**Session: _____**

# MENTORING AND TRAINING OF PH.D. STUDENTS IN THE STEM ACADEMIC ENTERPRISE: TIPS FOR DOCTORAL STUDENTS AND THE OVERALL EFFECTS ON STEM STUDENTS

Krystal S. Corbett[1, 5], Melanie G. Watson[2, 5], C. Kyle Prather[3, 5]
Michael Swanbom[4, 5], David E. Hall[4, 5]
[1]Computational Analysis & Modeling, [2]Biomedical Engineering, [3]Material Science & Microelectronics, [4]Mechanical Engineering, [5]College of Engineering and Science
Louisiana Tech University, Ruston, Louisiana 71270
Email: ksc016@LaTech.edu

## Abstract

Most Science, Technology, Engineering and Mathematics (STEM) graduate programs lack effective training programs for Ph.D. students aspiring to shift into faculty positions. Ph.D. students are often expected to have effective teaching skills without the necessary guidance. In reality, the transition of a Ph.D. student to that of a lecturer can be extremely arduous, while potentially causing major reservations from the university administration and the individual making the student to faculty change. This paper examines the experiences of three Ph.D. students along with two faculty members through a co-teaching/teaching mentorship as part of a first-year, project-centered engineering course program. The freshman engineering curriculum courses have served as an ideal setting for the Ph.D. student-lecturer mentoring. Ph.D. student-lecturers are first trained through a process of co-teaching a course alongside an experienced faculty member. After one quarter of mentorship, the Ph.D. student is qualified to solo-teach a similar course. This paper follows the Ph.D. students as they complete their mentorships and take full responsibility of their own course sections. Thus, the primary topic concentrates on the evolution of Ph.D. students into competent lecturers. Tips are provided to others interested in becoming lecturers and faculty wanting to utilize their own Ph.D. students as lecturers. Some tips include: developing self-confidence while delivering course material to classes, establishing professionalism in a classroom setting, and maintaining respect from undergraduate students. The paper also provides assessment data to document the teaching effectiveness of the Ph.D. students during the transition from student to faculty while co-teaching/teaching in undergraduate classrooms.

## 1. Introduction

The utilization of graduate students as instructors in undergraduate Science Technology Engineering and Mathematics (STEM) classrooms is a common practice conducted by most universities. This is a great resource to both the graduate student as well as the university. Having graduate students teach courses in the undergraduate programs allows for lighter teaching loads of full time faculty members as well as for flexibility in teaching schedules. From the graduate student perspective, the opportunity of being the class instructor during their graduate studies leads to various skill sets that future employers would desire whether they continue into academic or industry careers. In many cases, however, most universities do not

provide the necessary resources that prepare the graduate students to properly oversee a course. Many times a graduate student is assigned a course by the university and expected to have the skills of an experienced professor. These skills will not appear instantly; they develop over time. The development can be expedited through an understanding of successful lecturing practices and exercising a pre-teaching/mentorship program. Faculty members along with three graduate students at Louisiana Tech University who teach in the first year freshman program developed various tips outlining successful lecturing practices through their experiences with a mentoring to teaching program. To aid in the development of the tips, information on the affects that the graduate students have on the undergraduate students was compiled through a series of survey questions.

