lot of being ready for the job is knowing what the class about" (factors that help)
	Go to class	"When they do in class activity, I walk around and talk to students" (neutral perception)
	Notify of schedule changes	(No Comment)
	Student emails	"Students don't email us, unless, yes, they mainly email the GTAs or professors" (neutral perception)
	Attend meetings	"We don't have a lot of time so we a lot of time with the course and we wanna go away and do other stuff and do others more efficient so I think that meeting had to be cut down to be more short" (factors that hinder)
Hierarchy	Faculty support	"If I have any difficulty with students, I always feel that professors are answering any questions and concerns that I have" (positive perception)
	Support GTAs	"I was able to create a community of graduate TAs and those are good friendships in a work place" (factors that help)
	Manage UTAs	"So that was one of my least favorite ones because you put this into position while you are expected to manage a lot" (negative perception)
Training	Attend & participate	"The in person training was also helpful" (positive perception)
In class	Preparation for class	"It's always good to give good response to the student questions. Always be prepared for class" (positive perception)
	Know technology	"I always tried to strength my knowledge in MATLAB" (factors that help)
	Help with in-class activities	"I always reviewed the homework assignments and in-class activities" (factors that help)
	Know your role	"You put this into position while you are expected to manage a lot but it wasn't clearly mentioned" (factors that hinder)
	Facilitate good teaming behaviors	"Teaming, and it was very interesting because we teach it as to the students and students learning from exams so they know different stages of teaming" (positive perception)
Grading	MEA grading	"A lot of the times the rubric was unclear so I wasn't too sure how to assign points, especially with MEAs" (factors that hinder)
	Other grading (e.g., quiz, h.w.)	"Then the other thing was grading, the homework exams, tests" (neutral perception)
Help students	Help students and answer their questions	"I was enjoy talking about where they come from, what their plans and helping them achieve them" (factors that help)
	Help regarding MEAs	"As far as MEAs, there is a huge dis-connect from a classroom" (factors that hinder)

IV. Results

In this section, the first results reported are the frequencies of times that G/UTAs discuss their various responsibilities along with their general perceptions of their positions. The three main topics that both GTAs and UTAs discussed are training, grading, and helping students. Their perceptions of and affecting factors (help or hinder) on these responsibilities are reported in greater detail. The four UTAs are referred to as Peter, Piper, Patrick and Parker and the four GTAs are referred to as Gail, Grace, Greg, and Gus. All names are pseudonyms, but with correct gender implied. The specific open-ended problem solving activities that TAs discussed are typically referred to as MEAs (Model-Eliciting Activities).

A. Frequency

During the interviews, the TAs discussed various aspects of their responsibilities with positive (+), negative (-), or neutral (~) perceptions. The UTAs (Peter, Piper, Patrick, and Parker) generally had a positive or neutral perception of their responsibilities. The GTAs (Gail, Grace, Greg, and Gus) had a mix of positive, negative, and neutral perspectives on various aspects of their responsibilities. All of the UTAs discussed their responsibility to attend class, attend and participate in training, grading responsibilities, and help students and teams. All of the GTAs discussed their responsibility to support the faculty, manage the UTAs, attend class, attend and participate in training, know their in-class role, grade, and help students and teams. All of the UTAs and GTAs both discussed training, grading, and helping students and teams. Table 2 shows all of these discussed findings. The table lists the interviewed UTAs and GTAs and shows an "x" for each relevant responsibility topic that they discussed at some point during their interview. The table also shows a frequency count for the number of times that the corresponding topic was brought up during the interview (with a maximum count of once per a question) for all of the UTAs and GTAs. The table also states the overall perception (i.e. the most frequent perception) that the TAs had about the relevant aspect of their responsibility. The shaded areas illustrate responsibilities that were discussed more frequently by UTAs or GTAs.

