

Work-in-Progress: Undergraduate Teaching and Research Experiences in Engineering (Utree): An Engineering Student Organization with a Communication Focus

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Introduction

In engineering, many undergraduate organizations foster the professional skills of the students. Such organizations seek to help students prepare for the next stage of their careers—be that stage as a graduate student or as a professional engineer in industry or government. Most organizations, such as the American Society of Mechanical Engineers, target students through the discipline that those students have chosen. Other organizations, such as Society of Women Engineers, target members because of gender, race, or ethnicity. This work-in-progress paper introduces an organization that recruits engineering undergraduates based in large part on how well they communicate engineering.

Such an organization has inherent value for the discipline of engineering because the set of skills needed to excel in writing a technical report or making a technical presentation are skills important for succeeding as a graduate student in engineering or as a professional engineer. For instance, creating an excellent technical report or presentation requires the ability to perform library research, to organize information in a logical manner, and to target an audience.

The organization UTREE (Undergraduate Teaching and Research Experiences in Engineering) assembles students with such skills, as well as high academic achievement in technical classes, and seeks to further develop those skills. That development mainly occurs through preparing those undergraduates to teach a small set of class periods and then having those students teach those class periods multiple times.

Two potential benefits exist for a college of engineering to have such an organization. First, the peer teaching provided by the organization has the potential to enhance the teaching in a college of engineering for a number of reasons including decreasing instructor-to-student ratios [1–2]. Second, because the organization develops the professional skills of students who are excelling in their technical classes, the organization creates a pool of students who are primed to excel as graduate students or professional engineers.

As far as costs to our College of Engineering for the operation of this organization, they are relatively small, if the faculty member's volunteered time to serve as advisor is excluded. The basic operating budget for the group is about \$4000 each year to support the scheduling of the class periods (by one of the UTREE members), the upkeep of the web-site [3], food for meetings, and the professional activities for the members. From its teaching outside the University, the group earns about half that sum. In addition, the group has been successful at obtaining small grants to produce teaching films that are used in the class periods and to secure teaching assistantships for some members in upper-level courses.

Given how much teaching and service this organization performs each semester and how many active members the organization has, UTREE has shown itself to be a successful organization for the College of Engineering at Pennsylvania State University. The question arises whether such an organization would work at other engineering colleges. To determine that, a formal assessment would be needed that would answer the following questions:

- (1) Does UTREE foster the professional growth of its members in a statistically significant way?
- (2) Is the teaching by UTREE members effective?

This work-in-progress paper outlines our plans to answer these two questions. First, to provide a sense of possible teaching, research, and service that such an organization could provide to a college of engineering, this paper provides an overview of those activities by UTREE at Pennsylvania State University. Second, to determine whether a formal analysis would even be warranted, this paper analyzes the results of two surveys. The first is a self-evaluation by the UTREE members of their own professional development, and the second is a survey by faculty about the effectiveness of the teaching by UTREE members. Third, this paper discusses what would be needed to make an organization such as UTREE a sustainable organization for the long-term at an institution. Interwoven in this discussion are the criteria that a college of engineering should meet before adopting such an organization.

Overview of UTREE's Activities

Now in its third year, UTREE is an engineering student organization at Penn State that has twenty members representing eight different engineering disciplines. These students are chosen based on their overall academic achievement (the average GPA of the group is about 3.7 out of 4.0) and their particular achievement in a required speech course. UTREE's mission is to leverage the technical and communication skills of the members to raise the professional skills of all students in the College of Engineering. UTREE accomplishes this mission through teaching, research, and service.

Teaching. With respect to teaching, UTREE mentors teach or assist the teaching of class periods about communication and teamwork in several engineering courses. In 2013, UTREE taught more than 60 class periods on communication and teamwork. Most of the students that UTREE teaching mentors instruct are first-year design students, but UTREE also teaches upper level classes and assists in the teaching of graduate student seminars. Table 1 shows a breakdown of the types of class periods taught.