The mentoring through teaching program was designed by the Louisiana Tech University College of Engineering and Science in order to foster the ideal qualities of successful lecturers within the graduate students. The program is developed so that the graduate students work closely with experienced faculty members in the first course in the freshman engineering series. The course is an excellent fit for the graduate students to gain their initial lecturing experience due to the well-developed curriculum and dedicated instructors. The course was created with aid from an NSF grant where the undergraduate students participate in a hands-on project-based course called "Living *with* the Lab." The courses were developed with themes from "The Engineer of 2020: Visions of Engineering in the New Century" and ideals from the National Science Foundation Educational Coalitions [1, 2]. The curriculum spans three quarters throughout the undergraduate students' freshman year where each quarter has a length of ten weeks. The class meets twice a week for 110 minutes [3]. General introductory level engineering fundamentals are taught with aid from a microcontroller as a platform for learning. Seven themes, systems, electromechanical devices, fabrication and acquisition, software, fundamental engineering concepts, communication, and broadening activities, are the objectives of the course each interwoven throughout each quarter of the first year experience [3, 4]. The "Living *with* the Lab" curriculum has been fully developed by experienced faculty members and refined over the years. The lesson plans and master notes are pre-determined for each day of the class. This minimizes the preparatory work required by the graduate students allowing them to focus on the lecturing and classroom management required in a college course. Also, the graduate students are expected to have more than adequate knowledge of the concepts taught in the course, since a requirement to teach these courses as graduate students is that they are studying an engineering discipline and have a bachelors degree in an engineering discipline as well. Co-teaching the course first with an experienced instructor provides a level of mentorship that helps the graduate student to become accustomed to the role of instructor more comfortably than just being assigned to a class without the co-teaching experience. In addition, the co-teaching aspect helps to raise a level of comfort for the graduate students on some of the more innovative learning tools in the course that they may not have been exposed to such as the microcontroller. Thus, helping them become familiarized with all the material in the course prior to being the lecturer solely responsible for disseminating the information to the undergraduate students. Another benefit to the co-teaching mentorship program is that when a graduate student is finished with the co-teaching phase of the graduate student development they are still in contact with their mentor and will be able to rely on their mentor throughout future quarters whenever issues arise as they instruct independently in the classrooms.

The impact the graduate students have on the undergraduate students they teach is of particular interest. Since most universities do utilize graduate students as instructors, an understanding of their affect in the learning process of an undergraduate is vital. Assessment of this impact was conducted through surveys developed by the graduate students as well as with help from an experienced assessor. Each of the three graduate students completed their co-teaching requirement and was the sole lecturer in the undergraduate classroom; therefore providing three class sets of data for analysis. The 21-question survey was given early in the quarter to the 69 students who were divided amongst the three classes. The undergraduate students were asked questions ranging from the graduate students' ability to convey information to their impact on undergraduate students' self-efficacy. The survey questions were identified into four main categories, which include:

- How the undergraduate students felt in relation to the graduate students age, gender, and students status,
- Two sections concerning a graduate student as an instructor versus a full time faculty member,
- Questions expressing negative feelings towards the graduate student instructor from the undergraduate students experience, and
- Questions expressing positive feelings towards the graduate student instructor from the undergraduate students experience.

Through the results of the surveys and the experiences of the graduate students co-teaching then teaching independently, the various tips for graduate student lecturing success was developed. A model is created in which other universities can easily implement, thus reaping the benefits associated with properly utilizing the graduate students as lectures.

## 2. Methods

*1.1 Tips*

The following are tips are for graduate student instructors conducting university level classes, arranged from the most to least important concerns:

1. Focus on the students' learning of the material as opposed to the graduate student's performance as an instructor.
2. Teach the curriculum alongside a professor and use their feedback.
3. Exhibit confidence to gain respect.
4. Become comfortable with content knowledge through lecture prep, practice, and proven lesson plans.
5. Dress professionally.
6. Be comfortable with making mistakes.
7. Keep it fun.

The students' grasping of the course material is paramount [5, 6]. The instructor's ability to teach is only useful insofar as it helps students reach course goals. Issues with respect may occur due to lack of content knowledge or a lack of perceived social barriers due to closeness in age. Having recent exposure to the material in the same environment that it will be taught can provide

valuable experience and build confidence. Dressing up upholds the perceived authority of the instructor. When mistakes occur, students may catch them. The appropriate response is to say "Thank you," and to focus on the students' comprehension as in tip number 1. The final tip reinforces that one of a graduate student instructors' strengths is closeness in age. Students may feel a greater sense of belonging in their respective curriculum by learning from a more relatable and approachable instructor.

*1.2 Survey Description*

Three PhD candidates were paired with teaching faculty for one quarter. The graduate students taught an entry level engineering class alongside the faculty in preparation for teaching their own class. This preparatory quarter served to familiarize the PhD candidates with the course curriculum, provide them with a faculty example for the coursework they were to be teaching, and allow them to teach some classes on their own under the guidance of their professors.

