120th ASEE Annual Conference & Exposition
FRANKLY, WE DO GIVE A D*MN
June 23-26, 2013

Paper ID #6877

Active Learning in Engineering: Perspectives from Graduate Student Instructors

Dr. Tershia A. Pinder-Grover, University of Michigan

Tershia Pinder-Grover is an Assistant Director at the Center for Research on Learning in Teaching (CRLT) and the Center for Research on Learning and Teaching in Engineering (CRLT-Engin) at the University of Michigan (U-M). In these roles, she is responsible for teacher training for new engineering graduate student instructors (GSIs), consultations with faculty and GSIs on pedagogy, workshops on teaching and learning, and preparing future faculty programs. Prior to joining CRLT, she earned her B.S. degree in Fire Protection Engineering from the University of Maryland and her M.S. and Ph.D. degrees in Mechanical Engineering from the U-M. Her current research interests include examining the effect of instructional technology on student learning and performance and assessing GSIs' perception and use of active learning teaching methods.

©American Society for Engineering Education, 2013

Active Learning in Engineering: Perspectives from Graduate Student Instructors

Abstract

At large research universities, graduate students are often employed as teaching assistants (TAs) or graduate student instructors (GSIs) to support the educational mission of these institutions. In order to maintain a high quality of teaching, and to provide opportunities for graduate students to grow as teachers, the College of Engineering at the University of Michigan requires all new TAs to participate in a one-day training session prior to the start of the term and a follow-up practice teaching session focusing on active learning teaching methods later in the term. The purpose of this paper is to explore engineering graduate students' perceptions of their teaching experiences, especially their use of active learning teaching methods at a large public research university. This paper investigates how graduate student instructors describe and use 'active learning' in their classes, and identifies potential factors that may contribute to the likelihood that a graduate student instructor will adopt these techniques in their teaching practice.

To address these topics, all engineering TAs were invited to participate in an online survey which collected data about their teaching experiences (including terms of teaching and responsibilities), their definition of "active learning," and their use of these teaching methods. The data shows that the majority of respondents value "good teaching" and can articulate how they apply active learning in their classes. Further, the majority apply these approaches at least once per week and believe they are "somewhat successful" or "very successful" with their implementation. Those respondents who *did not* use active learning were unsure how to use these methods in their specific class, believe that their teaching responsibilities did not allow them to use these approaches, or did not feel as though active learning was necessary. This paper examines these responses further to determine whether or not their teaching responsibilities, their confidence with a variety of teaching-related tasks (e.g., lesson planning, working with students, etc.), and use of teaching peer mentors influence their decisions to incorporate active learning into their teaching practice. Recommendations for faculty supervisors and TA training program organizers are provided.

1. Introduction

Equipping graduate students with the skills they need to succeed in an academic career is a paramount issue in engineering education. There has been much concern that while graduate students receive extensive support in developing themselves as research scholars, there are few opportunities for them to receive training on how to teach.[5,10,24] Further, the recommendation in the Educating the Engineer of 2020 (p. 92) calls for creating learning environments "in which students (1) were more actively engaged than taking notes, (2) focused on problems, design challenges and artifacts in addition to concepts, and (3) often worked with other students to understand and complete assigned tasks.[14]" Since active learning teaching methods, like the ones mentioned in this report, have been shown to improve student learning[4, 7, 17] and retention[1] preparing engineering instructors to effectively incorporate these methods into their teaching is vital.

The purpose of this paper is to explore engineering graduate students' perceptions of their teaching experiences, especially their use of active learning teaching methods at a large public research university. At this university, all new engineering graduate student instructors or teaching assistants (TAs) are required to participate in an all-day pedagogical training designed by engineering faculty/TA developers prior to the start of classes. Additionally, they are expected to plan and teach a short lesson that includes active learning to a small cohort of their peers. During this practice teaching session, a trained facilitator helps the TA and his/her colleagues reflect on the strengths of the lesson and any areas of improvement. Although a one-day orientation with a follow-up training module may not be as extensive of training as a week-long orientation or a semester long course, the strategic emphasis on active learning during this orientation warrants a close review. This paper investigates the following research questions focused on TAs and active learning:

- How do graduate student instructors describe 'active learning' and use these teaching methods in their classes?
- What factors contribute to the likelihood that a graduate student instructor will adopt the use of active learning in their teaching practice?

2. Background

The College of Engineering at the University of Michigan requires all new graduate student instructors, which is typically 250-300 student instructors per term, to attend a teaching orientation organized by the campus' teaching center (See Appendix A for an agenda). Prior to the start of the term, TAs attend an 8 hour orientation, where they have two opportunities to select a workshop based on their teaching responsibilities. These interactive sessions offer topics such as leading discussions and lab sections, handling office hours, teaching problem solving skills, and grading issues. These workshops are developed by faculty/TA developers from the university's teaching center, but are adapted and co-facilitated by experienced TAs. This peer-facilitation model is an approach recommended by Hollar, Carlson & Spencer (2000) for TA training.[6] These workshops incorporate active learning teaching methods that meet the goals for a particular session so that the facilitators can not only model such approaches as the think-pair share, case studies, role playing, and jigsaw; but they can also deliberately articulate the purpose for using a particular technique during the session. In addition, TAs participate in an interactive theater performance focusing on issues of classroom climate.[8] Participants also receive a packet of resources describing on-campus teaching resources including a TA guidebook[2] and additional information about academic integrity, university policies on sexual harassment, etc. They meet briefly with their teaching peer mentors, which is a group of experienced TAs who are trained by the teaching center to observe classes, gather student feedback and consult with their peers. The TAs learn more about this program and the teaching-related services that are available to them.[12, 16,19,20]

At this initial training, participants also choose to either present a 5-minute practice teaching lesson or role-play office hour scenarios with a small group of their peers (approximately 5 total TAs and a trained facilitator) based on their teaching responsibilities. Practice teaching (also known as microteaching) is a practice that is recommended by Prieto, Yamokoski, & Meyers (2007) for graduate student development because the practice helps increase TAs' self-efficacy.[21] During the 5-minute practice teaching, TAs plan & present a topic, reflect on their teaching with

the support of a trained facilitator (often a peer teaching mentor) and provide feedback to a small group of their peers about their teaching. For students where English is their second language, we ask students to self-select into microteaching sessions where there is at least one facilitator who is trained to provide English language feedback and pedagogical feedback. Since there are a considerable portion of TAs whose primary duties are to hold office hours, the training for new TAs includes a practice teaching session focusing on office hour interactions. For the 6-minute office hour role play, participants receive a problem statement with an explanation of the solution. They interact with at least two other TAs who play the role of students and have a question about the problem statement or they might ask other types of questions often asked in office hours (e.g., grading concerns, requests to be excused from class, or general advice on study skills and/or career).