One of the class periods that UTREE mentors teach concerns rethinking the topic-subtopic approach that most engineers and scientists follow for structuring their engineering presentations. In this class period, the mentors first discuss the weaknesses of the topic-subtopic structure, which is reflected in the presentation's slides: a topic-phrase headline supported by a bulleted list of subtopics. Heavily influenced by PowerPoint's defaults, this structure leads to presentations that are not well focused and do not communicate technical information in an effective manner [4]. Second, the mentors teach students an assertion-evidence approach to creating presentations. In such an approach, the presenter builds the talk on assertions, rather than topics, and supports these

assertions with visual evidence rather than with bulleted lists. In their teaching, Utree teaching mentors show the students one of the following slide structures that follow this assertion-evidence approach: the assertion-evidence structure [11] or *pecha kucha* [5].

Table 1. UTREE Class Periods Taught in 2013.

Class Period Offered	Number of Class Periods Taught
Working in Teams	7
Group Presentation	15
Assertion-Evidence Structure of Presentation Slides	31
<i>Pecha Kucha</i> Design of Presentation Slides	11

In the assertion-evidence slide structure, students place their assertion (the main message of the scene) as the sentence headline at the top of the slide. Rather than using a bullet list to support this headline, students come up with visual evidence such as graphs, photos, or equations [10]. With *pecha kucha*, which is Japanese for “chit-chat,” students write down the main assertions for the talk and then develop a sequence of scenes to communicate those messages. This style typically calls for a sequence of 20 scenes (or slides) with each slide showing for 20 seconds. Because each slide appears for only 20 seconds, the scenes are primarily graphics with few words (if any) used. Although this style of presentation is not ideal for a number of engineering presentations, the resulting presentations are often a significant improvement over presentations that follow PowerPoint defaults [11].

Both class periods emphasize a rethinking of the common practice of visual evidence found in engineering presentations. One underlying assumption for assertion-evidence presentations is that the slides are meant to aid the audience in understanding content, rather than to assist the speaker in recalling information. Because the UTREE mentors teach strategies that go against the common practice, this class period is a challenge [6]. In other words, because most students are accustomed to the ubiquitous topic-subtopic default of PowerPoint, they are naturally resistant to an alternative, no matter whether that alternative is introduced by a faculty member or a peer. For that reason, much work has gone into the design of this class period.

UTREE also offers a class period that seeks to improve the teamwork of engineering students. This “working in teams” class period introduces instructional videos created by UTREE mentors and then includes discussion about those videos. These online videos, such as one in which a slacker resides on the team [7], point out common

problems that arise in engineering teams as well as strategies for overcoming those problems. Sometimes in combination with this class period, UTREE mentors give an example of a group presentation to show best practices for teams taking on the task of a group talk.

UTREE does not limit its teaching to our own university. For instance, each semester, three UTREE teaching mentors help teach a video-conferenced class period about slide design to engineering students at five different Korean universities. Shown in Figure 1 is a photo that captures the projected teaching slide (shown on the left screen) and a UTREE mentor teaching five classrooms at different Korean universities (shown on the right screen). After this class period, which occurs in the evening for Penn State and in the morning of the next day for the Korean universities, each student team from these five Korean universities submits a set of slides that the UTREE teaching mentors critique.



Figure 1. Scene from video teleconference class taught by UTREE students at Penn State to engineering students at five Korean universities. Shown on the left screen is the teaching slide being discussed. Shown on the right screen is the Utree teaching mentor (upper left frame) and views of the five Korean classrooms: (two small frames at bottom and three small frames at the right).

In addition, in May 2013, six UTREE students and the group's faculty advisor traveled to Northeastern University in Boston to teach a workshop to 40 graduate students in engineering. The UTREE students helped give a lecture about the assertion-evidence approach and then held individual consultations with the graduate students to help them with the slides for their next research presentation. On that same trip, the mentors traveled to the University of Massachusetts Medical School in Worcester to help teach two workshops on the assertion-evidence approach to members of administration, research faculty, post-docs, and graduate students at the university. Attending each of these two workshops were about 35 participants. As with the graduate students at Northeastern, the UTREE students held individual consultations with the workshop participants to critique a set of slides for their next presentation. Figure 2 shows a scene from one of those workshops. In the Spring 2014 semester, UTREE will help teach similar workshops to two medical schools that are within driving distance of Penn State.