The entry-level course consisted of twenty class periods taught over a period of approximately twelve weeks. Class periods were between an hour and a half and two hours, and the PhD candidates taught approximately half of the classes. This provided experience teaching in a university classroom as well opportunities for feedback from the faculty while dividing the responsibility of conducting a class between the student and the mentoring professor. Upon completion of the course, the PhD students were made responsible for their own courses. The curriculum and lesson plans of these courses were identical to those of the introductory courses with mentoring.

A survey was conducted to gauge the effectiveness of the PhD candidates as instructors. The survey was administered to students enrolled in each of the three sections of the course. It prompted one of five responses: “completely disagree”, “disagree”, “neither disagree nor agree”, “agree”, and “completely agree”. Questions were intended to focus on a variety of aspects, and are listed below:

1. I am more comfortable with the graduate assistant because he/she is closer to my age.
2. The graduate assistant was more approachable than other faculty members.
3. I am more comfortable with the graduate assistant due to the student-status of the graduate assistant.
4. The instruction that I received from the graduate assistant was more effective than similar instruction from a faculty member.
5. I am more comfortable with my graduate assistant than the instructor due to gender.
6. It was evident that the graduate assistant had minimal college teaching experience.
7. I feel that the graduate assistant communicates effectively.
8. The graduate assistant improved in his or her ability to teach over the course of the quarter.
9. I would consider choosing a class taught by a graduate assistant in the future, even if one were also offered by a faculty member.
10. It is important that a graduate assistant dress professionally to gain the respect of the students.
11. I prefer a graduate assistant to teach my class instead of a faculty member.
12. I would be disappointed to have to take a class taught solely by a graduate assistant.

13. I feel the graduate assistant displayed mastery of the technical content delivered in this course.
14. The graduate assistant was a confident instructor.
15. The graduate assistant treated me with respect.
16. I am comfortable approaching the graduate assistant for help outside of class.
17. I have not felt discouraged about pursuing an engineering degree.
18. I will be an excellent engineer.
19. I have friends in engineering.
20. I can have a fulfilling career in engineering.
21. I feel like I belong in engineering.

Questions 1, 3 and 5 deal specifically with the age, gender and student status of the graduate instructors and their undergraduate students' responses to those factors. Similarly, questions 2, 15 and 16 address how comfortable students are with their graduate instructors in interpersonal communication. Questions 4, 9, 11, and 12 were intended to make the undergraduate students compare graduate instructors PhD teaching faculty and consider potential disparities. Each specifically mentions the graduate instructors as they relate to solely faculty-led courses. Questions 6, 7, 8, 10, 13, and 14 focus on the ability of the graduate students to conduct a college-level course. They include questions on communication skills, content knowledge, and professional attire. These skills are believed to come with experience, and these questions are designed to provide insight to the effectiveness of the mentoring experience. Questions 17 through 21 are student-centered, and provide a baseline for how the students are feeling toward their education in Engineering. The gender of the students was included in the survey. This was included to determine if the genders of the graduate students would in any way alter the perception of the above questions.

## 3. Results

The "Living with the Lab" program has provided an excellent source for understanding how first year college students perceive graduate student instructors and their teaching skills [7, 8]. From the survey, previously mentioned categories were listed to better understand the student's opinion of the graduate instructors based on several factors including gender, perceived age, approachability and student status of the instructor. Of the three courses taught by graduate instructors, 69 students participated in the survey with 21 questions and one comment section. Question sets were determined by linking similar questions or questions that represent certain concepts that were considered valuable for this survey (e.g. student's importance for course instruction based on gender of the graduate student).

The three graduate instructors' survey results were combined and averaged. Figure 1 summarizes the average per question based on the 69 student results. The data was based on the Likert survey scale of 1 to 5 with 1 as completely disagree to 5 as completely agree. Standard deviation error bars were used to emphasize the relative results similarity between several questions. From the aforementioned survey questions, the overall student opinions toward the graduate students can be gathered based on the results of each question.