Approximately two weeks after the start of the term, TAs participate in an advanced practice teaching session where they prepare a 10-minute lesson incorporating active learning teaching methods.[18] Like the microteaching session that occurs prior to the start of the term, the TAs present a lesson to a small group of their peers and receive feedback. Unlike the earlier microteaching sessions, the TAs may have the opportunity to win a small prize (i.e., $5 gift certificate) for the TA who incorporates active learning into their lesson most effectively. Since there are many active learning teaching strategies, for the purpose of this TA training, participants are asked to select one of six active learning teaching methods for their lessons: (1) the minute paper, (2) think-pair-share, (3) brainstorming, (4) case studies, (5) inquiry learning, and (6) cooperative groups (See Appendix B for definitions and sample instructor explanations). These methods were chosen to include strategies that are relatively easy to implement as well as strategies that are more involved. The more challenging techniques are provided for those TAs who may have had other teaching experiences prior to their new TA appointment at this institution.

To support their development of a lesson, the participants are introduced to active learning during the main orientation. Specifically, the program organizer who is a faculty developer with an engineering background presents two research studies in order to highlight the performance benefits of these approaches and the range of active learning techniques that can be used to achieve these goals. For example, the study by Ruhl, Hughes, and Schloss (1987) is described to show the effectiveness of three 2-minute pauses during a 45-min class, where students were instructed to review notes and develop questions during these breaks.[22] Student performance, as measured by short term and long term recall, improved in these classes in comparisons to those without a break. The purpose of discussing this study is to show that active learning can be an effective approach that may need little preparation and in-class time to facilitate. In contrast, the second research article depicts a study which required more preparation and in-class time in order to demonstrate the wide range of active learning techniques available to instructors. Laws, Sokoloff, and Thornton (1999) highlight how an inquiry learning approach in an introductory physics class resulted in higher student performance on concept inventory tests.[9] In this study, students were asked to make predictions or define hypothesis, then they were able to view or manipulate a laboratory demonstration. These research studies are only a few of the possible evidence-based research that could be presented to new TAs. Other research describing the benefits of active learning on retention, performance, and attitudes have also been considered for this overview. [4,13,23]

During the active learning presentation, the participants also watch a short video clip of a GSI or TA teaching and then the participants brainstorm ways to make the class session more interactive. At this point, the presenter briefly describes the six active learning teaching methods they will use during their advanced practice teaching session at the end of the term. Finally, TAs receive a handout specifying engineering specific examples of how these teaching methods are enacted in engineering courses and are provided with links to videos showing TAs conducting microteaching lessons with active learning.[3]

3. Methodology

After obtaining approval from the university's institutional review board, 213 Engineering graduate student instructors were invited to participate in an online survey developed in SurveyMonkey (73 respondents, 34% response rate). The survey was administered 2-3 weeks before the end of the semester and it asked TAs questions about (1) their background (i.e., department served, number of terms teaching, responsibilities, etc.), (2) their definition of 'active learning' and whether or not they were able to incorporate it in their classes, and (3) their beliefs about the value of "good teaching" and their confidence on teaching-related items (e.g., preparing teaching materials, encouraging student interactions, etc.). Respondents were also asked to explain their comments for additional qualitative analysis. Demographic data such as gender, race/ethnicity were not collected for this analysis. Not all the TAs who responded to the survey answered all of the questions; therefore, some questions may be oversampled by particular populations.

For this study, descriptive statistics were obtained and the quantitative responses are primary; however, selected quotes are highlighted to further illuminate key numerical findings. Open-ended survey responses were coded by quantifying the frequencies of particular responses and identifying emerging themes. To improve the trustworthiness of these findings, the open-ended responses were initially coded and then recoded one month later.

3.1 Data Analysis

Descriptive analysis of the online survey data included (1) background experiences (teaching terms and primary responsibilities), (2) whether GSIs were able to incorporate active learning in their classes, (3) GSIs' confidence on teaching-related items (thinking of their students as "active learners" and encouraging student interactions), and value GSIs placed on good teaching. Two-tail independent t-tests were used to determine significance. Then, we developed an alternative measure for active learning use by counting only respondents who indicated they had tried one or more specific teaching methods. This logistic regression was used because of the lack of variation in the initial responses to active learning use and the uncertainty about how respondents interpreted "active learning."(See "Re-characterization of 'active learning' use" in section 4.2 for additional details).

3.2. Respondents

Seventy-three engineering TAs provided information about their backgrounds and their perceptions to inform this research. Nearly half of the respondents (47%) were appointed as new

TAs during the semester, while 34% taught for two terms and 19% taught for 3 or more terms (Table 1). Based on past surveys, this trend, where the bulk of respondents have taught for primarily 1-2 terms, is typical for TAs in the College of Engineering at this university. A slight majority of respondents (about 56%) were TAs for courses in electrical engineering & computer science (EECS), mechanical engineering (ME) or industrial and operations engineering (IOE). For the past 10 years, the relative percentages of TAs across departments have remained relatively constant. Holding office hours and e-mailing students are activities done by over 85% of the respondents; nearly 55% of the respondents attend classes, grade exams and create solutions for homework, exams, etc. Activities such as teaching a discussion section or creating assignments are done by nearly 40% of the students. Only about 30% teach a lab, hold review sessions, maintain a website, give occasional lectures, and supervise graders. Although some TAs have multiple responsibilities, the primary teaching duties of engineering GSIs in this study were to (1) teach a lab (27%, N=20), (2) teach a discussion section (26%, N=19), (3) hold office hours (22%, N=16) (4) grade homework, papers, labs or projects (10%, N=7), (5) give lectures (7%, N=5) or (6) supervise team projects (4%, N=3).

Table 1. Teaching Assistant Background Characteristics for Winter 2012

	Winter 2012	
	Number	Percentage
Terms Teaching		
One	34	46.6%
Two	25	34.2%
Three or more	14	19.2%
TOTAL	73	100.0%
Teaching Department		
Aerospace Eng.	2	2.7%
Atmospheric & Space Sciences Eng.	1	1.4%
Biomedical Eng.	5	6.8%
Civil and Environmental Eng.	8	11.0%
Chemical Eng.	10	13.7%
Electrical Eng. & Computer Science	24	32.9%
Engineering First Year Programs	2	2.7%
Industrial and Operations Eng.	8	11.0%
Mechanical Eng.	9	12.3%
Materials Science & Eng.	3	4.1%
Nuclear Eng. & Radiological Sciences	1	1.4%
TOTAL	73	100.0%
Teaching Responsibilities*		
Hold office hours	64	87.7%
Attend class	42	57.5%
Teach a lab	24	32.9%
Teach a discussion section	28	38.4%
Give lectures (not in a discussion section or lab)	23	31.5%
Grade homeworks or papers	17	23.3%
Grade exams	43	58.9%
Grade student labs or projects	29	39.7%
Supervise team projects	12	16.4%
Supervise graders	23	31.5%
Hold review sessions	24	32.9%
Email with students	68	93.2%
Maintain website	24	32.9%
Create assignments (homework, exams, etc.)	33	45.2%
Create solutions (homework, exams, etc.)	41	56.2%

*TAs were allowed to choose more than one option, so percentages do not add up to 100%

4. Presentation and Discussion of Findings

To understand engineering TAs' perceptions of active learning, we'll first examine how TAs define active learning, their successes with this teaching method including types of methods used, frequency of use, and perceived success. In addition, the challenges associated with active learning will be described including self-reported barriers to its use. In the later half of this section, specific factors will be analyzed to determine whether or not engineering GSIs in this study adopt active learning techniques. The particular factors under consideration are the GSI's teaching experience (i.e., number of terms teaching), teaching responsibilities, their interactions with a peer teaching mentor, and perceptions of "good teaching" and confidence about particular teaching-related factors (i.e., perceiving students as active learners and encouraging student interaction).

