What's stopping them? Perspectives of teaching assistants on incorporating diverse teaching methods

Ms. Martha E. Grady, University of Illinois, Urbana-Champaign

Martha E. Grady is a doctoral candidate within the department of Mechanical Science and Engineering at the University of Illinois at Urbana-Champaign. She holds a B. S. degree in Mechanical Engineering from the University of Central Florida and an M.S. degree in Theoretical and Applied Mechanics from the University of Illinois at Urbana-Champaign. She intends to finish her doctoral degree in Theoretical and Applied Mechanics in the Spring of 2014. Her research interests include active learning techniques, peer to peer learning, and participation of underrepresented groups in engineering.

Mr. Ryan Christopher Reuer Gergely, University of Illinois at Urbana-Champaign

Ryan Gergely is a Ph.D. candidate in the Department of Mechanical Science and Engineering at the University of Illinois at Urbana-Champaign where he is pursuing a degree in Theoretical and Applied Mechanics. He received his B.S. (2006) and M.S. (2010) in Mechanical Engineering from Rose-Hulman Institute of Technology. He plans to finish his studies at UIUC in 2015

What's stopping them? Perspectives of teaching assistants on incorporating diverse teaching methods

ABSTRACT

The benefits of active learning have been demonstrated in recent research. Still, instructors of courses particularly in engineering hesitate in adopting such methods, teaching assistants included. This paper discusses an online survey sent to teaching assistants within the mechanical engineering department at a research university where information was collected regarding perspectives and practice of non-traditional teaching techniques. The survey contained eight items that included a mixture of selected response and open-ended response. Motivated by the outcomes of the survey, this paper then presents a variety of teaching activities tailored to overcome the barriers that teaching assistants face in incorporating diverse teaching methods. The 'tricks of the trade' that are selected require modest preparation and few resources that instructors can easily incorporate into the lecture to break up the pace, regain focus, and strengthen the amount of information retained. At institutions where a smaller discussion section supplements a large lecture, the reduced class size is ideal for a novice instructor to introduce unfamiliar teaching methods. The included techniques (pauses, think pair share, minute papers, effective questions, and a flipped review session) are specifically adapted for use in engineering courses and personal examples from the classroom are given.

Introduction

Engaging students within the context of lecture-based courses is a key challenge for engineering faculty. One of the principles for good practice in undergraduate education is for instructors to encourage active learning.[1] Active learning at its core is engaging students into active participation (e.g., discussing, questioning, sharing, doing) rather than passive participation (e.g., listening).[2] Lectures traditionally promote only passive participation and suffer because attention spans are finite.[3] The instructor can, however, incorporate active learning activities into the lecture though few instructors within engineering choose to do so. One unheard voice is that of teaching assistants. At many universities, teaching assistants are employed to lead discussion sections, provide grading assistance, and provide laboratory assistance. The purpose of this report is twofold: 1) To describe perspectives of engineering teaching assistants on incorporating non-traditional teaching methods and 2) To propose methods that minimize the perceived barriers reported by engineering teaching assistants.

An online survey was chosen as the assessment method to describe perspectives and practice of engineering teaching assistants. The use of surveys for assessment in engineering education is a common practice.[4] This method was chosen because it provides a way to capture data that cannot be observed. To attempt to control question bias an expert reviewed the survey prior to

administration, a common and accepted method for validating survey questions.[5] Another common concern of surveys is low response rates, however this study recorded a high response rate (47%). Similar surveys of teaching methods and barriers to using student-centered and research-based learning methods have been conducted at the faculty level.[6]

Survey

An anonymous and voluntary survey was sent via e-mail to 107 current teaching assistants within the mechanical engineering department at a research university. The survey was sent the morning of Monday Nov 18th 2013, a reminder email was sent the afternoon of December 3rd and the survey was closed that evening at 8pm. The total time of collection was 16 days. The response rate (47%) was satisfactory to obtain trends and represent the population of teaching assistants in mechanical engineering at the university.

