The Benefit of Training Undergraduate Teaching Assistants

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Abstract
We report on a new program to train Undergraduate Teaching Assistants (UTAs) that we are implementing at our institution, the University of Virginia. The mixed methods research study explored the impact of the Teaching Methods course for UTAs and demonstrates the success of our program. A discussion of the program and preliminary outcomes are discussed in this paper.

Introduction
Undergraduate Teaching Assistants [UTAs] provide a fundamental support to our educational mission. We started to employ them, as an experiment, in 2014 in a Differential Equations course, and we have reported about the details in [1a]. After few years many more courses in our Engineering school, and Applied Mathematics (APMA) courses in particular, have introduced UTAs in their class activities. The project of this effort has grown substantially to become a stable feature of our program. Students who enroll in our APMA courses know that in class activities are regular and that UTAs are an essential support to their learning process together with faculty and graduate teaching assistants.

Almost all of our UTAs have no teaching experience, which is expected since they are quite young and hardly had any practice of teaching. In the past we relied mostly on their personal skills and on their ability to adjust rapidly to the new pedagogical environment. The common perception of faculty and UTAs alike was that most of the UTAs selected were the top students in their class and very brilliant - they would learn quickly. However, despite their knowledge of the material, their inexperience with engaging students in learning within a classroom context had a limited impact.

Since the early years, the scope of UTAs activity has evolved; in several cases they are superseding Graduate Teaching Assistants. First year students relate more with second year students than with graduate students, seen as much older than their peers. Time UTAs spend tutoring students is now greater than it used to be at the beginning of the program. Some of them even hold regular office hours for specific tasks, for instance Matlab or R.

Now that their role is more relevant, their inexperience can have a greater impact on the class. In addition we are recruiting many more UTAs, and we cannot expect from all of them the same exceptional response we had from the few.

Literature Review
According to the National Center for Educational Statistics, nearly half of undergraduate STEM majors exit the discipline [1]. Important factors in student attrition from STEM disciplines include: 1) instructional experiences such as first-year Mathematics courses and faculty expectations [1][2] and 2) individual self-efficacy, epistemologies, and goal orientations [2][3].

In order to enhance student cognitive and affective outcomes and retain students in STEM disciplines, undergraduates have been used as Learning Assistants (LAs), course UTAs, and lab UTAs with positive results [4][5][6]. For example, UTAs used in an inquiry-based general

chemistry laboratory context have similar student content knowledge gains as GTAs in the same position [5]. As another example, in a large-enrollment introductory physics course, students have significantly higher electricity and magnetism content knowledge when in a course that uses LAs compared to students who do not have LAs[6].

These positive student outcomes cannot be solely attributed to the presence of an undergraduate in the learning environment. UTAs/LAs need to have support in learning how to teach in the form of TA training, teaching workshops, and teaching methods courses [7] [8]. Details about the literature related to UTAs, the impact of TAs on student outcomes, and UTA professional development will be elaborated in the final paper.

Purpose and research questions

Given the potential importance of UTAs and the need to support them in learning how to teach, we have developed a 1-credit *Teaching Methods for UTAs* in APMA course, described below. The present study seeks to understand the impact of the Teaching Methods course on the UTAs and the students they teach. The research questions driving this study were:

1. How, if at all, do UTAs' beliefs about their own Math ability, beliefs about teaching, confidence in teaching, and skills in engaging with student groups change across a semester of UTAing and taking a Teaching Methods course?
2. What components of the Teaching Methods course did UTAs find the most helpful in supporting their role as a UTA?
3. How, if at all, did APMA students' math self-efficacy and beliefs about Math ability change over the course of a semester enrolled in APMA courses with UTAs?

Description of UTA Teaching Methods courses

In Fall 2017, we received a grant to create a special course on *Teaching Methods for UTAs* teaching in APMA. The new one-credit course was designed and created with faculty from [a center at our institution] with the objective of filling in UTAs' immediate gaps in pedagogical and educational experience, but also to offer UTAs a vision of the composite phenomena that surround the learning adventure of undergraduate students.