4.1. How do graduate student instructors describe 'active learning' and use these teaching methods in their classes?

Definition of Active Learning

All TAs (new and returning) were asked to define the term "active learning." Forty-eight out of 73 TAs provided a definition (66% response rate for this question). The most common definitions included specific examples of classroom activities (N=13), or the use of words such as "engagement" or "engage" (N=12) and "participation" or "participate" (N=11). In addition, TAs also defined active learning in terms of what it is *not*, namely, not passively listening to lectures or simply lecturing (N=12). Some TAs also defined active learning in terms of "interaction" (N=5). Some examples are listed below:

> "Having more than just a straight lecture-style of teaching, by engaging the students with lots of questions or activities such as multiple-choice questions, case studies, talk to a partner about a topic, write for a couple minutes by yourself about a topic, etc." (1st term TA)

> "Students are actively engaged with the learning process. Unlike traditional lectures, active learning involves mini discussion groups, individual brainstorming and the like to spark students' understanding and connections." (1st term TA)

> "Learning that occurs by taking action, as opposed to passively listening and taking notes on a lecture. Examples of active learning include asking the class questions for them to think about, getting the class to answer those questions, having students discuss problems in small groups, or having students vote on questions." (3rd Term TA)

> "…Active learning is an approach to teaching by which students actively engage with the material while they are learning it, and in order to learn it. This may involve working on real-world problems in class (alone or in groups), or discovering/creating knowledge for themselves. …" (6th Term TA)

In general, the definitions posed showed at least a fundamental understanding of active learning and how it may be used in the classroom. Recall, that engineering TAs at this university are required to attend an advanced practice teaching session where they are to present a 10-minute lesson using active learning to a small group of their peers. Therefore, this level of familiarity with the terminology is not surprising. However, the subsequent sections will explore whether or not TAs are able to apply this knowledge in their own teaching contexts.

Success with Active Learning

All respondents where asked, "Did you ever use active learning teaching methods in the class you taught this semester?" While the majority of respondents (75%) indicated that they used active learning teaching methods at some point during the term, their explanations highlight the varying degrees to which they integrated active learning into their classroom. Out of the 48 TAs who claimed to use active learning, 31 explained their response (65%). The most commonly cited explanation was a description of their classroom activities (N=28). Specifically, respondents said that they asked questions (N=12), had students solve problems (N=9), and gave group work (N=7). It is interesting to note that all but one of the six specific active learning teaching methods that were selected for TA training were mentioned (N=13). Cooperative groups (or group work) was the most prevalent of the 6 strategies (N=7) followed by think-pair-share (N=4). Minute paper, brainstorming, and case studies were mentioned once. Inquiry learning was not mentioned by the respondents. Some sample responses are shown below:

> "I try to ask questions to my class and wait for them to think about it, then respond. I have also, more rarely though, asked students to briefly discuss a problem with their neighbors." (3rd term TA)

> "I had students work through numerical problems in class and then share their answers with the group, instead of just demonstrating the problems on the board. I asked the student's questions during class to find out how much they already knew about the material." (1st term TA)

For those TAs who reported that they used active learning during the term (N= 48), they were also asked how often they used active learning teaching methods (Figure 1). TAs were most likely to use active learning once a week (N=11) or once per class (N=9). Since discussion and lab sections are typically held only once a week, it seems to indicate that this is the most common choice. Fifteen TAs offered additional explanations about their frequency of use. One of the 3 TAs who explained why he/she used active learning "2 or more times per class" said, "The most common active learning technique was asking students how to approach solving a problem after they had spent time attempting to do so on paper." Another TA who reported using active learning "once a class" said, "I generally used think-pair-share, especially on topics that had long derivations." These responses highlight an awareness of engaging pedagogies from new and returning TAs and focus on the student experience. These kinds of sentiments reflect a shift from a "senior learner" dimension of TA development, which is more instructor-centered, to a more advanced dimension.[15]

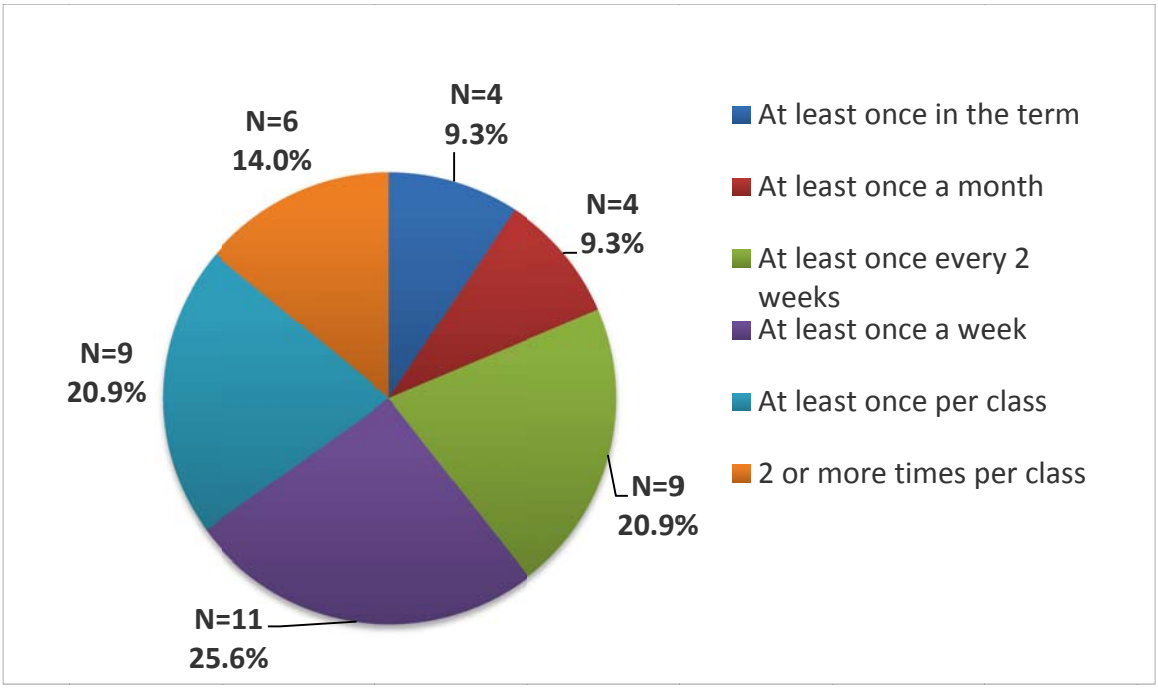

Figure 1. TAs' responses to the question, "How often did you use active learning techniques in your class this term?"

The majority of TAs (64%) who reported using active learning indicated that they were only "somewhat successful" implementing these strategies in their class, 12% reported being "very successful," while 17% reported being "unsuccessful" and 7% were "very unsuccessful" (Figure 2). For this question, only 14 TAs provided further explanation. Since the majority of the comments were from "somewhat successful" and "very successful" TAs, these comments centered around TAs receiving positive student feedback (N=11), and recognizing students being able to demonstrate their comprehension in a deeper way (N=2).