The electronic survey consisted of 8 multiple choice and short answer questions administered through an online survey provider, Survey Monkey. Items 1-3 were designed to elicit background information about the study's participants. These items addressed a) the type of teaching assistantship held (e.g., grader, lecturer, discussion leader), b) the TA's year in graduate school, and c) his/her current career interests. These questions were required to be answered by each participant. Item 4 was also required and asked if participants had an instruction portion in front of students during their assistantship. If participants did not have instruction duties, they were instructed to skip Items 5, 6, and 7 and continue to Item 8. Items 5 and 6 inquire about any teaching methods other than lecture that the participant used. If participants used alternative teaching methods or were familiar with methods other than lecturing, they were asked to provide those methods in open-ended response boxes. Item 7 instructed the participant to indicate the extent to which they believe that each of six prompts represent a challenge to using non-traditional teaching methods. Participants responded to a 5-point Likert-type scale from 'Strongly Disagree' to 'Strongly Agree' regarding prompts such as "Increased preparation time" and "Unfamiliarity with other methods". Item 8 was the final prompt and was an optional open-ended item that asked participants to briefly describe their perspective on the use of lecture as a teaching method in engineering courses. Items with multiple choices were randomized for each survey except for true or false, which appear in that order and number of years in grad school, which are listed chronologically. Survey responses and participants were all anonymous. A copy of the survey is included in the Appendix.

Analysis

The quantitative results to Items 1-7 are tabulated by the survey provider and reproduced here. Items with free response portions were produced as lists. Item 8, the free response question, was analyzed using a method of qualitative textual analysis applied by two separate individuals using the flow diagram in Figure 1. Where classifications on Item 8 differed between analysts, the response was discussed and together a classification was determined.

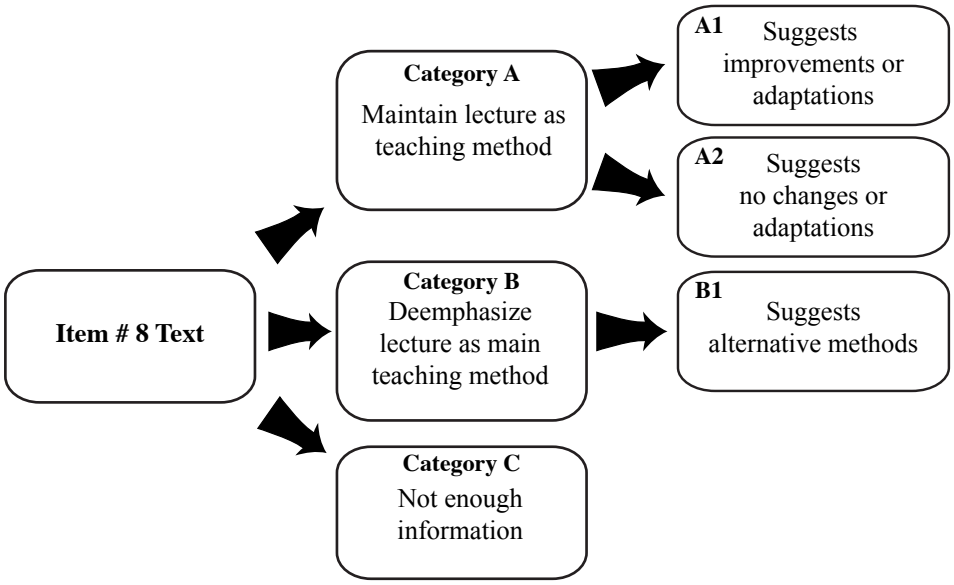

Figure 1. Flow diagram to sort responses to Item 8 into categories.

Responses were sorted into three categories: responses that indicated the lecture is to be maintained as a teaching method (A), responses that deemphasized the use of lecture as the main teaching method (B), and responses that did not include enough information (C). Of the responses in Category A, these were sorted into responses that suggested improvements or adaptations (A1) and responses that suggested no changes (A2). Category B was screened for responses that suggested alternative methods to lecturing.

Results

Items 1-3: Background Information

There were 51 participants who responded to Item 1 selecting as many categories as applicable and the fraction of responses are displayed in Figure 2. A majority of participants responded that laboratory assistant best describes their role in their current teaching assistant position. The second largest selection was a grader followed by discussion leader.