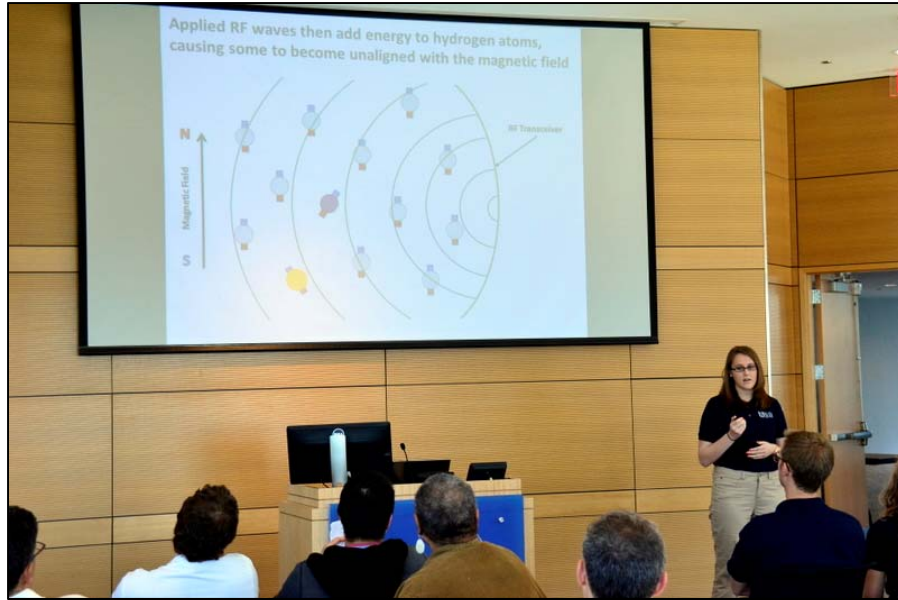


Figure 2. UTREE mentor teaching slide design at University of Massachusetts Medical School in Worcester. About 35 medical faculty, researchers, and students were in the room. This illustration conveys a sense of the professionalism carried by the UTREE teaching mentors.

Research. With respect to research, UTREE helps undergraduates, including its own members, obtain undergraduate research experiences not only at Penn State but also at other institutions. One way that UTREE helps students is through helping teach a first-year seminar that has a focus on undergraduate research. In this course, UTREE students who have undergraduate research positions give tours of their labs and make presentations about their research. These students also share strategies for how they obtained their research positions. In its first three years, UTREE has been instrumental in helping undergraduates at Penn State obtain research experiences both at Penn State and at other institutions including Northwestern University, West Virginia University, and Texas A&M.

Service. In regard to service, the main responsibility of UTREE students is to run the Leonhard Center Speaking Contest each semester. The Leonhard Center Speaking Contest, which is shown in Figure 3, is a contest spanning two semesters that seeks to raise the level of presentations given by engineering students through the performance, videotaping, and posting of model presentations given by engineering students [8]. One UTREE student is responsible for organizing the semi-final rounds, which occur at the end of one semester, and another UTREE student serves as coordinator for the final round, which occurs toward the beginning of the next semester. In addition, UTREE students serve as emcees and preliminary round judges. Additionally, UTREE students act as speaker angels for the final round of the contest. Similar to the speaker angels that serve TED.com events, these UTREE students provide feedback for all finalists so that contestants have the most opportunity for success.



Figure 3. UTREE student introducing one of the speaker finalists at the inaugural Leonhard Center Speaking Contest. This illustration provides a sense of the number of students whom the UTREE teaching mentors serve. Shown are a portion of the 200 people who attended the contest.