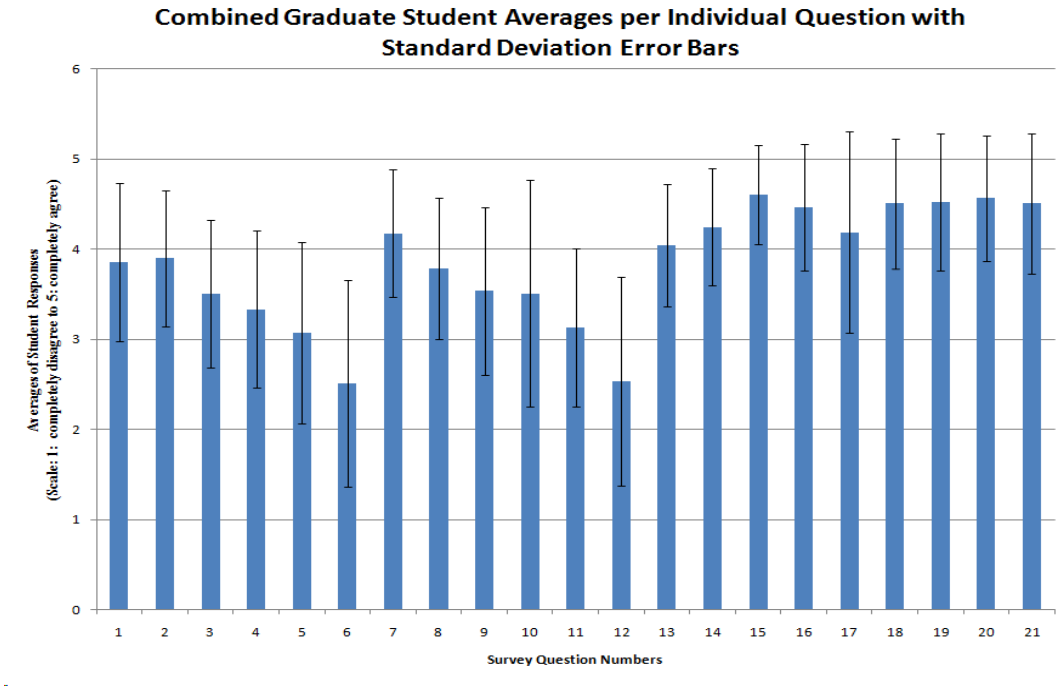


Figure 1 – Combined graduate student averages.

Figure 2 A examines each question to the individual graduate instructor. Standard deviation error bars are utilized to prove the small variation between the three graduate instructors at each question. Along with Figure 2A, a Two- Factor ANOVA test was performed with significance shown among the interactions for the three graduate students with a P-value of 0.143. This also proves that for each question the three graduate students showed a statistical significance dependence by having an ANOVA P-value threshold of >0.05. Figure 2 B looks at each question concerning the student's responses based on the gender of the graduate student. Standard deviation error bars confirm a general overlap thus emphasizing closeness of student responses to all questions except Questions #5 and 10.