Table 2. TAs discussion of their responsibilities

x: factor discussed by participant

+: Positive Perception -: Negative Perception ~: Neutral Perception

	Hierarchy			**General**					**Training**	**In-class**					**Grading**		**Helping Students**	
	Faculty support	Support GTAs	Manages UTAs	Know course layout	Go to class	Notify of schedule changes	Student emails	Attend meetings	Attend and Participate	Prepare for class	Know technology	Help with in-class activities	Know your role	Facilitate good teaming behaviors	MEA Grading	General Grading	General Help	MEA Help
Peter				x	x			x	X				x		x	x	x	x
Piper		x		x	x		x		X	x		x		x	x	x	x	x
Patrick	x	x	x		x		x		X	x	x	x	x		x	x	x	x
Parker	x	x		x	x				X	x	x	x	x	x	x	x	x	x
Frequency	7	7	1	3	8	0	2	1	22	4	8	7	7	2	41	20	31	11
Overall Perception	+	+	~	~	+		~	+	+	~	+	+	~	+	~	~	+	+
Gail	x	x	x		x		x	x	X	x	x		x	x	x	x	x	x
Grace	x		x		x		x		X				x		x	x	x	x
Greg	x	x	x				x	x	X		x		x	x	x	x	x	x
Gus	x	x	x		x				X	x	x		x	x	x	x	x	x
Frequency	21	11	16	0	5	0	5	6	21	3	3	0	18	6	45	13	34	17
Overall Perception	+	+	-		+		~	-	~	-	+		-	+	~	-	+	+

B. Training

Training is a responsibility that every TA discussed in their interview. The TAs' various perspectives on the topic and the factors that enabled or hindered them from completing their responsibility are reported in this section.

1. Perceptions on Training

The UTAs generally had a positive perception of training and the GTAs had a more diversified perception, but overall fairly neutral. Some TAs, such as Patrick and Piper, had a positive, neutral, and negative perspective about training at various points in the interview. Patrick expressed a positive perception of training four times in the interview, while only expressing a neutral perception twice and negative once; it can be assumed he an overall positive perspective about training based on the frequency of various perceptions. Parker and Gus are the only TAs that only had one expressed perception in their interviews. Park had a positive perception and Gus had a neutral perception. Greg is the only TA that only discussed factors that helped and

hindered his ability to attend and participate in training, but did not express his opinion regarding training.

2. Factors related to Training

Amongst the eight TAs, 11 different factors regarding time, workload, training format, and training content were discussed that they felt either helped or hindered their training experience. Three factors, *completing the open-ended project*, *face-to-face discussions*, and *face-to-face lecture* discussed as main helpful factors. Major hindering factors were *too much work* and *too much information.*

3. Helpful Factors related to Training

The *completing the open-ended project* for the semester was identified to be the most helpful factor on training participation, since three TAs (Piper, Gail, and Greg) explicitly discussed this factor. Piper mentioned completing an MEA and doing MEA grading prior to face-to-face training was helpful. Gail states that completing the MEA helped her understand the problem that will be completed in class and discussed in training:

> The training itself was helpful... like having to do the projects... so what's helpful about training is going through all the materials beforehand, knowing the project beforehand, so when the students ask you questions, you've done it …

Greg discussed that working through the problem before coming to training was helpful in discussing details about potential errors:

> TA training was good in a sense that you got to work on the problem and work through quick sample and try to reach a solution and try to figure out what those issues are and then come and discuss it.

The TAs also identified the *face-to-face training discussions* and *lecturing* to be helpful. For example Greg mentioned:

> The helpful part was the in person training, having that two hour session, discussion type of things work out really well.

4. Hindering Factors related to Training

The TAs did not bring up many similar factors that they felt hindered their attending and participating in training, although two TAs did bring up that the training had *too much information*. Also three TAs (Piper, Gail, & Greg) brought up that the overall training required *too much work* and they felt this hindered their ability to complete the training. Piper discussed the heavy workload of having to do a lot of practice grading prior, during, and post training:

> [MEA training] was a 2.5 hour training and they went through all these points … and then how to grade them. And what the students need, what is the point of doing MEAs. And we did sample grading also for like 2 or 3. … we had to do the MEA grading online. We did on hard paper 3 in class then after that they gave us like another 3 MEAs to grade like to practice online. … It might have been a little too much because they gave us 3 again so took a lot of time.