As another example of service to the College, UTREE also served as a sponsor for a College of Engineering guest speaker Rick Gilbert, who is the author of *Speaking Up* [9]. In his talk, Gilbert gave practical tips for presenting to upper-level managers or executives, which is a topic not covered in classes. This talk was attended by more than 150 students in the College.

In addition to fostering the professional development of all engineering students in the College, UTREE members also participate in activities to foster their own professional development. For instance, each semester, UTREE students participate in team building exercises, such as rock climbing or traversing a high ropes course (shown in Figure 4). In addition, UTREE students have the opportunity to take a research writing course that serves as a substitute for the required technical writing course. In this research writing class, mentors learn how to write documents such as correspondence, proposals, posters, and research papers that occur often in engineering research.



Figure 4. UTREE students traversing a high ropes course. This illustration depicts the teamwork that is required for the professional development activities of the group.

Preliminary Assessment of the UTREE Program

To determine whether a formal assessment of UTREE would be warranted, this section presents two preliminary surveys intended to evaluate the effectiveness of the UTREE program. The first survey called on UTREE members to self-assess their own professional development. The second survey called on faculty members who hosted UTREE teaching mentors in their classrooms to evaluate the effectiveness of the teaching of the UTREE teaching mentors.

Methods. To identify the professional development of the students, 26 UTREE members were surveyed and asked to self-evaluate the effect of teaching and service. As shown in the Appendix, students were asked a total of ten questions. Some questions asked students to discuss the most beneficial part of being in the group or to identify the ways in which UTREE is preparing students for the next stage of their careers. Other questions probed for specific details such as the number of UTREE activities that a student participated in or the number of class periods that a mentor has taught. Eighteen of those 26 members responded to this survey.

To identify the impact that UTREE classes have on the students who view the presentations, ten faculty members at Penn State were surveyed. Six of those ten responded. The questions of this survey addressed to the effectiveness of the UTREE class periods. As with the first survey, the actual questions of this survey appear in the Appendix.

The main audiences of the UTREE classes, including undergraduate students and graduate students, were not surveyed for this preliminary assessment because of the challenge of determining the effectiveness of the teaching by the mentors from surveys about a single class period of the mentors' teaching. First-year students who have had little exposure to engineering presentations may view the teaching in a required class very differently from a graduate student who has chosen to attend a UTREE event for her or his own benefit.

Results and Discussion. This subsection presents the results of the two surveys to determine whether a formal assessment of UTREE is even warranted. To gain a sense of the professional development of the UTREE teaching mentors, we considered the results of the first survey: the self-assessment by UTREE members of their own professional development.

This first survey revealed that perhaps the most beneficial parts of being in UTREE was having opportunities to present, which increased the confidence of the members in their presentation skills. For instance, 15 out of 18 mentors discussed being able to further their presentation skills. One UTREE graduate said, "In networking, public, and work settings, I am less nervous to say something. It has become a strength that a lot of people notice right from the start." This mentor felt that UTREE has prepared her for her career as a civil engineer by preparing her for mentoring and effectively communicating.

Since graduating, she has offered workshops and help sessions on tips for successful presentations to her colleagues.

As shown in Table 2, most responding members of UTREE participated in the group’s activities by teaching class periods on communication and teamwork. For instance, 16 of the 18 responding had taught class periods to first-year students, 12 had taught to class periods to sophomores, juniors, and seniors, and 8 had helped teach workshops to graduate students or professionals. Of those 8 students who had helped teach graduate students or professionals, 5 volunteered the comment that this type of teaching was the most valuable. In the survey, one mentor explained that one of the benefits of leading workshops for graduate students and professionals was that they “were the most critical of the content in the presentations, which was a situation most [students] do not get a chance to experience.” Certainly, such teaching situations were potential confidence builders for the UTREE members. In effect, because the UTREE members had presented successfully to graduate students and professionals, those members no longer perceived those types of presentations as “unattainable.”

Table 2. Types of teaching self-reported by UTREE mentors.