In addition, the course is now a requirement in order to become a UTA in our program, and most of our previous UTAs have to take it. We grant exceptions only to current UTAs who are graduating in three/two semester. After all 'grandfathered' UTAs will graduate; the course will become a critical step to transition from "passive grader" to active participant in the course. Below we describe the course and modifications we have made through our second iteration. *Pilot ULA course* The class provides tools and support for UTAs to reflect on the several aspects of their activity, from the most effective teaching practices, such as student-centered and inquiry based, to relevant educational methods, grading techniques, and including tips to improve interpersonal skills. Topics covered include: Constructivism, Motivation, Problem solving, Engaging with Groups, Grading and Feedback, and Metacognition (see Appendix A for full course syllabus)

These topics are organized around three main modules during the semester. The first one is based on understanding the *learning process* as an elaborated process where individuals have to construct knowledge in their own terms, mediated by their prior experiences, interactions with

others and the material, and the effort they put forth in learning. The understanding of the variety and complexity of learning is critical for UTAs to understand their role, which is then refined in the second module, where they explore different *pedagogical approaches*. Historically UTAs tended to stick to a role they found comfortable, a sort of equilibrium state, and rarely tried different strategies to help students during class. The discussion generated in this module is quite illuminating for these UTAs, and is intended to stimulate their trying of new pathways of engaging students in learning. Finally, the third module is concerned with the *benefit of the feedback*, and how to deliver constructive and supportive information to students. This part introduces UTAs to the concept of thinking about the process of understanding. The metacognition related to this part has been fascinating for several of our UTAs, as reported in the results below.

Over the course of the semester, UTAs have several out-of-class projects meant to solidify their understanding and skills related to teaching. These projects include an observation project, four teaching reflections, and a mid-semester student feedback project. The course ends with a problem-solving project where UTAs prepare a video for their class. Further details on these projects and the course structure will be provided in the final paper.

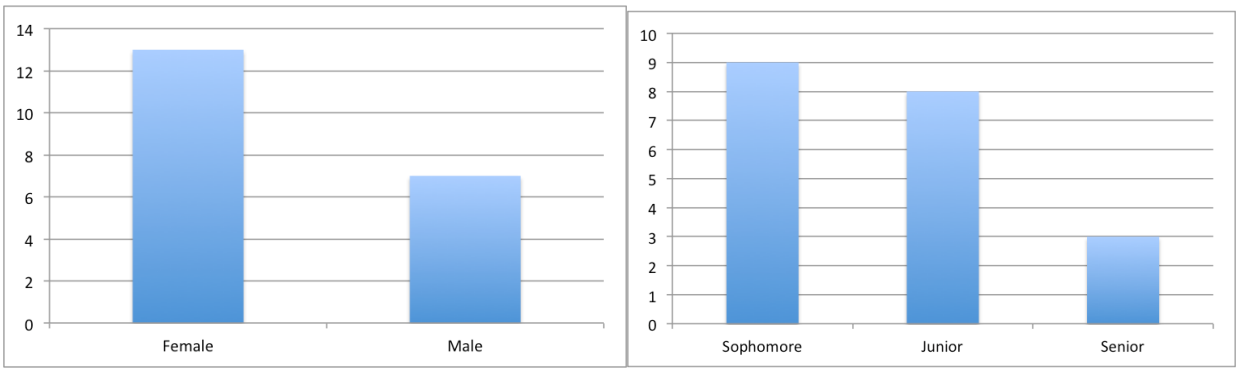
Methods

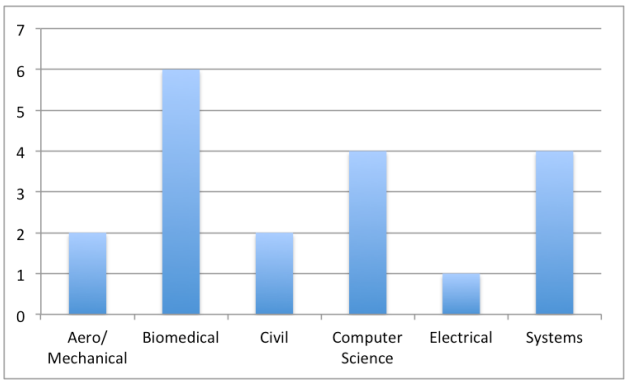
The present mixed-methods study occurred during the fall 2017 semester in a mid-Atlantic, research-intensive university. Participants included UTAs enrolled in the Teaching Methods course and students enrolled in APMA courses. Data sources included pre- and post-surveys and UTA Teaching Methods course assignments.

Participants

Participants included 20 of the 26 students (77%) enrolled in the three different sections of the Teaching Methods courses who consented to participate in the IRB-approved study. See Table 1 for UTA participant demographics. The majority of participants were UTAs for calculus-based courses; two participants (10%) UTA'd Calculus I, four participants (20%) UTA'd Calculus II, two participants (10%) UTA's for Multivariable calculus, six participants (30%) UTA'd for Differential equations, one participant (5%) UTA'd for an Honors calculus, and one participant (5%) UTA'd for Systems of Differential Equations. The remaining four participants (20%) UTA'd for statistics-based courses.