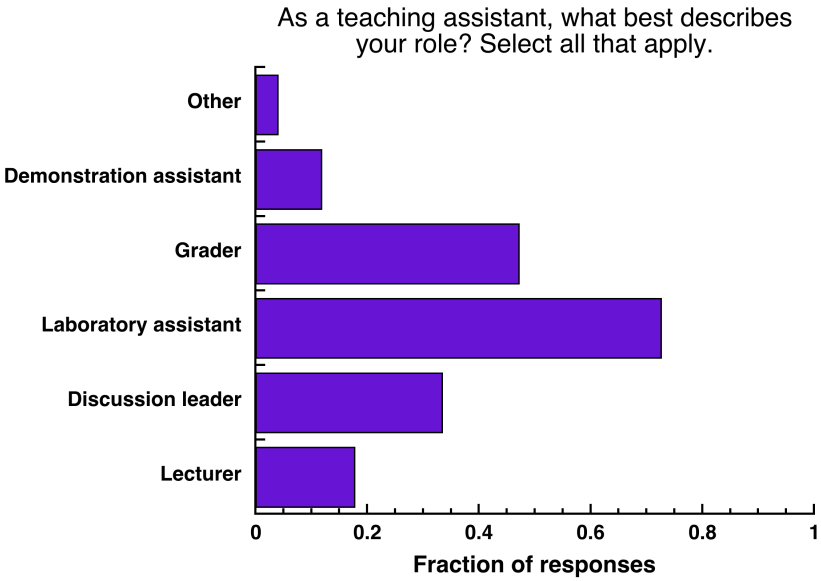

Figure 2. Distribution of responses to Item 1.

Item 2 was also required and therefore had 51 responses. The even distribution between the number of years in graduate school demonstrates participation by teaching assistants from all levels as seen in Figure 3.

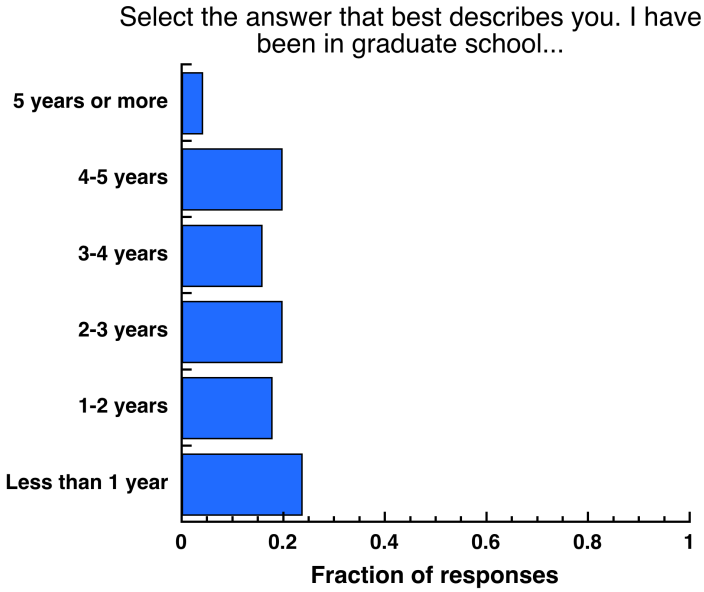

Figure 3. Distribution of responses to Item 2

Responses to Item 3 are shown in Figure 4 as an average rating where 1 represents "No interest" in career path, 2 represents "Some interest", 3 represents "Medium interest" and 4 represents "High interest." Overall respondents were most interested in industry and national laboratory career paths, while starting a company was ranked lowest overall. This item was required and received 51 responses though participants could skip ranking a certain prompt (a maximum of 5 participants skipped a particular prompt). The average ranking for the two faculty career paths

was compared to the average ranking for the other three career paths. There were 19 participants who ranked their interest in faculty career paths higher than the other three career paths, 29 participants who ranked interest in faculty career paths lower, and 3 participants whose average ranking was equal amongst the two groups.