Gail discusses the amount of trainings and the amount of information and workload for the various training, in addition to the already heavy workload going on outside of training:

> ... we had several training sessions … It was just a lot of information. I took so many notes in training because it was overwhelming and then I just stopped because I

> realized you are not going to memorize that... There was training for MEAs ... but before you get to the training, you have to do the assignment ... you are already doing a million other things … Then you have to go to do training. … So you are going through that but meanwhile you are still required to do all your other list of TA duties while you are doing this MEA stuff … The idea of training itself is good. The amount of time it takes to do training does not match all of the other things as far as homework, quizzes, exams, grading. Like it doesn't align at all, like it's just too much.

Greg discusses some of the things he liked about training, but also stated the fact that he felt that there is just too much work required in training "just the amount of things that we have to do was just way too much."

C. Grading

Grading is a responsibility that every TA discussed in their interview. The TAs' various perspectives on the topic and the factors that enabled or hindered them from completing their responsibility are reported in this section.

1. Perceptions on Grading

The UTAs generally had a neutral perception of grading; the GTAs had a more negative perception of grading. Gail and Gus had only a negative perception of their grading responsibility; Grace, Peter, and Piper had neutral and negative perceptions in their interviews. Greg and Patrick had neutral and positive perception in their interviews regarding training. Parker had only a neutral perception of his grading responsibility.

2. Factors related to Grading

Amongst the eight TAs, 20 different factors regarding time, workload, assessment rubric, grading tools, grading methods, teamwork with other TAs and instructors, previous experiences, nature of assignments, and interaction with students were discussed that they felt either helped or hindered their training experience. The *training* was the most helpful factor regarding grading. *Time commitment*, *open-endedness nature of the project*, *difficulty understanding students' responses*, *the online tool used for grading*, and *the open-ended project rubric* were found to be the most hindering factors.

3. Helpful Factors related to Grading

Training was the most helpful factor and was discussed by six G/UTAs. Most of the comments were about open-ended project training, in which TAs asked to do the modeling problem and come up with a solution first. Then they practice grading sample students' response and compared their grading with of an expert. Gus noted:

> So I always felt [completing the open-ended project in] training was really beneficial. It was a little difficult coming up with a solution the first time… Then you've seen, ok, here's what is expected, and then you're in a better position to 1) anticipate what things you might encounter in responses and then 2) know how to respond to those things and I guess, 3) learn how to make good judgment cause that's a big part of it.

Peter mentioned comparing his grading with an expert:

> The most helpful was comparing my grading with the expert's grading (in the online portion of training). Like after we grade each section we see the comparison to expert and when do we compare I see how the expert graded and I see where I go wrong.

Another aspect of training was about giving feedback. Patrick discussed:

> As a peer teacher, we actually were taught (in training), and as a student (in class) too, I was actually taught how to give constructive feedback and if we were giving criticism saying we shouldn't do that, this is a problem. We also have to think about that how we are supposed to fix that or how students are supposed to fix that.

Finally, Grace was feeling more confident after the training:

> [Training] helped me in grading. I was a little but more confident in grading, because I had gone through it once.

4. Hindering Factors related to Grading

The main factors hindered students ability to do their responsibilities were *time commitment, open-endedness, online tool, difficulty understanding students' responses,* and *the open-ended project rubric.*

Time commitment was the major factor that was brought up by seven TAs as an issue. Grading the open-ended project usually took more time than expected for most of the TAs. That made grading an unpleasant activity for TAs. Parker mentioned:

> I guess the thing I least look forward to is the actual time it took to grade one MEA. It takes so long if you want to do a good job.

Timing also influenced the quality of feedback provided in grading. Grace noted:

> Providing quality feedback is an issue when you're crunch for time … So I really wanted spend the time going through the solution that they provided and then pinpointing exactly all the issued that they needed to fix. But when you got a bunch of teams to grade and each MEA solution take like a couple of hours to go through you really end up just skimming and trying to hit the main points as suppose to really refining it.

And finally some TAs "cut corners" to survive. Gail said:

> If I actually did everything I was supposed to do I would be probably working 50 -60 hours per week, but in order to stay alive, you have to cut corners.... they will tell you that you need to spot check all the homework assignments after the peer teachers graded them … If there ends up being a general issue, it's kind of easier to just turn the homework in, let the students have their homework. … Fix the grades, do a re-grade, it is easier to do it that way then actually then spot checking because it is going to happen inevitably.