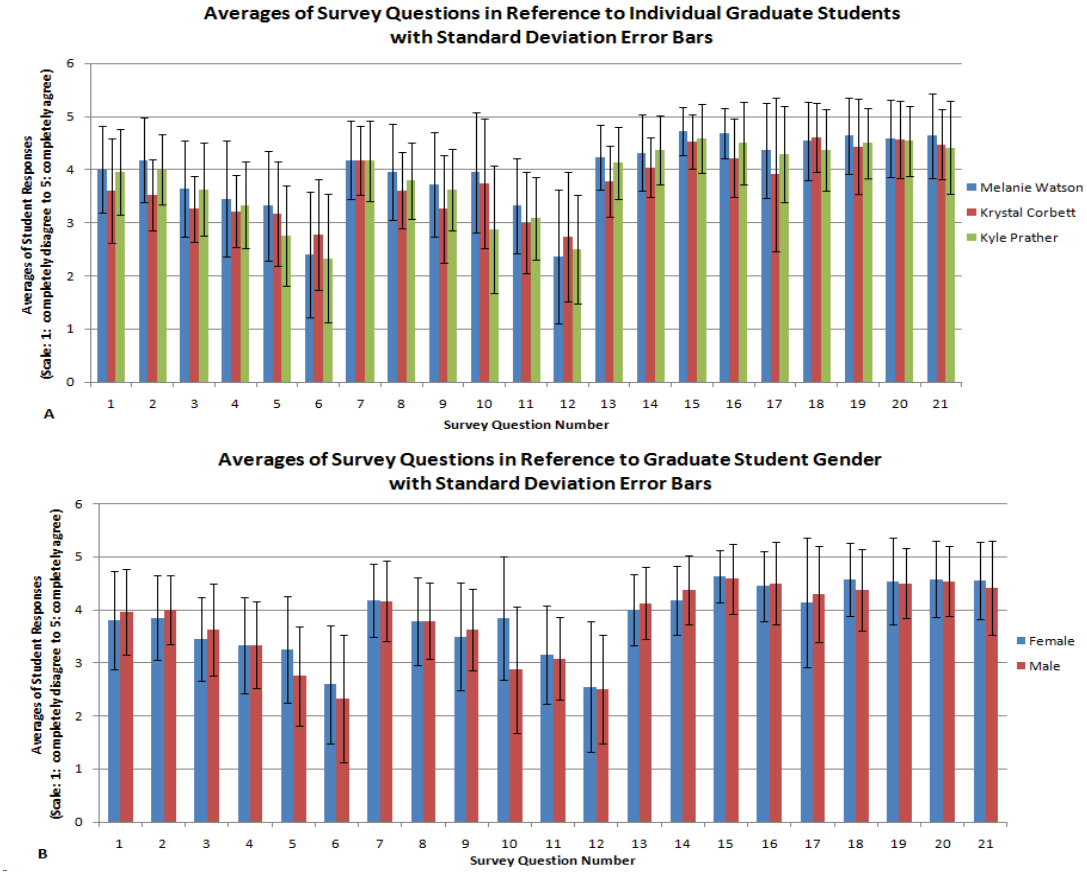


Figure 2 – A) Graduate student survey question averages with standard deviation error bars. B) Graduate student survey question averages with standard deviation error bars based on the gender of the graduate student.

Figure 3 displays the effects of the graduate instructors in reference to questions sets. Questions set #3 shows how the graduate instructors fare against the student's perception of other professors. Figure 3A shows Questions #9 and 11 responses that the students were mainly indifferent as to whether they would chose to be taught my a graduate instructor in the future, and/or prefer the graduate instructor to the professor altogether. Question set #4 represented questions posed in a negative connotation toward the graduate instructor. In Figure 3B, the graph shows 2.5 averages for Question #6 and 12. Based on the Likert scale, 2.5 is between disagree and neither disagree nor agree. Question set #5 grouped the positively posed questions concerning the graduate instructor. Figure 3C displays these averages from Questions # 7, 13 and 14. Question set #7 combines a positive and negative questions #6 and 13. From Figure 3D, a variation of approximately 1.5 points from Question #6 to Question #13 on the Likert scale proves that the students do respond positively toward the graduate instructors. Question set #8 displays how approachable the students perceive the graduate students as compared to other professors. In Figure 3E, the students overall agreed to completely agreed that the graduate instructors are more approachable.