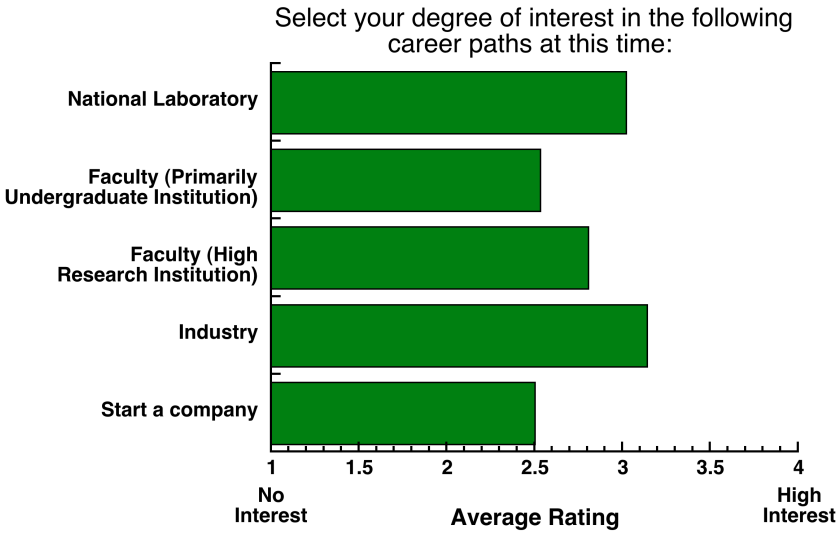

Figure 4. Average rating by respondents to Item 3.

Items 4-6: Teaching Practice

Item 4 asked participants to "Answer True or False: My role as a teaching assistant included an instruction portion in front of students." If they answered False, they were asked to skip down to Item 8. All others were to answer Items 5-8. This item was required and received 51 responses, of which 41 answered "True" and 10 answered "False." Items 5, 6, 7 were intended to probe the familiarity of the teaching assistants with non-traditional teaching methods. If the teaching assistant did not have an instruction portion in front of students, it is less likely they are familiar with instruction methods and would skew the results to Items 5, 6, and 7. The results of Items 5 and 6 appear in Table 1 below, where fractions are calculated for each selection out of the total number of respondents. For Item 5, participants could select more than one answer. For example, both "No I did not incorporate any additional methods" and "No, I do not know of any additional methods" could be selected simultaneously. In response to Item 5, a slim majority of participants (22 out of 39) indicated they did not incorporate teaching methods other than lecture, either they chose not to or do not know of any additional methods. However, Item 6 indicated that a stronger majority of participants (25 out of 37) do not know of any additional methods.

Table 1. Results of survey Items 5 and 6.

Item 5: Other than lecture, were there any teaching methods or learning activities (e.g., round table discussion, think pair share) you employed as a teaching assistant? Select all that apply.

Choices	# Selected	Fraction
Yes, I incorporated the following methods:	17	.44
No, I did not incorporate any additional methods	16	.41
No, I do not know of any additional methods	8	.21

Item 6: Please list any additional teaching methods or learning activities, that you are aware of, but did not use as a TA.

Choices	# Selected	Fraction
Additional methods I know:	12	.32
I do not know of any additional methods	25	.68

Item 7: Assessing barriers to diverse methods

Item 7 asked students to rate the degree to which they agreed or disagreed that a certain reason presented a significant challenge to incorporating alternative teaching methods. The participants responded on a 5 point Likert-type scale where 1 was "Strongly disagree", 2 "Somewhat disagree", 3 "No opinion", 4 "Somewhat agree", and 5 "Strongly agree". The responses where averaged across each prompt shown in Figure 5, where selections of "No opinion" were removed from the average. Therefore, an average rating above 3 indicated participants generally agreed that a particular reason was a challenge and an average rating below 3 indicated participants generally disagreed. A prompt of "Other methods are less effective" received an average rating of 2.89 and was the only prompt to receive an average score less than 3. Of the prompts that received an average rating greater than 3, the highest was that of "Main instructor's preference" receiving an average rating of 4.09. It can be inferred from such a high rating that this prompt over the others was the most significant challenge that teaching assistants must overcome to incorporate diverse teaching methods. The next highest ratings were "Unfamiliarity with other methods," which received an average rating of 3.80 and "Increased preparation time," which received an average rating of 3.79. The prompt "Lack of teaching experience" received an average rating of 3.55 and "Disinterest" received an average rating of 3.17.