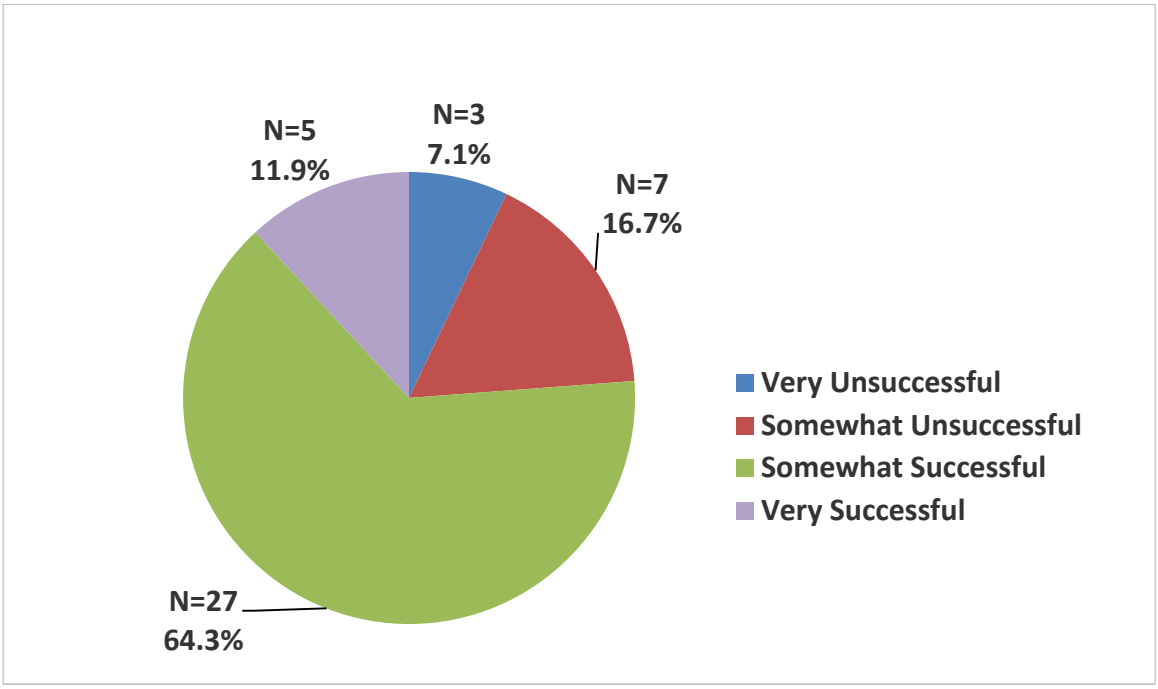

Figure 2. TAs' responses to the question, "Overall, how successful were you teaching with active learning techniques in your class this term?".

Challenges with Active Learning

Although some respondents indicated that they did use active learning at least once during the term, their explanations indicate some concerns or the barriers TAs faced when implementing more engaging pedagogies. These explanations included student resistance (N=2), lack of comfort with the approach (N=1), insufficient time to prepare/plan lessons (N=1), and a perceived disconnect between active learning methods and their teaching context (N=1). For instance one TA, who indicated that they were somewhat unsuccessful said, "While I know that the methods do help students to learn the material, I'm not sure how to use the techniques and still cover all the material I need to."

For the less frequent users of active learning, the few responses highlight some struggles they had with implementing the process. For instance, 24% of TAs who responded that they used active learning reported being "unsuccessful" or "very unsuccessful." The few who offered explanations described facing student resistance (N=4), and being able to apply active learning to their teaching context (N=1). For instance one TA who used active learning once every two weeks, but was "somewhat unsuccessful" said, "I try to at least have some sample questions for them when we don't have too much material to go over for active learning to be practical. Occasionally I'll ask them to work in teams for 20 minutes to solve a more involved problem but then they just sit there and don't do anything." This example of student resistance is supported by previous research which indicate that some barriers (e.g., institutional, cultural, lack of role models etc.) may exist to prevent TAs' from successfully adopting best teaching practices . [11]

Those TAs who did not use active learning were asked to describe their reasons for not using active learning. Sixteen respondents answered "no" to the question, "Did you ever use active

learning teaching methods in the class you taught this semester?" They were also asked to select reasons why they did not use active learning teaching methods (Figure 3). The most commonly cited reason was "I did not know how to use it in my class" (41%, N=7). For instance, one second term GSI said, "I have had the effectiveness of active learning in view, but I have not used specific methods. The reason is that these active methods, while I see their motivation, in practice seem awkward and contrived." One first term GSI said, "I taught one lecture, and I pretty much just went by the material in the slides the professor gave me. I was nervous and just wanted to get through it…" A second reason for not using active learning is that the TAs felt that their "teaching responsibilities did not allow them to use active learning" (35%, N=6). Finally, TAs did not feel as though active learning was necessary (29%, N=5) or didn't have time to plan for it (24%, N=4). While these responses comprise a small number of respondents, these responses warrant further study.