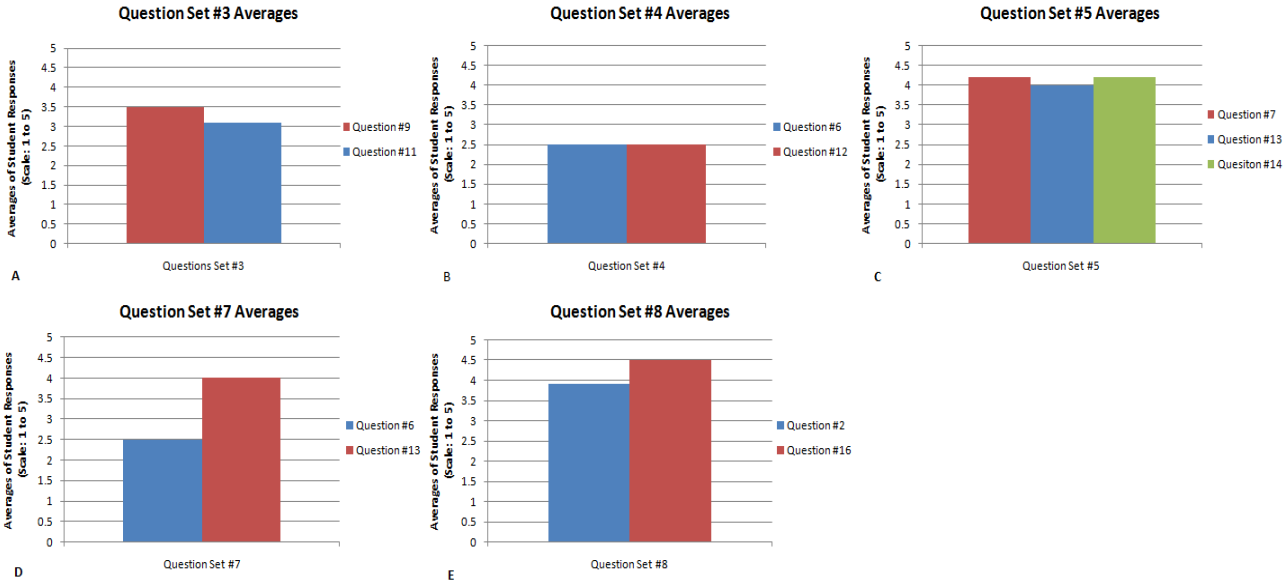


Figure 3 – Question set average pairings. A) Question set #3 B) Question set #4 C) Question set #5 D) Question set #7 E) Question set #8

Table 1 displays a summary of ANOVA and correlation data between the five questions sets includes the P-value for statistical significance and correlation percentages. In Table 1, Question set #3 shows a P-value of <0.05 with a correlation of Questions #9 and 11 of 58% suggesting although these question responses vary somewhat there is a correlation of these two questions whereas one would increase or decrease the other is likely to do follow the same pattern. Question set #4 shows a strong statistical significance of its P-value at 0.883 with little variation among the data. The correlation shows a 32% between these two questions. Question set #5 also has a P-value >0.05 and a strong correlation among each of the three questions. Question set #7 has the smallest P-value much <0.05 with a negative correlation of -12%. This suggests that as one question would decrease in response the other would increase. Question set #8 has a small P-value at <0.05. Although, it does show a correlation between Questions #2 and 16 of 43%.

| | *ANOVA* | *Correlation* | | |
|---|---|---|---|---|
| | P-value | 1st Question to 2nd Question | 1st Question to 3rd Question | 2nd Question to 3rd Question |
| | | % | % | % |
| Question Set #3 - 9, 11 | 0.009299 | 58.1056 | | |
| Question Set #4 - 6, 12 | 0.882703 | 32.4086 | | |
| Question Set #5 - 7, 13, 14 | 0.206449 | 60.2007 | 57.7236 | 51.1718 |
| Question Set #7 - 6, 13 | 5.54E-17 | -12.425 | | |
| Question Set #8 - 2, 16 | 1.04E-05 | 42.7879 | | |

Table 1 – ANOVA P-values and Correlation percentages based on question sets #3, 4, 5, 7 and 8.

## 4. Conclusion

From Figure 1, standard deviation errors bars were utilized as a method for determining the variation between each question. From Questions #1, 2, 7, 8 and 13 to 21, the averages showed little variation all ranging at approximately 4 on the Likert scale. This implies that students agreed with the majority of questions. Questions #3, 4, 5, 9, 10 and 11 averaged around 3 suggesting that students neither agreed nor disagreed with these topics. Questions # 6 and 12 were the only averages ranked below 3 at a disagree value. It is noted that these questions were the negatively posed questions directed toward the graduate instructors while the other questions were either positively posed or completely unrelated toward the graduate instructors.