Type of teaching	Number of respondents (percentage)
Taught presentations or teams to first-year students	16 (89%)
Taught presentations or teams to sophomores, juniors, or seniors	12 (67%)
Served as paid teaching assistant in a 3-credit course: Effective Speaking for Engineers	12 (67%)
Gave a research presentation in first-year seminar on undergraduate research	7 (39%)
Helped teach a presentations workshop for graduate students or professionals	8 (44%)

Given the positive responses of the UTREE teaching mentors to the self-assessment survey, we have decided that a formal assessment of the professional development of the UTREE teaching mentors is warranted.

To gain a sense of whether the peer teaching by the UTREE members was effective, we considered three inputs: (1) the results of the faculty survey, (2) the self-assessments of the UTREE members, and (3) whether faculty invited UTREE mentors to come back to teach in a later semester.

In the faculty survey, six of the ten faculty polled provided responses. All six of the responding faculty members considered the teaching by UTREE mentors to be successful. According to one faculty member, “The presentation was more effective because my students saw a peer perform at a very high level.” Three of the responding faculty had specific suggestions on how the mentors could improve their presentations or how the class period itself could be improved, but all of these suggestions fell into the category of continual improvement.

In addition, all six faculty members asserted that they believed their students benefitted from the class period. According to one faculty member who taught a senior design class and for whom a junior in UTREE student gave a sample assertion-evidence presentation, “My students commented on the quality of [the mentor’s] presentation. They unanimously agreed that he was very effective in conveying the importance of his topic. They also mentioned that they learned something from his presentation (a true mark of effectiveness).” Another faculty who taught first-year design students remarked, “[my students] were engaged in the material during that class, and without [me] reteaching the material they were able to create presentations at the end of the semester using the assertion-evidence structure.” Still a third faculty member, who taught upper-level students, remarked, “In their course reflection papers my students mentioned that it was very helpful to see the UTREE students give the group presentation. Many of them modeled the group dynamics and transitions demonstrated by UTREE students in their own presentations.”

In regard to their success as teachers, the UTREE mentors were harder on themselves than the faculty members were. The self-assessment survey revealed a split on the question whether the students had accepted their advice in the class periods. In other words, some mentors believed that their teaching was accepted, while an almost equal number questioned whether it was. One mentor provided a possible explanation, “Different settings have different types of audiences. Some freshman classes have a majority of students who do not want to be there so only a few students really get into the information we are presenting. Other settings, such as graduate seminars, involve people who are much more willing to take what we have and run with it.”

Perhaps the most compelling evidence for the success of the peer teaching provided by the UTREE mentors comes from the requests by faculty in subsequent semesters to have the mentors return to their classes. Almost all the faculty who have had UTREE mentors teach in their classes have requested return visits. This set of faculty includes the faculty members from Korea who had requested the videoconference class for five semesters in a row and the faculty at Northeastern University and the University of Massachusetts Medical School who have an open invitation for UTREE to return. In

regard to the last three sets of faculty, those requests have been accompanied by promises for stipends (about \$1000 each) to cover travel expenses (in the case of the last two) and to help support the running of the organization.

Given the positive responses of the faculty survey and the continued requests for UTREE teaching mentors to return to classrooms, both on-campus and off-campus, we consider that a formal evaluation of the teaching effectiveness of the UTREE teaching mentors to be warranted. However, such an evaluation will require the input from the students themselves. Moreover, because first-year students who have little experience making engineering presentations or working in engineering teams will be involved, that input should be done from both a short-term and long-term perspective.

Sustainability of UTREE and Prospects for Dissemination to Other Colleges

Given that the previous section has recommended that the professional development and teaching effectiveness of UTREE teaching mentors be assessed in a formal way, this section discusses what is needed to make UTREE sustainable at an engineering college. Interwoven in this discussion are the criteria that should be met for a college of engineering to consider adopting UTREE.

As mentioned, from an operating cost perspective, UTREE at Penn State is run for less than \$5000 per year. Given that our organization teaches about 30 class periods per semester, our organization provides the teaching equivalency (not including grading or office hours) of one instructor for a 3-credit course. So far, that argument has sufficed in the procurement of \$2000 each year from our College to support the organization.