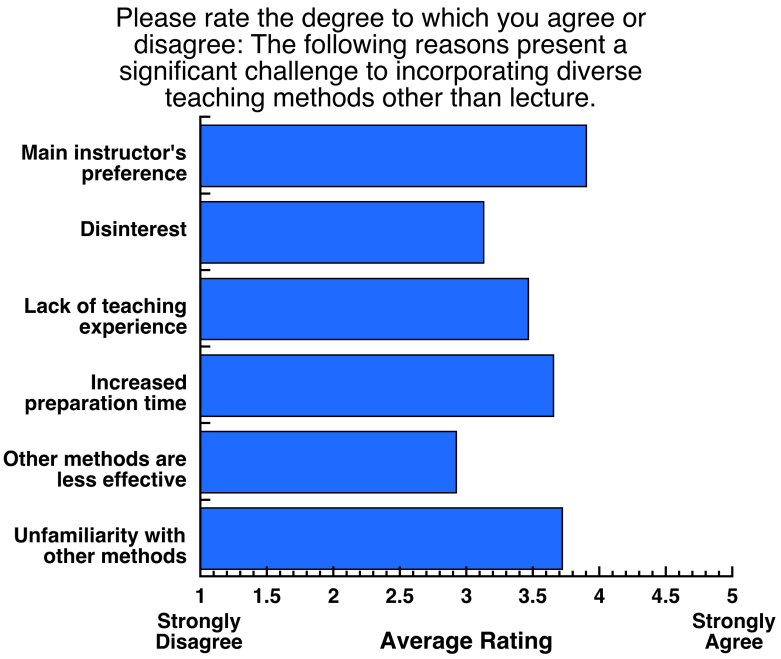

Figure 5. Average rating by respondents in response to Item 7.

In addition to calculating the average rating reported by survey participants, comparing the number of responses of agree or disagree is another measure of the results. Interestingly, the number of those who responded with "Somewhat agree" or "Strongly agree" on the prompt "Other methods are less effective" outnumber those who responded with "Somewhat disagree" or "Strongly disagree" 14 to 13. However, more respondents with an opinion on "Unfamiliarity with other methods" responded in agreement, 29, verses disagreement, 6. Thus many of the teaching assistants surveyed have little familiarity with other methods and yet agree that these other methods are less effective. The number of responses for each prompt in Item 7 are shown in Table 2.

Table 2. Number of responses for each prompt in Item 7.

Item 7: Please rate the degree to which you agree or disagree: The following reasons present a significant challenge to incorporating diverse teaching methods other than lecture.

	Strongly Disagree	Somewhat Disagree	No Opinion	Somewhat Agree	Strongly Agree	Total	Average Rating
Main instructor's preference	0	2	7	23	7	39	4.09
Unfamiliarity with other methods	2	4	4	22	7	39	3.80
Increased preparation time	1	6	7	18	8	40	3.79
Lack of teaching experience	3	6	6	18	6	39	3.55
Disinterest	5	6	10	17	2	40	3.17
Other methods are less effective	5	8	11	13	1	38	2.89

Item 8: Perspectives on lecture

There were 31 participants who supplied a response to Item 8, which represents a majority (60%) of participants who took the survey, a surprising result as many optional free response questions are often skipped. These responses were sorted into categories as described previously (Figure 1) and the number of responses in each category are shown in Table 3. A strong majority of participants indicated the lecture should be used as the main method of instruction (Category A). Of those in Category A, 42% indicated that the lecture should include other methods suggesting improvements or adaptations of the format (Category A1). However, responses sorted into Category A2 made up the majority of responses within Category A. There were 3 responses sorted into Category B that made statements that deemphasized lecture as a main teaching method and two of those suggested other teaching methods to replace the lecture. There were two responses sorted into Category C that did not provide enough information to be sorted into either Category A or B.

Table 3. Results of sorting Item 8 responses into categories.