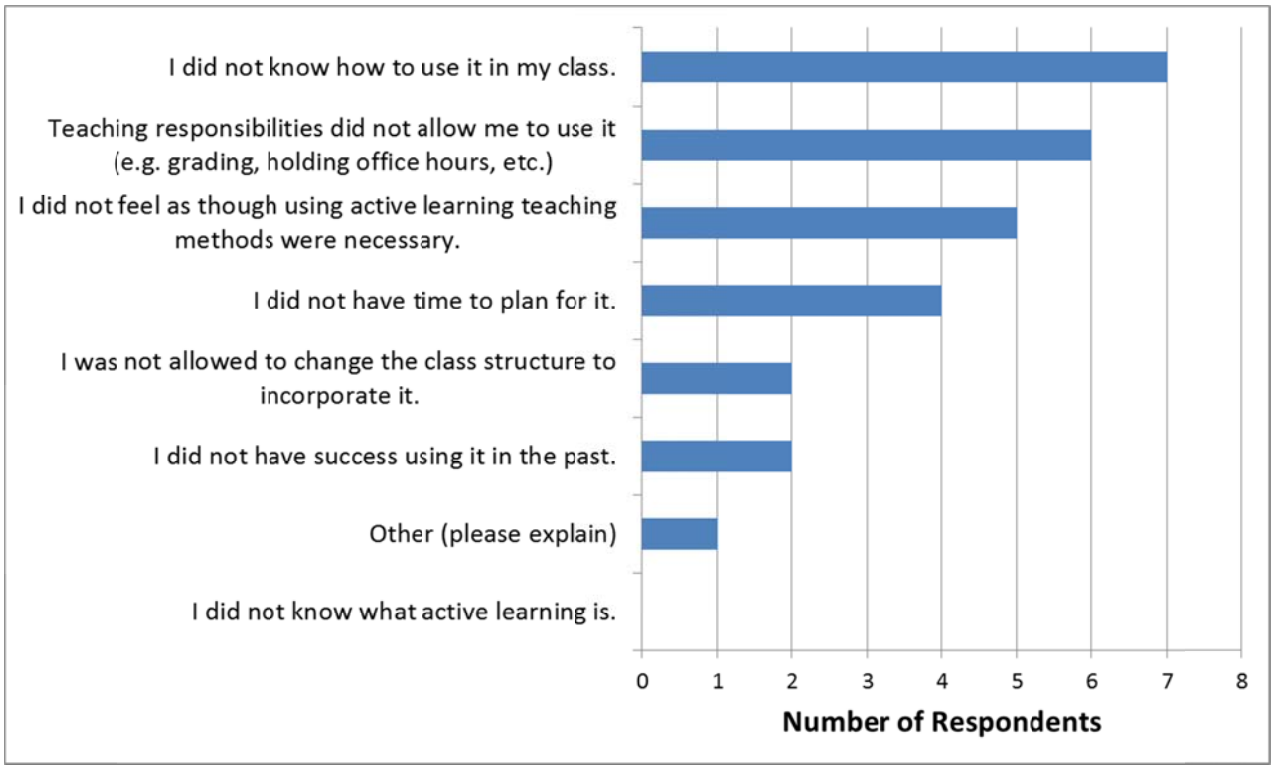

Figure 3. Reasons why TAs chose not to use active learning during the term.

4.2 What factors contribute to the likelihood that a graduate student instructor will adopt the use of active learning in their teaching practice?

To determine whether or not particular factors are associated with TAs' adoption of active learning teaching methods, the following variables were analyzed statistically: number of terms taught, teaching responsibilities, interactions with a peer teaching mentor, and their self-reported beliefs about the value of good teaching and confidence levels. To initially test for significance, we examined the graduate students response to the question, "Did you ever use active learning teaching methods in the class you taught this semester?" against the parameters listed previously. Using two-tailed independent t-tests, the only significant factor in this study was the participants' confidence about thinking of students as active learners (β=1.40, S.E.=0.70, $p<0.05$). In other

words, those TAs who indicated that they perceive students as being "knowledge builders" rather than "information receivers" were more likely to report that they used active learning. In particular, 42 out of the 62 TAs who were "very confident" or "confident" self-reported that they used active learning. Examining the 15 TAs who were "very confident" in their ability to perceive students as active learners, the majority (73%) used active learning at least once/week (N=6), once/class (N=2) or more than twice per class (N=3). One first term graduate student instructor (GSI) described his or her class as follows:

> "We have discussion sessions that allow students to work with the GSI on problem sets, as well as clear up concepts that are unclear in class. These sessions allow for a back and forth interaction, rather than just being lectured at. We also make use of a variety of teaching demonstrations and computational resources to flesh out complex concepts from the course."

In addition, 83% of those "very confident" TAs who responded to the survey question (N=10) indicated that they were either "somewhat successful" or "very successful" when implementing active learning. When asked to explain, one second term TAs said, "when I use active learning the students actually think about the question and get involved, which was exactly what I was looking for." It is interesting to note, that the 15 TAs who were "very confident" about perceiving students as active thinkers consisted of 6 first term TAs, 4 two term TAs, and 5 three or more term TAs.

Re-characterization of "active learning" use

Recall that 75% of the respondents (N=48) indicated that they used active learning, but many reported different approaches, frequencies of use, and success rates. To take this variation into account, we analyzed responses to another question that asked TAs, who originally indicated that they used active learning, whether they used a range of specific teaching methods. This list of teaching methods highlights a range of possible approaches that vary from instruction that is teacher-centered to student centered (Table 2). These teaching methods were adapted from an internal faculty survey to incorporate approaches that TAs could use to make office hours, labs and discussions more "active." Over 60% of respondents indicated that they paused during a lecture for students to ask questions or review notes. Recall that during the main orientation for new TAs, they are presented with the educational research basis for this practice as reported by Ruhl et. al. (1987).[22] Over 40% of respondents said that they asked students to think aloud in an office hour setting (45%), asked content questions about a demonstration or lab (45%), had students solve problems with class discussion afterward (43%), and lectured with at least 15 minutes for discussion (43%). They were least likely to choose more challenging student-centered activities such as role playing (0%), students-developed questions to lead the discussion (2%), and student presentations individually (2%) or in small groups (5%). It is important to note, that some of these activities might be less applicable for graduate students who may not have the autonomy to design such activities.

From this list of 23 teaching approaches, eight were chosen to create a new way to define which students used active learning that was based on specific active learning teaching methods and not self-reported perceptions. While there are a range of teaching methods that could have been chosen for this analysis, this new definition for active learning use is based on approaches that

are relatively easy for graduate students to implement, yet would require some amount of preparation time in order to fully develop the activity. Further, the selected teaching methods reflect those approaches that were most applicable to the discussion and laboratory environments and not necessarily for those instructors whose primary responsibility was to grade.

The following 8 teaching methods reflect these choices:

- I led a class discussion about an audiovisual stimulus (e.g. a graph, schematic, flow chart, photograph, etc.)
- I had students solve a problem without having class discussion afterward.
- I had students solve a problem that was followed by at least 15 minutes of class discussion.
- I had students solve a problem that was followed by a significant class discussion lasting 15 minutes or more.
- I had students engage in a problem solving game or simulation.
- I had students engage in a brainstorm activity.
- I assigned a small group discussion focused on structured questions or in class problems.
- I assigned a student-centered class discussion (i.e. students developed the questions and led the discussion that followed)

Using this measure, the respondents were more evenly split in that (51%) used at least one of these measures. In terms of teaching responsibilities, there is good representation of those who are teaching discussions, labs, etc. who used and did not use active learning. Specifically, of the 30 who reported using active learning, 23% held office hours, 23% taught labs, 20% taught discussion sections, 17% gave lectures as their primary duty. The remaining 17% supervised team projects, created assignments, or did not respond to the survey about their primary duty. Although those TAs whose primary responsibilities were to grade homeworks or labs are entirely represented in the "did not use active learning" category, this distinction was expected. Once again, there were no statistically significant differences between the various factors, however the trends provide some interesting insights.

Table 2. Range of specific teaching methods TAs used in their classes

Teaching Method	*Percent*	*Number*
I lectured and paused from time to time so students could ask questions or review their notes.	64.3%	27
I asked students to think aloud about how to solve a problem in office hours.	45.2%	19
I asked students content questions about the demonstration or lab.	45.2%	19
I had students solve a problem that was followed by at least 15 minutes of class discussion.	42.9%	18
I lectured with at least 15 minutes of time devoted to class discussion and questions.	42.9%	18
I had students solve a problem on their own in office hours.	38.1%	16
I used demonstrations.	38.1%	16
I had students engage in a brainstorm activity.	35.7%	15
I had students teach one another in office hours.	31.0%	13
I asked students to apply their knowledge about the demonstration or lab to another context.	28.6%	12
I lectured for the entire period.	19.0%	8
I assigned a small group discussion focused on structured questions or in-class problem.	16.7%	7
I had students solve a problem without having class discussion afterward.	16.7%	7
I led a class discussion about an audiovisual stimulus (e.g. a graph, schematic, flow chart, photograph, etc.).	16.7%	7
I had students engage in a problem solving game or simulation.	14.3%	6
I gave a "surprise" short quiz (graded or ungraded).	14.3%	6
I had students complete a self-assessment activity (e.g. complete a questionnaire about their knowledge in or comfort with a particular topic).	11.9%	5
I had students solve a problem that was followed by a significant class discussion lasting15 minutes or more.	11.9%	5
I showed a film or video.	9.5%	4
I assigned small group presentations (e.g. debates, panel discussions).	4.8%	2
I assigned presentations to individual students (e.g. speeches, reports).	2.4%	1
I assigned a student-centered class discussion (i.e., students developed the questions and led the discussion that followed).	2.4%	1
I had students engage in a role playing activity.	0.0%	0