What this analysis does not include is the time expended by the faculty member who advises UTREE. In our case, the faculty member estimates that the time needed to advise this organization is about the same amount of time spent on a 3-credit course. Time requirements include attending and contributing to the weekly meetings, assisting in the training of new UTREE teaching mentors, attending and contributing to the service events such as the Speaking Contest, and organizing the professional development activities. While the student members contribute as much as they can to all of these activities, time and effort from the advisor is still required. At present, our College of Engineering does not formally compensate the advisor for this time. So what is in it for the advisor?

In our College of Engineering, the UTREE advisor is an engineering communication specialist, who teaches engineering communication classes and gives guest lectures on communication in engineering courses. Having UTREE mentors teach engineering communication class periods in first-year design and other courses offsets to an extent the time that the advisor spends on the organization. Given that, for a college of engineering to consider adopting UTREE, the college would want to consider having an advisor who would be in a similar position of providing a significant number of guest lectures on communication to engineering courses. For many large colleges, such personnel exist, as does the need for such guest lectures.

Another step to make UTREE sustainable would be to treat the organization as a startup company and apply the principles for startups that Stanford Professor Steve Blank advocates [12]. In short, Blank argues that startups originate because of an innovation, but that the creators of the innovation do not fully realize what the features of that innovation are until various customer segments begin using that innovation. Likewise, because UTREE is so new, the benefits to the students being taught, the faculty whose classes are served, and a college of engineering are not yet fully known. By putting UTREE through the startup process of identifying customer groups and testing value propositions for those groups, then this organization could gain a deeper understanding of its intrinsic value.

Conclusion

This work-in-progress paper has introduced a new undergraduate organization in engineering that has a dual mission of providing professional development of its members and performing peer teaching for our College of Engineering. Indications are that the organization is meeting both of its missions. At Penn State, the College of Engineering is pleased enough with the organization to continue supporting it, both with the group's small operating budget and with small grants for teaching films and teaching assistantships. This paper recommends that a formal assessment be performed to determine whether long-term sustaining and widespread dissemination should occur. At present, the organization seems better suited for large engineering colleges that have an engineering communication instructor who can serve as the faculty advisor. In such a situation, the class periods on communication taught by the organization can help offset the time spent by the faculty member to advise the group.

Acknowledgments

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Appendix: Surveys to UTREE Members and to Faculty

Survey I: Your Experience as a Member of UTREE

1. Why did you get involved with UTREE?
2. Identify the kinds of teaching that you have done for UTREE?
 - Taught presentations or teams to first-year students
 - Taught presentations or teams to sophomores, juniors, or seniors
 - Assisted in the teaching of CAS 100A for Engineers
 - Gave a research presentation in First-Year Seminar on Research
 - Helped teach a presentations workshop for graduate students or professionalsWhich of these were the most valuable and why?

3. Roughly, how many classes have you taught for UTREE?
0-4
5-9
10-15
15+
4. Typically, how do (or did) you prepare for teaching a class?
5. From your perspective, how do you think that the students you taught viewed you as an instructor? In other words, do you think that the students accepted the advice you gave them? Please back up your answer with observations/
6. Please list any other activities that you did for UTREE?
Helped run the Leonhard Center Speaking Contest
Participated in a Shaver's Creek activity
Traveled to another institution to teach a UTREE workshop off campus
Helped create a teaching film
7. For the above question, which of these were the most valuable to you and why?
8. In what ways do you think the teaching of UTREE is preparing you (or has prepared you) for the next stage of your career?
9. For you, what are (or were) the most beneficial parts of being in UTREE?
10. How could the experience of UTREE, especially the teaching, be improved?

Survey II: Request for Your Feedback on Class Visits by UTREE

1. Please describe how effective the UTREE students were at communicating the material of the class period(s) that they taught for you this semester? In particular, please describe their strengths as well as any ways in which their teaching could be improved.
2. How would your students describe the effectiveness of the UTREE students at communicating the material of the class periods? On what basis, do you make this evaluation?

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