Table 1. UTA Participant Demographics





Student participants included 101 students across eight APMA courses taught by seven different instructors who completed both the pre- and post-survey. The majority of student participants were freshmen (n=76, 75.2%) and took AP calculus in high school (n=88, 87.1%).

Data collection

Data sources included pre- and post-surveys for both UTAs and APMA students who volunteered to participate in the study (see Appendix B and C for UTA and APMA student surveys, respectively). UTA course assignments, in particular their reflections on teaching, were included as a second data source to triangulate qualitative survey data related to the impact of the Teaching Methods course. The UTA survey included Likert scale survey questions to gauge participants' beliefs about their math ability (modified from[9]), beliefs about teaching [10], confidence in teaching [5]. Open-ended scenario-based questions were also included on the UTA survey that was intended to assess their skills in responding to various student group dynamics. Demographics questions were also included on the UTA pre-survey. Open-ended and Likert questions related to UTAs' perceptions of the Teaching Methods course and its ability to support them in their UTA role were included on the post-survey.

APMA students' survey included Likert questions on their beliefs about their math ability using a math self-efficacy scale [11], and Math mindsets (modified from [9]). The survey also included questions on students' help-seeking behaviors. Math self-efficacy questions fell into four main self-efficacy categories; mastery experience (i.e., previous success informs belief about math ability), vicarious experience (i.e., success of others informs belief about math ability), social persuasions (i.e., encouragement from others informs beliefs about math ability), and physiological state (i.e. anxiety, stress, etc. can inform beliefs about math ability). Mindset questions gauge the extent to which students perceived their ability as fixed (i.e. abilities are inherent and cannot be changed) or malleable (i.e., abilities can be changed with effort and work). Help-seeking behaviors related to their willingness to seek help from peers, UTAs, attend office hours, and ask for help when they were stuck. Beliefs about math ability focused on students' beliefs about the fixed or growth nature of their abilities in Math. Demographic and prior math background experiences were included on the pre-survey. Likert and open-ended questions related to their perceptions of their UTA and learning in the APMA course were included on the post-survey.

Data analysis

Reliability analysis were performed on each Likert scale construct (e.g., mindset, UTA confidence, self-efficacy) and sub-construct (e,g, mastery experience, UTA confidence in engaging students in learning) to identify whether the individual questions could be combined into a single value. All reliability for each combined sub-construct was $\alpha > .80$. All individual questions were averaged into a value for each sub-construct, with the exception of mindset, which was summed.

Paired t-tests were performed for each pre- and post-survey construct for student participants to identify any changes across the semester. Given the small sample for UTA participants and the non-normality of the data, a Wilcoxon sign ranked test was used to identify any significant changes in UTAs across the semester. Descriptive statistics were calculated for quantitative UTA perceptions of Teaching Methods course components that were helpful in supporting their teaching. Descriptive statistics for student perceptions of their TA were also calculated.

Qualitative data for UTAs included open-ended survey response questions as well as reflection assignments for the Teaching Methods course. These data were analyzed using systematic data analysis [14], where the literature informs the analysis but the data are used to inductively derive codes and themes. For example, the literature on teaching confidence [5] informed the analysis of the reflective writing assignments. From these assignments, the data were read holistically to explore how UTAs discussed their confidence in teaching. Initial codes were created from reading the data that included 'changes in confidence' and 'factors that influence confidence'. Confirming and disconfirming evidence were coded into these categories to better understand the range of ideas around confidence. For example, in 'factors that influence confidence', UTAs made statements about realizing that knowing the content did not mean they could teach students, which reduced their confidence. On the other hand, receiving feedback from students as part of a mid-semester project for the Teaching Methods course helped UTAs feel more confident in their teaching.

Results

Below we report on the quantitative and qualitative data on changes in UTAs beliefs, confidence, and math ability and the factors that impacted these changes. Next, we discuss the components of the Teaching Methods course that UTAs perceived as supporting their UTA role. Finally, we report the student outcomes in APMA classes based on those that had UTAs and those that did not.

Changes in UTA Confidence, Math Ability

Overall, UTAs' beliefs in their math ability (i.e., mindset) did not change significantly over the course of the semester (Table 2). This is expected as these participants applied for, and were accepted as UTAs based on their success in prior APMA courses. UTAs confidence in their ability to create a safe learning environment for students significantly improved across the semester ($z=-2.156$, $p=.031$), as did their confidence in being able to engage students in learning ($z=-2.362$, $p=.018$).