Teaching Experience & Responsibilities

Based on this characterization, analysis shows that TAs use of active learning teaching methods was independent of the number of terms teaching (Table 3). Specifically, 48% of all first term TA respondents, 53% of all second term TAs and 54% of all TAs who taught 3 or more terms used active learning. With more experience, one might think that TAs would be more willing to use active learning, however based on the previous discussion about the reasons why TAs do not use active learning, it seems reasonable that having difficulty translating the teaching methods to each teaching context and student population may be one of the reasons why the use of active learning does not necessarily increase with terms taught.

With regards to TAs' teaching responsibilities, the analysis focuses only on those TAs whose primary teaching duties were to teach a discussion, lab section, or lecture. Only a small fraction (N=8) who responded to this question were not included in this analysis. In all, 27 respondents used active learning. When sub-dividing this data set, there are too few TAs who responded in any particular category to provide meaningful statistical data about how the TAs responsibilities influenced their use of active learning.

Interactions with Peer Teaching Mentors

Contact with a peer teaching mentor was analyzed to determine whether or not this interaction results in increased active learning. Recall that during the main orientation, new TAs are introduced to these teaching mentors and all TAs have ongoing contact with them throughout the term via email and in-person consultations and gatherings.[12, 16,19, 20] About half of the respondents (N=32) indicated that they interacted with a peer teaching mentor (Table 3). There are several types of interactions which include resource emails about upcoming events and teaching-related support; general consultations about teaching via email, phone or in-person; collection of student feedback with a consultation; classroom observation with a consultation; and participation in a small group discussion with fellow TAs over lunch. Not all interactions with a peer teaching mentor have the same impact on the TA's use of active learning. Sixty-five percent of those TAs who had received student feedback or classroom observation used active learning teaching methods. In comparison, half of those who had other types of interactions and nearly 60% of those TAs who had no interactions with their peer teaching mentor did not use one of the 8 specific active learning techniques. Although the number of responses are low, this trend is informative because it suggests that working with a consultant has the potential to support TAs integration of active learning in their courses.

Table 3. Comparison of Teaching Assistants' Background Characteristics/Experiences & Use of Active Learning

	Used Active Learning		Did Not Use Active Learning	
	Number	Percent	Number	Percent
Terms Teaching				
One	15	48.4%	16	51.6%
Two	9	52.9%	8	47.1%
Three or more	6	54.5%	5	45.5%
Teaching Responsibilities				
Teach a lab	7	46.7%	8	53.3%
Teach a discussion section	6	42.9%	8	57.1%
Hold office hours	7	53.8%	6	46.2%
Grade*	0	0.0%	6	100.0%
Give lectures	5	100.0%	0	0.0%
Supervise team projects	2	66.7%	1	33.3%
Other/Unknown	3	100.0%	0	0.0%
Interaction with a Peer Mentor				
Gathering feedback, observations	13	65.0%	7	35.0%
Other interaction	6	50.0%	6	50.0%
None	11	40.7%	16	59.3%
Value				
Personally value "good teaching"				
Very high & high	24	54.5%	20	45.5%
Average	5	41.7%	7	58.3%
Very low & low	1	33.3%	2	66.7%
Confidence				
Think of students as active learners				
Very confident & confident	9	69.2%	4	30.8%
Neutral	15	57.7%	11	42.3%
Very unconfident & unconfident	6	37.5%	10	62.5%
Not applicable	0	0.0%	2	100.0%
Did not respond	0	0.0%	2	100.0%
Encourage Student Interaction				
Very confident & confident	8	72.7%	3	27.3%
Neutral	12	54.5%	10	45.5%
Very unconfident & unconfident	9	45.0%	11	55.0%
Not applicable	1	25.0%	3	75.0%
Did not respond	0	0.0%	2	100.0%

*Grading incorporates homework, papers, student labs or projects)

Beliefs about "Good Teaching" and Confidence

TAs were asked to rate the degree to which they personally value "good teaching." Nearly 75% (N=44) of the respondents indicated that they have a "very high" or "high" value for good teaching (Table 4). Since this study is conducted at a research university, it is important to note that the majority of the TAs who responded to this survey personally value "good teaching" even through they are in an intensive research environment. Upon further examination, only 54% of those who reported to have a "very high" or "high" value for good teaching (N=24) actually used active learning (Table 3). This result is based upon the modified definition of active learning, where respondents indicated which teaching methods they used in their classes. This represents only a slight majority over those students who personally value good teaching, but did not use one of the 8 active learning teaching methods.

Table 4. TAs' perceptions of their personal value of good teaching

	Winter 2012	
	Number	Percentage
Value placed on good teaching		
Very high	16	27.1%
High	28	47.5%
Average	12	20.3%
Low	3	5.1%
Very Low	0	0%
TOTAL	59	100.0%

Further, TAs were asked to rate their confidence on seven teaching related-items (Table 5). Over 80% of the respondents were "very confident" or "confident" about preparing teaching materials and spending time necessary to plan classes and office hours. There were two teaching-related items that had nearly 30% of the respondents indicating that they were "very unconfident" or "unconfident." These items were "think of my students as active learners, which is to say knowledge builders rather than information receivers" and "encourage the students to interact with each other." Both of these responses are strongly related to active learning and warrant further examination.

Table 5. TAs' responses to the question, "Rate your level of confidence for the following teaching-related items. How confident am I to …"

	very unconfident	unconfident	confident	very confident	N/A
Spend time necessary to plan my classes	6.3% (4)	3.2% (2)	47.6% (30)	3.3% (21)	9.5% (6)
Spend time necessary to plan for my office hours	4.8% (3)	1.6% (1)	50.8% (32)	31.7% (20)	11.1% (7)
Select appropriate material for class activities	6.3% (4)	6.3% (4)	50.8% (32)	23.8% (15)	12.7% (8)
Evaluate accurately my students' academic capabilities	6.3% (4)	19.0% (12)	42.9% (27)	27.0% (17)	4.8% (3)
Prepare the teaching materials I will use	6.3% (4)	3.2% (2)	41.3% (26)	39.7% (25)	9.5% (6)
Think of my students as active learners, which is to say knowledge builders rather than information receivers	9.7% (6)	19.4% (12)	43.5% (27)	24.2% (15)	3.2% (2)
Encourage the students to interact with each other	8.1% (5)	27.4% (17)	37.1% (23)	21.0% (13)	6.5% (4)

Using the modified definition of active learning, where respondents indicated which teaching methods they used in their classes, 13 out of the 59 respondents indicating that they were "very confident" or "confident" about thinking of students as active learners. Of these, 69% (N=9) used active learning teaching methods (Table 3). The majority of all of the respondents (26 out of 59) were "neutral" about thinking of students as active learners. Not surprisingly the majority of the respondents who were "very unconfident" or "unconfident" (10 out of 16 respondents), *did not* use active learning teaching methods (Table 3). Although these results are not statistically significant, most likely due to the low number of respondents in this survey, the same trend is true for those who have high confidence levels in encouraging student interaction. Seventy-three percent of those respondents who were highly confident about their ability to encourage student interaction (8 out of 11) used use active learning, while 55% of those who were "very unconfident" or "unconfident" did not use one of the 8 active learning teaching methods in the analysis.