Category	# Responses
A: Maintain lecture as teaching method	**26**
A1: Suggests improvements or adaptations	11
A2: Suggests no changes or adaptations	15
B: Deemphasize lecture as main teaching method	**3**
B1: Suggests alternative methods	2
C: Not enough information	**2**

While analyzing written responses we observed a few unanticipated results. Among the 31 respondents, 8 made reference to the shortfalls of either the professor or student in the current teaching environment, either implied or directly stated. For example: "(lecture is) the 'easy way out'", and "students tend to be fairly passive". Additionally, two respondents mentioned the necessity of lecture for large class sizes, and 5 respondents explicitly stated that the "analytical", "factual" or "theoretical" aspect of teaching engineering necessitates the lecture format.

Discussion

Overall the survey indicated that respondents had little familiarity with non-traditional teaching techniques and respondents generally agreed it posed a significant barrier to implementing diverse teaching methods. However, the greatest barrier perceived by teaching assistants was that of the preferences of the main instructor. We only know that the barrier is *perceived* by the teaching assistant and may not accurately represent an unfavorable disposition towards alternative teaching methods by the main instructor. The other two major barriers of "Increased preparation time" and "Unfamiliarity with other methods" can easily be addressed by giving teaching assistants resources on research-based teaching methods that require little preparation

time. Responses to Item 8 demonstrated that almost half of the teaching assistants surveyed were open to improving and adapting the lecture, some even opting to replace the lecture entirely. Of the 51 respondents, 19 indicated higher interest in a faculty career path so it is advantageous to provide teaching resources to train future faculty. We propose in the second half of this paper some active learning techniques that teaching assistants can implement into their courses.

Recent literature on active learning reviews the research, even addressing common problems interpreting the literature on active learning.[7] Prince's review suggests that although results may vary in strength, there is support for all forms of active learning examined. Active learning techniques also gain support from research on ways to engage effective information processing.[8] Given the perceived hurdles to incorporating diverse teaching methods into lecture, it is easy to see why teaching assistants are reluctant to implement them. Though a teaching assistant may be limited in their ability to make large structural changes to a course, there are several techniques that can be readily incorporated into an existing lecture that keep in mind the barriers teaching assistants face. The included techniques (pauses, think pair share, minute papers, pauses, effective questions, and a flipped review session) are specifically adapted for use in engineering courses by teaching assistants and personal examples from the classroom are given. These specific techniques were selected from the wealth of teaching activities because there is a large body of research touting their efficacy, they require little or no preparation time, and can be used by new teaching assistants without prior experience.

Tricks of the Trade

Pauses

It may seem counterintuitive but pausing the lecture may actually help students retain more information. Ruhl *et al.* adopted a pause method (two minutes) during lecture and found students were able to recall 20% more facts short term and score higher on exams in the long run.[9] An effective pause while lecturing is a simple suggestion, but with great benefits. It can be effective while moving between concepts within a lecture or while solving problems. The pause allows students the opportunity to clarify notes and read over what they have written (instruct them to do so). This allows the student another chance to encode this information into memory. This pause can also be an opportunity for the instructor to adjust pace, add a transition into the next topic, and field questions the students may have after realizing they missed something in their notes.

Think pair share, yes even in statics!

Think pair share is a common active learning technique used to generate discussion and interaction between students.[10] The common format is thus:

1. Have students respond to a question and give them a few minutes to write an answer
2. Ask students to pair up with another student or group
3. Ask for examples from students

This technique is better suited when questions are similar to:

- What methods can you use to solve this problem?
- Can you think of an experiment to test the solution?

For example, ask students to describe the types of problems where using the method of joints is applicable. Another example is to use this technique after solving for a coefficient of friction and asking students to come up with an experiment to test the solution. Questions that would be inappropriate for this method are asking students for an answer to a problem where only one correct answer is possible. For example, simply asking what the answer is to an equation.

Minute paper

Another common active learning technique that aids in the process of elaboration and retrieval of information is the minute paper.[11] The common format is simple:

1. Have students spend 3 minutes (or another short period of time) writing a summary of the main points of the lecture or a concept
2. Ask a few of them to read what they wrote

Minute papers are especially useful when there are a few minutes left in class but not enough to tackle another problem or concept. For example, ask students to summarize how to find zero force members in a truss or to compare/contrast the difference between a frame problem and a truss problem. Having students recall the information during class will increase the likelihood of recalling it later. The instructor may also choose to collect these minute papers as a form of ongoing assessment of what students are learning. Another more creative way to use the minute paper is to have students describe how the course content fits into their selected career. The instructor can administer this type of minute paper at the beginning of the course and at the end to compare student perspectives.