Open-endedness nature of the project was another factor that was discussed by five G/UTAs. Some of the UTAs were having difficulties understanding the concept as a student and sometime even when they had been a TA. Piper mentioned difficulty understanding the problem and established dimensions of the MEA; she stated:

> I've done like the sample grading and I always get it wrong. It's very hard to differentiate. … I get confused. … I think I just don't get the concept. And the words they use throw me off.

Gus also found grading open-ended problems (MEAs) challenging:

> Um, the first time or maybe the first two or three times that I graded MEAs, I'm certain that I wasn't very good at grading them, um, because it is so open-ended and it is a big challenge to grade something that doesn't have a finite answer cause you're left with a lot of responsibility as a grader…. It was kind of my duty to the students and to those that I work for to do my best at grading it, cause it's very different than grading MATLAB code.

Another factor that discussed by four of G/UTAs was *difficulty understanding students' responses*. This was mostly for open-ended project (MEA). For example Piper noted:

> It's difficult when the students' writing is very hard to understand. Grammar, or what points they're trying to put across.

Another factor discussed by six G/UTAs was *the open-ended project rubrics.* Two of these TAs discussed *the rubrics* both as a helpful and hindering factor. Gus acknowledges that the rubrics have come a long way, but he believes there is always room for improvement:

> With an open-ended problem and introducing the idea and concept of that and all the nuances of it, um, I think it leaves a lot more room for error … and you can only do so much to standardize that, but we have a very detailed rubric that has only gotten more detailed as time goes on, because we've learned more about, you know, you think you've seen every response possible, but oh wait, here's another one that maybe isn't so valid. Um, or maybe is valid and we hadn't thought of it.

Patrick believed the rubrics need to be more flexible on grading points:

> … a lot of the times the rubric was unclear so I wasn't too sure how to assign points. MEAs have point system, 5, 3, 2, 1 and 0 for 3, 2, 1, but there was no 2.5. Some students have the requirements for 1 point, but they did a really good job, they had partially 2 points, but the rubric was so clear-cut, they get 1 point.

Grading was done via an online system for the open-ended projects. The *online tool* was discussed by six G/UTAs as a hindering factor. Technical difficulties was one of the complaints about the online tool. Piper mentioned "The MEA system goes down a lot." The design and features of the online system was also discussed by several G/UTAs. Grace believed the tool made the grading experience worse:

> Most of my complaints are about the implementation of the grading system. It's online. That was just really messy and awful, and not helpful … The online tool made the grading system seemed messy.

D. Helping Students and Teams

Helping students and teams is a responsibility that every TA discussed in their interview. The TAs' various perspectives on the topic and the factors that enabled or hindered them from completing their responsibility are discussed in this section.

1. Perceptions on Helping Students and Teams

Both UTAs and GTAs generally had a positive perception of their responsibility to help students and teams. None of the TAs had a negative perceptive of their responsibility to help students and

teams. Patrick, Gail, and Greg only had positive things to say about this responsibility. The other five TAs had positive and neutral perceptions about helping students and teams.

2. Factors related to Helping Students and Teams

Amongst the eight TAs, 26 different factors regarding time, workload, teamwork with other TAs and instructors, nature of assignments, interaction with students, feedback methods, and feedback environments were discussed that they felt either helped or hindered their training experience. The *TAs' prior experiences and knowledge* and *personal intrinsic motivation to help the students* were the most helpful factor regarding their responsibility to help students and teams. The *open-endedness nature of the project* was found to be the most hindering factor.

3. Helpful Factors related to Helping Students and Teams

Prior knowledge and experience was one of the main factor discussed by seven TAs. All UTAs and some of GTAs had taken the course before becoming a TA; thus, they were familiar with the content of the course. Grace noted:

> … I went to the program. So I completed MEAs as a student … and as a TA. I see both sides …

Most of G/UTAs also had tutoring or prior TA experience that they believed was helpful. For example Gail discussed how her prior TA experience was helpful:

> I guess the fundamentals of ... handling student issues [carried over from prior TA position]…So if there are issues that come up with students in the class that are relevant to the class, but are not affiliated with the assignments, but its impacting the student's performance I was somewhere.