5. Recommendations

These preliminary results highlight a few recommendations for engineering faculty supervising TAs and faculty & faculty developers who are responsible TA orientations. Providing TAs with some initial pedagogical training has been advocated for years, but it is helpful to create an environment where TAs are informed about the research basis for the use of active learning. Recall, that TAs were more likely to use active learning in their classroom if they reported that they "think of students as active learners rather, which is to say knowledge builders rather than information receivers." In particular, it may be helpful for faculty to review some of the educational literature[4, 7,13,17,23] to inform TAs about educational research which support the use of active learning. Recall that TAs receive a brief overview of some of the educational research which highlights the benefits of active learning during the initial orientation. Further, the program organizer meets with the workshop co-facilitators to ensure they are using appropriate active learning techniques during the session, as well as, spending time reflecting with the TAs about the types of active learning used in the workshop. This metacognitive approach is

particularly valuable in the "Teaching a Discussion" workshop because it provides concrete examples of how active learning techniques are used in practice.

It is also valuable to give TAs the opportunity to implement these teaching methods in a low-stakes environment. The practice teaching session focusing on active learning was specifically designed for this purpose. Since the TAs often reported using many of the approaches used it the advanced practice teaching, it is recommended that designers of TA training suggests strategies that are easy to implement in the engineering environment (such as the think-pair-share). Further, more challenging active learning techniques may be introduced in workshops later in the term since they are less likely to be implemented by the majority of new TAs (such as inquiry learning). Likewise, engineering faculty who supervise TAs, should consider talking with TAs about the interactive teaching methods they use in the classroom to support student learning, which would provide TAs with a faculty role model. The following resources are valuable to faculty and the TAs they supervise:

- *Recommendations for making active learning work and video examples*: http://www1.umn.edu/ohr/teachlearn/tutorials/active/recommendations/index.html
- *Videos of faculty teaching in the classroom using active learning*: http://www.engin.umich.edu/teaching/crltengin/
- *Videos of experienced TAs showing different elements of a lesson (i.e., interactive introduction, in-class activity, etc.): http://www.engin.umich.edu/teaching/crltengin/gsi_serv/gsitraining/practiceteaching.html*
- *Engineering faculty narrative and resources for incorporating active learning techniques:* http://depts.washington.edu/next/storyID_07538.php

Even when TAs are familiar with the term "active learning," it may be helpful to provide additional support when they are attempting to implement these teaching methods. As reported in the literature, there are many barriers which may prevent TAs from attempting more engagement with their students.[11] Therefore, it may be helpful for new TAs to meet with a peer mentor trained to observe classes and gather student feedback. This type of peer-to-peer support provides a non-evaluative interaction and the peer mentor can brainstorm with the TA to customize the type of active learning that would be most effective for student learning and most comfortable for the TA to implement.

6. Conclusions and Future Work

This preliminary analysis of the perspectives of graduate student instructors at a large research institution shows that TAs self-report a high value for good teaching and are able to define 'active learning' in their own words. In particular, the majority of TAs in this study indicates that they did use active learning at some point in their classes. This fundamental knowledge about engagement pedagogies is established in part because of the College's commitment to teaching excellence and supporting the advanced practice teaching sessions, as well as the peer mentor program. In spite of this support, barriers exist which hinder TAs' ability to fully implement these approaches in their own classes.

While these results are promising, many questions still remain. How do students perceive the level of engagement of their TAs? It may be valuable to triangulate the TAs' perception of their

use of active learning with a classroom observation. In addition, are there other factors such as career aspirations, faculty support for the use of active learning in the classroom, and previous positive student experiences with active learning that are more likely to predict whether or not novice TAs use these engagement pedagogies in their class? Even further, are there additional questions that might illuminate TAs' motivation for using active learning based on self-efficacy or self-determination theory? These questions pose interesting directions for continued research. This approach to improving undergraduate education through the professional development of graduate student instructors has the potential to create a culture of active engagement among the graduate student population.

7. Acknowledgements

I would like to thank Kris Gorman, CRLT Postdoctoral Research Scholar, who conducted the statistical analysis for this project. Additionally, I am grateful to James Holloway, Associate Dean for Undergraduate Education and the College of Engineering for their continued support and commitment to excellence in graduate student instructor training and the Engineering Teaching Consultants program (peer mentor program).

References

1. Bullard, L., Felder, R., & Raubenheimer, D. (2008, June). *Effects of active learning on student performance and retention*. Paper presented at the 2008 American Society for Engineering Education Conference and Exposition, Pittsburgh, PA.

2. Center for Research on Learning and Teaching (n.d.) *A guidebook for University of Michigan graduate student instructors. University of Michigan.* Ann Arbor, MI. Retrieved from http://www.crlt.umich.edu/gsis/gsi_guide

3. Center for Research on Learning and Teaching in Engineering (n.d.) *Practice teaching*. University of Michigan. Ann Arbor, MI. Retrieved from http://www.engin.umich.edu/teaching/crltengin/gsi_serv/gsitraining/practiceteaching.html

4. Deslauriers, L., Schelew, E., & Wieman, C. (2011). Improved learning in a large-enrollment physics class. *Science*, *332*. 862-864. DOI: 10.1126/science.1201783

5. Golde, C.M., & Dore, T.M. (2001). *At cross purposes: What the experiences of doctoral students reveal about doctoral education*. Philadelphia, PA: Pew Charitable Trusts.

6. Hollar, K., Carlson, V. & Spencer, P. (2000). 1+1=3: Unanticipated benefits of a co-facilitation model for training teaching assistants. *Journal of Graduate Teaching Assistant Development*, *7* (3), 173-81.

7. Johnson, D.W., Johnson, R.T., & Smith, K.A. (1998). *Active learning: Cooperation in the college classroom*. Edina, MN: Interaction Book Company.

8. Kaplan, M. & Steiger, J. (2011). Strategies for incorporating theater in faculty development. In C. Cook & M. Kaplan (Eds.) *Advancing the culture of teaching on campus: How a teaching center can make a difference*. (pp. 183-195). Sterling, VA: Stylus Publishing.

9. Laws, P., Sokoloff, D., & R. Thornton, (1999, July) Promoting active learning using the results of physics education research, *UniServe Science News, 13.* Retrieved from http://science.uniserve.edu.au/newsletter/vol13/sokoloff.html

10. Luft, J.A., Kurdziel, J.P., Roehrig, G. H., & Turner, J. (2004). Growing a garden without water: Graduate teaching assistants in introductory science laboratories at a doctoral/research university. *Journal of Research in Science Teaching, 41* (3), 211–233.