Effective questioning

Engaging students with questions can often be intimidating for a new teaching assistant. Questioning students during the lecture aids in learning by asking students to process some of the information they have received, and to retrieve this information possibly with some elaboration. McKeachie gives some tips on what to do when you have the same student answering all the questions and other helpful guidelines for fielding questions.[10] First time teaching assistants often make the mistake of asking the first question they think of, which inevitably is something like, "Does everyone understand?" This question should be avoided because the silent bobbing of heads tells you very little information about student understanding. Better questions to start with:

- Are there any questions at this point?
- Are there any questions on how this solution was determined?
- Are there any questions on topic A?
- You can have students write down a question on topic A and you can collect them for the next class or to answer via an online course system (or e-mail)

Questions that require more higher-order thinking:

- What is missing from this solution? (e.g., units, direction, formatting)
- Why does the problem we solved fall under this topic?
- We came up with solution A, but let's say we came up with solution B, how can we tell right away that it is incorrect? (e.g., use a common mistake for solution B)

One example for the last question is to provide solution B that is too high or too low to make sense for the problem. For example, if the problem is solving for reaction forces for simple loading on a beam, and the student solves for a reaction force an order of magnitude higher than the sum of the other forces, they should immediately question the validity of their solution. This type of questioning is aimed at giving students intuition on the solutions to problems. Other resources for effective questioning are works by Hyman and Greene.[12,13]

Flipped review session

During a typical review session in science or engineering, instructors prepare a set of problems that represent the topics covered throughout the course. The instructor typically solves these problems for the students highlighting important criterion to review for an exam. In a flipped review session, the instructor plays a minor role allowing the students to take ownership of what they have learned; therefore, flipping the focus onto the students. The general format is thus:

1. The students are assigned into groups of 3-5 and pick from a selection of review topics (syllabus).
2. They then have 15 minutes to prepare a problem and a solution that reviews that particular topic (textbook).
3. Students present the problem to their peers. At least one student is chosen from each group to present the problem and its solution to the class.

By selecting a representative problem for their topic, students must sift through information and identify what is most important. Then, within their group, they solve the problem, which is another opportunity to practice and help each other understand. Finally, when students present their problem, other students frequently ask questions. Occasionally, presenters will get stuck, which allows the instructor to clarify a misconception that may have otherwise gone unnoticed.

The resources needed to accomplish this are: a syllabus with the course topics, and a way of splitting students into groups, which could be a roster or seating arrangement. The preparation time is almost none; the instructor needs only to notify students to bring their textbook to class. This type of activity is appropriate for up to 35 students for a 50-minute time frame. Discussion courses supplemental to a main lecture are the perfect opportunity to implement a flipped review session where class sizes are typically small. For larger classes or limited board space, groups can be randomly selected to present problems or volunteer groups can be solicited. Not every group would have to present in order for this technique to be an effective learning exercise.

Conclusions

An electronic survey was sent out to 107 engineering teaching assistants at a research university in order to describe perspectives and practice using non-traditional teaching methods. Responses were collected from teaching assistants across a range of number of years in graduate school as well as various types of teaching assistants: graders, laboratory assistants, discussion leaders etc. The survey indicated that respondents had little familiarity with non-traditional teaching techniques and respondents generally agreed it posed a significant barrier to implementing diverse teaching methods. However, the greatest barrier perceived by teaching assistants was that of the preferences of the main instructor. The other two major barriers selected by teaching assistants were "Increased preparation time' and "Unfamiliarity with other methods." Responses also indicated that almost half of the teaching assistants surveyed were open to improving and adapting the lecture, some even opting to replace the lecture entirely with 'flipped' classroom settings. In the second half of this paper, we proposed a selection of active learning techniques that teaching assistants can implement into their courses that addressed the perceived barriers found by the survey.

Acknowledgements

The authors gratefully acknowledge the contributing department faculty and office staff in support of this research as well as the guidance of Prof. Michael Loui.