Table 2. *Changes in UTA mindset and confidence.*

	Pre-survey, Mean (SD)	Post-survey, Mean (SD)
Mindset	37.45 (3.72)	37.15 (5.07)
Confidence in creating a positive learning environment	4.09 (.73)	4.41 (.51)*
Confidence in engaging students	3.56 (.73)	3.99 (.64)*

Note. Mindset sum from 7 (fixed) to 42 (growth). Confidence ranged from 1 (not at all confident) to 5 (very confident). * significant, $p<.05$

Qualitative data from UTAs' reflective writing demonstrates how teaching in their UTA role made them realize there is more to teaching than just knowing the content. One UTA stated in their reflection:

> Working as an Undergraduate Teaching Assistant for APMA 2130 for the first time, there has been a lot that I have learned within the first month of this semester. I quickly realized that although I did well in the course when I took it, this did not mean I would instantly be this perfect TA that I thought I would be ... It was almost as if there was a road block between the ideas formulating in my mind and the words that I was trying to speak. I immediately began to wonder how well I would actually perform as a TA and what steps I would have to take to be the kind of TA I envisioned myself being (UTA-1, reflection 1).

By the end of the semester, UTA's wrote about his confidence in being able to communicate better with students and feeling comfortable in doing so, as seen from the following quote:

> Looking back, I think that the most important thing I have learned in this class is the key to teaching: confidence. Personally, this was something that I struggled with at the outset of the class. I felt that I did not understand the material well enough to be teaching it; however, after obtaining feedback from students and learning that I was truly helping them, I became a great deal more confident and able to focus all of my energy on helping students, instead of getting caught up in nervousness. Furthermore, since I would like to have some sort of teaching component in my future career, I have learned the larger importance of confidence. Being nervous or insecure in one's ability to teach something they are obviously qualified to teach (otherwise they would not be chosen for the role) can only hurt their performance. Thus, in really anything I do, I have learned to recognize that I am doing it for a reason and deserve to be there – and this recognition really helps me be more confident. The discussion we had in class regarding confidence really helped me employ this mindset.(UTA-2, reflection 3)

UTA Perceptions of the Teaching Methods course

Post-survey quantitative data suggested that UTAs found the in-class discussions and instructor modeling as most helpful in supporting their UTA role in APMA courses. From student reflective writing assignments, metacognition was the most interesting and important topic to the UTAs. For example, one UTA wrote:

> During our discussion on metacognition, we first thought about how being metacognitive has helped us out in our college career so far. While I had not really thought about it prior to our discussion, I can definitely recognize how useful it is to be aware of the way you

> think and to be able to evaluate where you really are in a class. For example, being able to recognize areas of weakness in a subject is incredibly beneficial as it allows you to seek the right help and to plan accordingly for future exams. We learned in class that being metacognitive can sometimes be difficult to some of our students and it is important to try and get the students to reflect about where they are at in the class. Getting students to think about the way they think can allow them to perform better in the class and understand the areas in which they are strong in and those that they are weak in (UTA-3, reflection 3).

Further, UTAs find the topics they are learning in the Teaching Methods course not only translate to their UTA role but to their own role as learners in engineering and in their future career aspirations. For example, one UTA stated:

> I graduate after next semester and will start a job where I will be testing software. I hope to be able to use my knowledge gained from being a TA to be able to interact beneficially and successfully with teammates and supervisors. By knowing how to facilitate working in a group, I believe I can enhance my work environment. Even though I have a job in the industry for next year, I ultimately want to become a teacher of high school math. The experiences that I have gone through TA'ing have helped me realize what types of situations I may encounter as a teacher and understand how to react to them. When I teach in the future, I can apply the knowledge learned in this class and make sure to always allow students to think first, reflect on my own teaching, and motivate my students properly (UTA-5, final reflection).

APMA Student Outcomes

Overall students' self-efficacy did not change, while their help-seeking behaviors significantly improved, and students' mindsets significant shifted to more growth (Table 3). Students in courses with UTAs did not have any changes in their perceptions of mastery experience, vicarious experience, social persuasions, or physiological state over the semester. However, students felt significantly more comfortable seeking help from peers and UTAs over the semester and shifted their mindsets from more fixed to more growth mindset.