11. McGivney-Burelle, J., DeFranco, T., Vinsonhaler, C., & Santucci, K. (2001) Building bridges: Improving the teaching practices of TAs in the mathematics department. *Journal of Graduate Teaching Assistant Development*. *8* (2) 55-63.

12. Meizlish, D.M., Pinder-Grover, T., & Wright, M.C. (2012). Effective use of graduate peer teaching consultants: Recruitment, training, supervision, and evaluation. In K. Brinko (Eds.), *Practically Speaking* (pp. 307-313). Stillwater, OK: New Forums Press.

13. Miyake, A., Kost-Smith, L.E., Finkelstein, N. D., Pollock, S.J., Cohen, G. L. & Ito, T.A. (2010). Reducing the gender achievement gap in college science: A classroom study of values affirmation. *Science*. *330* (6008). 1234-1237 DOI: 10.1126/science.1195996

14. National Academy of Engineering. (2005) *Educating the engineer of 2020: Adapting engineering education to the new century*. Washington D.C.: National Academies Press.

15. Nyquist, J. D., & Sprague, J. (1998). Thinking developmentally about TAs. In M. Marinkovich, J. Prostko, & F. Stout (Eds.), *The professional development of graduate teaching assistants* (pp. 61-88). Bolton, MA: Anker.

16. O'Neal, C. & Karlin, J. (2004). Graduate student mentors: Meeting the challenges of the ongoing development of graduate student instructors. In C. Wehlburg & S. Chadwick-Blossey (Eds.), *To Improve the Academy: Vol.* 22. Resources for faculty, instructional and organizational development, (pp. 320-332). Bolton, MA: Anker.

17. Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93* (3), 223-231.

18. Pinder, T. (2007) Teaching practice: Emphasis on active learning. In C. Ross and J. Dunphy (Eds.), *Strategies for Teaching Assistant and International Teaching Assistant Development*. (pp.76-79). San Francisco, CA; Jossey-Bass.

19. Pinder-Grover, T. Meizlish, D.M., & Wright, M. (2011). Graduate peer teaching consultants: Expanding the center's reach. In C. Cook & M. Kaplan (Eds.) *Advancing the culture of teaching on campus: How a teaching center can make a difference*. (pp. 80-90). Sterling, VA: Stylus Publishing.

20. Pinder-Grover, T., Root, S., and Cagin, E. (2008, June). *Preparing graduate students to be successful as teaching mentors and as future professionals*. Proceedings of the 2008 American Society for Engineering Education Annual Conference and Exposition, Pittsburgh, PA.

21. Prieto, L., Yamokoski, C. & Meyers, S. (2007). Teaching assistant training and supervision: An examination of optimal delivery modes and skill emphases. *Journal of Faculty Development. 21* (1). 33-43.

22. Ruhl, K., Hughes, C., & Schloss, P. (1987, Winter), Using the pause procedure to enhance lecture recall, *Teacher Education and Special Education*, 10, (14–18).

23. Smith, M. K., Wood, W. B., Adams, W.K., Wieman, C., Knight, J.K., Guild, N. & Su, T.T. (2009). Why peer discussion improves student performance on in-class concept questions. *Science*, *323* (5910). 122-124. DOI:10.1126/science.1165919

24. Stice, J., Felder, R., Woods, D. & Rugarcia, A. (2000). The future of engineering education IV. Learning how to teach. *Chemical Engineering Education, 34* (2), 118–127.

Appendix A

Engineering Graduate Student Instructor
Teacher Training
Agenda

January 2012
9:00 a.m. — 4:30 p.m.

9:00—9:25	Registration and breakfast

9:25—9:55	Welcome remarks

Overview of Engineering GSI Teacher Training
Welcome from the College

10:00—10:55	Concurrent session A

Teaching a Discussion Section .....
Strategies for Organizing & Teaching Lab Sections .....
Handling Office Hours .....

11:00—12:30	Plenary session

Climate in the Classroom: A Theater Performance
Information about practice teaching and active learning

12:30—1:00	Lunch

1:00—1:55	Concurrent session B

Teaching Problem Solving Skills .....
Handling Office Hours .....
Grading: Policies, How to, and Tips.....

2:00—2:30	Graduate Student Union Informational Session: Employee Rights & Responsibilities

2:30—2:40	Break and travel time

2:40—4:30	Practice teaching sessions

Practice teaching sessions will be in various rooms on campus.

Advanced Practice Teaching Sessions

Please register for **one** of four available advanced practice teaching sessions listed below

- Session 1. Wednesday afternoon, 01/18/12. 2:45—5:15 p.m.
- Session 2. Wednesday evening, 01/18/12. 5:00—7:30 p.m.
- Session 3. Thursday afternoon, 01/19/12. 2:45—5:15 p.m.
- Session 4. Thursday evening, 01/19/12. 5:00—7:30 p.m.

Appendix B. Examples of active learning strategies required during advanced practice teaching

Active Learning Technique	**Sample Teacher Instructions to the Class+**
Minute Paper. This writing activity gives students the opportunity to reflect on their learning during a given lecture (Angelo & Cross, 1993).	"*Today, we discussed conductive heat transfer. List as many of the principal features of this process as you can remember. You have two minutes – go."*
Think-Pair-Share. First, students work on a given problem individually, then compare their answers with a partner, and synthesize a joint solution to share with the class.	*"Now that I've gone through this example, I'd like for you to work by yourselves for 2-3 minutes to solve this second example. I will give you time to discuss your approach with a neighbor before I call on groups of students to share their answers."*
Brainstorming. Individually or in groups, students write down their ideas about a particular subject/question without initially evaluating the response.	"*What are possible safety (environmental, quality control, etc.) problems we might encounter with the process unit we just designed?"*
Case Studies. Use real-life stories that describe specific challenges and/or dilemmas to prompt students to integrate their classroom knowledge with their knowledge of real-world situations, actions, and consequences.	*"I've given you a news article describing an explosion in a chemical plant. Discuss with a neighbor possible reasons for the accident using principles from this class. Later, you will act as investigators and generate a list of questions that you want to ask the plant operators about the cause of the accident."*
Inquiry Learning. Students use an investigative process to discover [scientific or engineering] concepts for themselves by making observations, posing hypotheses, and speculating conclusions.	*"I would like for you to interpret the pressure verses volume graph, and generate a hypothesis about the trends. Write your responses down and if you finish early think about how you might test your hypothesis."*
Cooperative Groups in Class. The instructor poses a question for each cooperative group to work on while the instructor circulates around the room answering questions, asking further questions, keeping the groups on task, and so forth. After an appropriate time for group discussion, the instructor asks students to share their discussion points with the rest of the class	*"As a group, I would like for you to experimentally investigate the stability differences between rear wheel brake lockup and front wheel brake using the model car provided."*

[+]Sample teacher instructions were developed by graduate student peer teaching mentors (Engineering Graduate Student Mentors/Engineering Teaching Consultants) and/or staff at the Center for Research on Learning and Teaching in Engineering.