References

1. Chickering, A., & Gamson, Z. (1991). Seven principles for good practice in undergraduate education. *New Directions for Teaching and Learning*, 47, 63-69.
2. Felder, R. M., & Brent, R. (2007). Cooperative learning. In P. A. Mabrouk (Ed.), Active Learning Models from the Analytical Sciences, ACS Symposium Series, Washington, D.C.: American Chemical Society, 34-53.
3. Hartley, J., & Davies, I. K. (1978). Note-taking: A critical review. *Programmed Learning and Educational Technology*, 15, 207-224.
4. Olds, B. M., Moskal, B. M., & Miller, R. L. (2005). Assessment in engineering education: evolution, approaches and future collaborations. *Journal of Engineering Education*, 94 (1), 13-25.
5. American Educational Research Association, American Psychological Association & National Council on Measurement in Education. (199). *Standards for Educational and Psychological Testing*, Washington, D.C.: American Educational Research Association.
6. Borrego, M., Cutler, S., Prince, M., Henderson, C., & Froyd, J. (2013). Fidelity of Implementation of Research-Based Instructional Strategies (RBIS) in Engineering Science Courses. Journal of Engineering Education, 102 (3), 394-425.
7. Prince, M. (2004). Does active learning work? a review of the research. *Journal of Engineering Education*, 93 (3), 223-231.
8. DeWinstanley, P. & Bjork, R. (2002). Successful lecturing: presenting information in ways that engage effective processing. *New Directions for Teaching and Learning*, 89, 19-31.
9. Ruhl, K., Hughes, C. & Schloss, P. (1987). *Teacher Education and Special Education*, 10, 14-18.
10. Svinicki, M. & McKeachie, W. J. (2011). McKeachie's Teaching Tips: Strategies, Research, and Theory for College and University Teachers, 13th ed. Belmont, CA: Wadsworth.

11. Wilson, R. C. (1986). Improving faculty teaching: Effective use of student evaluations and consultation. Journal of Higher Education, 57, 196-211.
12. Hyman, R. (1982). Questioning in the college classroom. *IDEA Paper No. 8, Kansas State University Center for Faculty Evaluation and Development.*
13. Greene, L. (2005). Questioning questions. *The National Teaching and Learning Forum*, 14 (2), 1-5.

APPENDIX: Survey Questions

Below are several items related to your current experiences as a teaching assistant in the College of Engineering. Please indicate the response that most accurately describes your experiences and/or thoughts.

1) As a teaching assistant, what best describes your roll? Select all that apply.
   - Lecturer
   - Discussion leader
   - Laboratory assistant
   - Grader
   - Demonstration assistant
   - Other (please specify) ☐

2) Select the answer that best describes you. I have been in graduate school…
   - Less than 1 year
   - 1 – 2 years
   - 2 – 3 years
   - 3 – 4 years
   - 4 – 5 years
   - 5 years or more

3) Select your degree of interest in the following career paths at this time:

	No Interest	Low Interest	Medium Interest	High Interest
Faculty				
Start a company				
National laboratory				
Industry				

Other (please specify): ☐

4) Answer True or False: My role as a TA included an instruction portion in front of students.
   - True
   - False

IF YOU ANSWERED "TRUE" TO QUESTION 4, ANSWER THE FOLLOWING QUESTIONS OTHERWISE PLEASE CONTINUE TO QUESTION 8.

5) Other than lecture, were there any teaching methods or learning activities (e.g. round table discussion, thick pair share) you employed as a TA? Select all that apply.
   - No, I do not know of any additional methods
   - No, I did not incorporate any additional methods
   - Yes, I incorporated the following methods:

☐

6) Please list any additional teaching methods or learning activities you are aware of, but did not use as a TA.
   - I do not know of any additional methods
   - Additional teaching methods I know:

7) Please rate the degree to which you agree or disagree:
   The following reasons present a significant challenge to incorporating diverse teaching methods other than lecture.

	Strongly Disagree	Somewhat Disagree	No Opinion	Somewhat Agree	Strongly Agree
Increased preparation time					
Unfamiliarity with other methods					
Other methods are less effective					
Main instructor's preference					
Lack of teaching experience					
Disinterest					

8) In a few sentences please briefly describe your perspective on the use of lecture as a teaching method in engineering courses.