In Figure 2A, the standard deviation errors bars were found to overlap on several questions showing very little variation between each graduate instructor. This suggests that between all three graduate instructors for each class the students answered along a similar pattern. Therefore, the results gathered from this survey prove the validity of this data, by not having wildly varying results between any of the graduate instructor. This is confirmed with the Two-Factor ANOVA results. The interactions of the three graduate instructor classes for each question show a P-value of 0.143 suggesting a statistical significance.

Figure 2B shows that the students were indifferent as to the gender of the graduate instructor for all questions except Questions #5 and 10. In Question #5, it asks if the students are more comfortable with the graduate instructor due to the graduate instructor's gender. Male and female students moderately preferred the female graduate instructors. Question #10 displays an overwhelming suggestion as to the importance of the female graduate students to dress professionally so that they may gain the respect of the students.

Question sets were used to compare specific questions. This allows topics of interest to be observed. As stated in Table 1, the information presented was used to further verify the significance of each chart in Figure 3. In Figure 3A, Questions #9 and 11 requested students to determine whether or not they prefer the graduate students or faculty members for course instruction. Results from the figure, correlation percentage and the P-value indicate that the students were indifferent. One reason students may have responded indifferently is because the majority of these students are in the first or second quarter of college and thus draw on little to no experience for other professors and graduate instructors. From Figure 3B, students generally disagreed with the negatively posed questions suggesting that they are responding positively to being instructed by graduate instructors. According to Figure 3C, the students across the board agreed that each graduate instructor was effective in teaching, respectful toward students and proved a mastery of technical content. In Figure 3D and its coinciding data in Table 1, they showed the most variation between the two questions. Along with the Figure 3E and Question set #8 results in Table 1, these figures and sets indicate a confirmation of the student's favorable assessment of graduate instructors.

The overall results of the survey validate the positive influences of the graduate instructors on the first-year college students and support the Tips suggested in the Methods section. The objectives of this paper have been met by providing advice for graduate student teaching skills in hopes that other graduate students succeed in their early lecturing experiences.

## References


[1] National Academy of Engineering, "The Engineer of 2020." *The National Academies Press*, Washington DC, (2004) www.nap.edu

[2] J. Richardson, C. Corleto, J. Froyd, P. K. Imbrie, J. Parker, R. Roedel, "Freshman Design Projects in the Foundation Coalition." *1998 Frontiers in Education Conference*, Tempe, Arizona (1998)

[3] S. Cronk, D. E. Hall, J. Nelson, "Living with the Lab: A Project-Based Curriculum for First-Year Engineering Students", *American Society for Engineering Education Gulf Southwest Division Annual Conference*, Waco, Texas (2009)

[4] D. E. Hall, S. Cronk, J. Nelson, P. Brackin, "The Facilitation of Lifelong Learning Skills through a Project-Based Freshman Engineering Curriculum" *American Society for Engineering Education Annual Conference and Exposition*, (2009)

[5] J. W. Rushin, J. De Saix, A. Lumsden, D. P. Streubel, G. Summers, C. Bernson, "Graduate Teaching Assistant Training: A Basis for Improvement of College Biology Teaching & Faculty Development" *The American Biology Teacher*, **59**[2] (1997) 86-90

[6] J. D. Nyquist, L. Manning, D. H. Wulff, A. E. Austin, J. Sprague, P. K. Fraser, C. Calcagno, B. Woodford, "On the Road to Becoming a Professor: The Graduate Student Experience" *Change*, **31**[3] (1999) 18-27

[7] A. E. Austin, "Preparing the Next Generation of Faculty: Graduate School as Socialization to the Academic Career" *The Journal of Higher Education*, **73**[1] Special Issue: The Faculty in the New Millennium (2002) 94-122

[8] L. R. Prieto, E. M. Altmaier, "The Relationship of Prior Training and Previous Teaching Experience to Self-efficacy Among Graduate Teaching Assistants" *Research in Higher Education*, **35**[4] (1994) 361-365