Table 3. *Students' Change in Self-efficacy across the semester*

Construct	Sub component	Pre-survey, Mean (SD)	Post-survey, Mean (SD)
Self-efficacy	Mastery experience (prior success)	4.62 (.87)	4.43 (.87)
	Vicarious experience (peer success)	4.33 (.88)	4.27 (.93)
	Social Persuasions (support for success)	4.58 (1.03)	4.56 (.97)
	Physiological state (anxiety)	2.38 (1.09)	2.21 (1.06)
Help-seeking	Seek peer help	4.37 (1.27)	4.98 (1.19)**
	Seek TA help	4.18 (1.16)	4.74 (1.30)**
	Attend office hours	3.59 (1.29)	3.50 (1.64)
	Ask for help when not understanding	4.12 (1.24)	4.73 (1.36)**
Mindset		30.51 (5.18)	32.50 (5.89)**

Note. All self-efficacy and help-seeking Likert scale from 1 (low) to 6 (high). Mindset sum from 7 (fixed) to 42 (growth). ** significant, $p<.01$

We further explored the relationship between self-efficacy components to understand how math anxiety played a role in their confidence. At the beginning of the semester students who had lower anxiety toward math tended to have higher perceptions of prior math success (r=-.661), and higher perceptions of support from others in feeling successful in math (r=-.375). There was no significant correlation between math anxiety and success of other students. At the end of the semester students who had lower anxiety toward math tended to have a higher perceptions of prior math success (r=-.633), a higher perceptions of others math success (r=-.410), and higher perceptions of support from others in being successful in math (r=-.318) (all ps<.05). Further, at the beginning of the semester, students with more math anxiety tended to have a significantly more fixed mindset (r=-.230, p=.024), a relationship not observed at the end of the semester. These suggest that: 1) math anxiety is an important factor that relates to their perceptions of their own success, 2) engaging in a course where students work in groups may help reduce math anxiety when their peers are successful, and 3) by the end of the semester, even students with math anxiety may perceive their math abilities as being able to be improved, and idea that may or may not have been fostered by their UTA.

Students' perceptions of their UTAs at the end of the semester demonstrated that they felt UTAs were supportive and helpful but could potentially improve on their ability to engage students with questions (Table 4). Based on the means and standard deviations, the majority of students perceived UTAs as treating students fairly, were knowledgeable, and were supportive. There was a large variation in student responses on their perceptions of UTAs ability to ask good questions.

Table 4. *Student perceptions of UTAs*

My UTAs…	Mean (SD)
treat all students fairly	5.41 (.50)
are knowledgeable.	5.26 (.71)
are supportive	5.23 (.86)
are approachable	5.16 (.93)
address questions during discussion	5.16 (.94)
are well-prepared	5.05 (.82)
help make problem expectations clear	5.04 (.99)
help me feel like I can succeed in the class	4.97 (1.13)
communicate well with students	4.89 (1.14)
spend the right amount of time interacting with me/my group	4.84 (1.27)
interact with students consistently throughout discussion	4.80 (1.35)
help me see the importance of the subject matter	4.79 (1.14)
give good feedback	4.68 (1.38)
are enthusiastic.	4.64 (1.32)
encourage group members to talk with one another	4.54 (1.41)
encourage students to ask questions	4.52 (1.45)
ask good questions	3.90 (1.62)

Note. Likert data ranged from1 (strongly disagree) to 6 (strongly agree)

Conclusion

This project is a second step (the first step is reported in [1a]) in an ongoing effort to improve our students' learning experience in APMA courses, facilitating in class pedagogies that have proven to be extremely effective [12] [13]. While this is a pilot study with a small sample of UTAs and APMA students, the results are promising. The Teaching Methods course appears to be effective in improving UTAs' confidence in teaching. At the same time, we want to offer students, who become UTAs a fulfilling and enriching experience to add to their college formation. A significant part of this research is to understand how UTAs pick up the "non-content knowledge" related to teaching and how this knowledge can influence their personal and professional growth as future engineers.

While there is no comparison of data from students who did not have UTAs, it appears that the UTAs may have played a role in helping students become more comfortable with asking for help and viewing their Math ability as something they can change. As evidenced in students' perceptions of TAs, the components of the Teaching Methods course that translated the best to practice were the topics of Implicit bias (e.g., treating all students fairly), engaging with groups (e.g., approachable, supportive), and problem solving (e.g., making expectations clear). The topics that UTAs struggled to translate were questioning (e.g., asking good questions, encouraging students to talk) and grading (e.g., feedback). The limited time UTAs have with students during class may also play a role in why some Teaching Methods activities translated well into their teaching while others did not. These data can help inform instructors of the ways in which UTAs can help support student learning in their Math courses.

Future research will explore differences in students Math self-efficacy and help-seeking behaviors for sections of Math courses that do a do not have UTAs. Observing interactions between UTAs and students over time will provide additional insight into the ways in which UTAs translate what they are learning into their teaching.

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