Gus also mentioned how his prior knowledge was useful for his job and also helping others:

> Yeah because I feel like I know MATLAB and Excel better than most of the people who work for us and so …when people don't know what to do, I think that I tend to be a resource frequently.

Intrinsic motivation to help the students was another factor discussed by four of TAs. This was one of the factors that made interacting with students a pleasant experience for most of the TAs. Greg mentioned he liked teaching in general:

> I always had this very strong interest with teaching. It comes from family ... I knew I could help students out …

Parker reported interacting with students the best part of her job:

> The part I like most is just interacting with students in class and helping out. I like the feeling of helping someone like learn how to do it and then they got it. … It's like rewarding sometimes like when you explain stuff to people or you fix their code or help them figure out what's wrong and … they're appreciative.

Grace mentioned how helping students helped her cope with the stress and workload:

> I mean I wasn't really mean to complain because I knew this needed to get done in order to classroom to run. I think that goes back to how I coped with the stress and understanding that these tasks need to be done in order to for the classroom to work and I wanted the classroom to work because I'm trying to help students.

Gus got more interested in teaching after this TA position:

> I never considered education as a career path before I got this job, but more and more I start to think well, you know, … I am getting more and more interested in academia

> and higher education specifically because… of the experiences I've had learning from students and having them learn from me and I feel like that's a valuable exchange that goes on and I would like to be a part of that in a positive way, cause, you know, there are lots of people out there who are plenty qualified to do what they do, but may not be so qualified to teach others what they do. Um, they're teaching, I have a lot of respect for people who teach.

4. Hindering Factors related to Helping Students and Teams

The main factor discussed by six TAs in hindering their ability to help students was the *new concept of open-endedness*. Grace described the open-ended problem solving (MEAs) good but frustrating:

> I like the overall intent of MEAs. I think it is actually a good method. And you're walking students through a solution process. How to develop a solution process. How do you implement that. But it's also very frustrating. Just because students you know don't seem to get it at first so. It's brand new so that how most learning experiences are. I think it's a decent method.

Some TA's also have difficulty understating the intention for some parts of the activity, thus made it difficult to help students. Peter mentioned:

> I think [students] are in the same position as a lot of peer teachers (UTAs), they don't understand why they are doing, like they are given a problem this person wants them to do this... but their immediate reaction is well why.. what am I gaining from this.. I mean yeah they know how to write a memo now and they can make a procedure and they can give user feedback, but I don't think they understand the purpose behind it like if there is a greater meaning to it.

V. Discussion

In summary, from 18 different responsibilities in six different categories, TA's most discussed five responsibilities were in the three categories of training, grading, and helping students. A summary of factors and perceptions related to these three categories are reported in Table 3.

Table 3. Summary of factors that influenced TAs' perceptions of their responsibilities

+: Positive Perception -: Negative Perception ~: Neutral Perception

Category	Perception	Factors Helped	Factors Hindered
Training	UTAs: + GTAs: ~	Completing open-ended project Face-to-face discussions Face-to-face lecture	Too much work Too much information
Grading	UTAs: ~ GTAs: –	Training	Time commitment Open-ended nature of project Difficulty understanding students responses Online tool for grading open-ended project Open-ended project rubrics
Helping Students	UTAs: + GTAs: +	Prior knowledge & experience Intrinsic motivations	Open-ended nature of project

Training was the only responsibility that was also discussed as a helping factor for other responsibilities (e.g. grading). Different aspects of training before and during face-to-face training sessions were found to be somewhat time consuming (with respect to the other responsibilities TAs already had) but overall useful by the TAs. Prior to the face-to-face training session, TAs were asked to solve the open-ended problem (MEA) via the online tool; then apply the rubrics to their MEA response. These pre-face-to-face training activities were intended to familiarize the TAs with the open-ended problem and the assessment tools, so that the face-to-face sessions could focus on issues of assessing student work. During the face-to-face session, the rubrics were explained to the TAs and two sample responses were reviewed. To familiarize the TAs with grading rubric, the rubric was applied to actual student responses.[21] After the face-to-face session, TAs evaluated three more student responses and compared their evaluation to that of an expert. The comparison of TA and expert grading of sample work helps the TAs self-calibrate their grading techniques.[21] This process resulted in both helping and hindering factors. In general, UTAs find the training more useful than GTAs. One factor may be the time commitment needed to do all the required work for training. Both GTA and UTA found completing the open-ended problem and the face-to-face session (lecture & discussion) to be beneficial. However some of the additional work was seen to be excessive to complete, especially for more experienced TAs.

Hindering factors brought up pertained to three primary topics of heavy work load (i.e. time, information, and tasks requirements), difficulties with open-endedness (i.e. nature of project and assessment tools), and troubles communicating with students (e.g. inability to understand teams' solutions). All hindering factors for *grading* and *helping students* (directly) and *training* (indirectly) relate to the open-ended problems in the course. While training does a good job in preparing the TAs, they still have difficulty in dealing with the open-ended problems both in grading and helping students. These finding aligns with Stepp-Greany's (2004) finding that the time and grading components of the teaching responsibilities can become overwhelming, especially when novel and experimental approaches are being used.[10]

Despite different difficulties that TAs are experiencing to execute their responsibilities (e.g. workload, time) many of TAs stay with the program for several years. The *intrinsic motivation* to help students may be an important factor. This rewarding experience helped them to overcome the difficulties of the job.

VI. Conclusions

This study took a first step in understating TAs' perspectives regarding their responsibilities in a large-scale introductory engineering course with innovative open-ended problem solving activities. Training was clearly a key aspect for graduate and undergraduate students to succeed in grading student work and giving feedback to scaffold student learning on open-ended problems; this was not only seen to be important by TAs and Roderick (2009).[15] The TAs felt that the face-to-face session portion of the training was one of the most beneficial parts of training. Some TAs mentioned that solving the open-ended problem enabled them to understand the challenge the students were to face and felt this helped them better communicate with students. These aspects are recommended to be fundamental for effective training. Although training was overall seen to be beneficial, some excessive aspects may have made training more

time consuming than necessary. It is recommended that the current additional materials completed online should be cut down based upon the TAs previous experience. Since there is a lot of work for TAs to complete, it may help to make some training materials optional, especially for more experienced TAs. This will also ensure that the training doesn't become a burden to TAs that may find the additional work monotonous (since it is required every semester, no matter the number of semesters in the current position).

Since more prior knowledge and experience enabled TAs to better help students, if there are a large number of potential candidates, previous experience should be made part of the screening process for hiring. TAs felt that any previous tutoring and/or other teaching assistant positions were helpful. Also intrinsic motivation should be a key element to hiring a potential undergraduate or graduate student for a teaching assistant position. TAs who had a desire to explore a future teaching career, study some aspect of STEM education, or even just had interest in helping other students succeed seemed to have a more positive outlook on and greater commitment to their position.

Potential hindering factors that should be monitored to ensure students greater success in TA positions are the assigned work load, their understanding of any assigned open-ended problems, and their communication with the students. Some TAs noted that the communication through an online environment made understanding student solutions more difficult, if the class sizes can permit it, any feedback regarding open-ended problems may be better conducted in-person.

One of the limitations of this study is that it only reports the perspectives of eight TAs out of about 90 in the First-Year Engineering program. To get a broader perspective of TAs' opinion on the program based on the finding of this study a survey will be implemented to gather perspectives of more TA regarding to their responsibilities.

Also this analysis only examines the common themes between UTAs and GTAs; further analysis via a survey should be conducted to explore common topics brought up amongst the GTAs and the UTAs separately. The GTAs are in the middle of the instructional team hierarchy so it makes sense that this is a common theme that they brought up and is something that needs further investigation to understand the shortcomings and successes of the current personnel structure. The UTAs discuss their in-class responsibility more probably because this is the majority of their time commitment in their position (4 hours of class per week for a 10 hours per week position). A survey of the TAs' perspectives will give a broader range of perspectives (both positive and negative) about their experiences, will identify more shortcomings of the current structure, and will more strongly suggest the successes of the program to allow for more generalizable suggestions.

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Appendix A - Interview Protocol

Interview #: Recorder Information: Interviewer: Date of Interview: Starts: Finish:

START: Background Information about the Study
Thank you very much for agreeing to let me interview you. For this interview I will go through a list of questions regarding your expectations and experiences as a teaching assistant for the first-year engineering program. Your responses today will help us conduct a study that addresses ways of improving TA training and the implementation of MEAs. I will request that you do not use any names in this interview, but rather refer to anyone by only their position title (i.e. GTA, UGTA, professor, etc.). If you do not feel comfortable discussing any of the following questions, please let me know and we can move on. This interview should take approximately 90 minutes.
Do you give permission for me to record this interview? *[Start Recording]*
Today is (date). My name is (recorder's name). *[Test Recorder]*

Part 1: Background Information
First, I'd like to ask you a few questions about yourself.

1. Please state your major(s) and year of study at Purdue University.
2. How long (how many semesters) have you been a teaching assistant in the first-year engineering program?
3. Have you ever held any other TA positions? Please explain.
4. What were your experiences with MEAs prior to this semester?
5. Do you have any other prior experience that you feel is relevant to this TA position? (e.g., internships, other campus jobs, grader, etc.)

Part 2: Hiring Process

1. Describe for me how you heard about this position?
   - If selected to apply, → Can you tell me why you were selected to apply for this position?
2. Can you tell me why you decided to apply for this TA position?
   - What factors influenced your decision to apply? (e.g., someone previously in the position, someone who knew of the positions, course materials, benefits of being a TA: money, work experience) *(e.g., only provided if TAs struggle to come up with any answer)*
   - What are your personal goals with respect to your TA position?
3. What were some things that you liked or disliked about the hiring process?

Part 3: Overall Experience

1. What was the most enjoyable part of this position for you?
2. What was the most challenging part of this position for you?
3. What do you think of your overall experience with the first-year engineering program? why?
4. If you ever thought about quitting this TA position, what were the reasons?
5. Do you plan to stay with the FYE program? Why or why not?
6. What did you learn from first-year engineering students?

Part 4: Thoughts on MEAs

1. What do you think about MEAs as a method for teaching students?
   - Did this view change through your TA experience? (If yes, please explain.)
2. What do you think of the current MEA implementation sequence? (Reminder: draft 1 – peer review – draft 2 – TA feedback – final response – TA assessment)
3. Which dimension was the most difficult (to learn, to teach, to grade, etc.) and why?

4. Do you have any suggestions on how MEAs in the FYE Program could be improved? Why? How?
5. How do you approach providing feedback for MEAs?
6. What did you find most difficult about providing feedback to MEAs?

Part 5: Training

1. Please briefly explain the training process (MEA and Departmental).
   - in-person TA training?
   - online TA training?
2. Which elements of the TA training were helpful? Why?
3. Which elements of the TA training were not helpful? Why?
4. When you completed training did you feel prepared for your TA position? Why or why not?
5. What did you learn through the training that will help you in your future career?
6. What suggestions do you have for making training more beneficial for TAs?

Part 6: Expectations and Responsibilities

1. Before you began working as a TA, what expectations did you have? (e.g., training, responsibilities)
   - With respect to MEAs, what expectations did you have?
2. What most strongly influenced your expectations? (e.g., written documents, human resources, prior experience)
   - With respect to MEAs, what influenced your expectations?
3. Based on your expectations, what did you most and least look forward to?
4. Once you started working as a TA, what , in a positive and negative way, surprised you most? Why?
5. Please describe your personal responsibilities for your position.
6. What do you feel you have learned through this position that will help you in your future career?
7. What challenges do you face? (e.g., grading, attending classes, meeting with other TAs and professors, providing feedback to students, online environment)
8. What did you like most about your responsibilities? Why?
9. What did you like least about your responsibilities? Why?

Part 7: Support and Mentoring

1. Did you receive any feedback on your job performance? Explain.
   - If no, would you have liked to receive any feedback on your job performance? Explain.
2. What support did you receive during the semester?
3. What opportunities did you have in order to build relationships with others (e.g. professor, other TAs, students, staff)?
4. Do you feel like there is someone you can go to when you are having difficulties with your responsibilities?
5. Do you feel like others come to you when they are having difficulties?
6. Do you have any suggestions on how TAs can be supported better? Why? How?

Final Question: Is there anything else about your experiences as a TA that you would like us to know?