Teaching Teachers To Teach Engineering: A Year Later

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Teaching Teachers to Teach Engineering (T4E) is a one-week short course offered during the summer at the United States Military Academy. The short course is offered to faculty of all engineering disciplines, in both two-year and four-year institutions, with a particular emphasis on junior faculty. The short course addresses topics in preparation, presentation, self-critique, learning models, course and lesson goals and objectives, advanced technology, student-teacher relations, testing/grading, advising, legal aspects of teaching, and time management. Perhaps the most unique feature of the course is that participants and instructors prepare, present, and critique practice classes. This work details the development, execution, and assessment of this innovative engineering teacher training program.

1. Introduction

The vast majority of engineering professors have had no training on how to educate students, and yet they are expected to be capable and efficient engineering teachers because of their technical schooling and engineering experience. While this situation would be intolerable with regard to technical knowledge, it is largely ignored with respect to teaching knowledge. The general lack of comprehensive engineering teacher training programs compromises student learning. Moreover, teaching engineering when you don’t know how may be considered unethical.1

Industry and professional societies have made an effort to promote teaching excellence, and indirectly teacher training, with various engineering teaching award programs. As an example, the Boeing Company initiated the Boeing Outstanding Educator Award in 1995 which honors top contributors to the improvement of engineering education.2 Another example is the Society of Automotive Engineers (SAE) which awards the Ralph R. Teetor Educational Award for significant contributions to teaching, research, and student development. Furthermore, the American Society of Mechanical Engineers (ASME) has a council on Education and the American Society of Civil Engineers (ASCE) has the Education Activities Committee which both seek to improve engineering education. Other societies not associated with the engineering profession are also promoting teaching excellence. The International Society for Exploring Teaching Alternatives (ISETA) looks for ways to move from standard lectures to other methods

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which, when coupled with learning models, tend to help students learn better. In addition, the literature is replete with information on teaching in general, as well as teaching engineering.\textsuperscript{3-10}

In an effort to improve university teaching, several graduate programs have established teaching assistant development programs in the form of workshops and graduate courses.\textsuperscript{11} Moreover, some universities have developed teacher training programs for engineering faculty. For instance, at Utah State University, the Undergraduate Teaching Workshop was initiated in 1993.\textsuperscript{12} This workshop consists of a set of six lessons that focus on teaching skills including the attributes of a good teacher, principles of learning and teaching, the use of technology in instruction, faculty expectations of students, non-class room factors, and the application of workshop material. At the United States Air Force Academy new faculty members attend a 3-week workshop focused on exposing new faculty members to the psychology of learning, effective teaching methods, and academic administration procedures.\textsuperscript{13} The Education Research and Methods Division (ERMD) of the American Society for Engineering Education (ASEE) has a strong program of conference sessions and workshops that cover a wide variety of education-related topics including teacher training programs. Through the National Effective Teaching Institute (NETI), North Carolina State University professor Richard Felder holds a 3-day workshop on teaching engineering which runs in concert with the annual ASEE meeting.\textsuperscript{14} This workshop focuses on the use of learning theory to shape engineering instruction.

For approximately the past 40 years, the Department of Civil and Mechanical Engineering at the United States Military Academy (USMA) has successfully developed new faculty members with an extensive 6-week Instructor Summer Workshop (ISW). With support from the NSF, an abbreviated version of the USMA ISW was offered during the summer of 1996 to civilian faculty from universities across the country. The short course, to be described in detail here, is unique among other teaching workshops because of the inclusion of practice teaching which is critiqued in a developmental manner. The primary goal of the workshop is to raise the standard of teaching excellence within engineering colleges by increasing the number of engineering faculty who have studied and practiced sound, proven teaching methods.

The paper begins with a discussion of pre-workshop items from advertising the course through mentoring. This is followed by a detailed description of the content of the course. Section 4 documents the assessment of the workshop. The paper closes with sections on lessons learned and the future of the course.

2. Preliminaries

Several avenues of advertising were pursued for the short course. First, a T\textsuperscript{4}E flyer was distributed to all engineering and engineering technology department heads and deans. The short course was also advertised in ASEE Prism and the Society for Women in Engineering monthly magazines as well as being posted on the ASEE electronic bulletin board. From this advertising initiative, 121 requests for application materials were received. A total of 61 applications were submitted for the 24 workshop slots. The authors were encouraged by the number of applications considering the short recruitment window due to the federal government shutdown in early 1996.
The application packet required a resume, a recommendation letter, and statements from the applicant regarding reasons for attending the short course, teaching philosophy, and how the participant will attempt to improve teaching at their home institution. Applicants were selected based on the materials submitted along with an over arching goal of recruiting a faculty group diverse in engineering disciplines, type of educational institution, gender, and race.

The program was designed primarily for junior faculty and as such 14 out of the 24 participants had less than 2 years of teaching experience, 8 had 3-4 years, 1 had 5 years, and 1 had 9 years. Of the 24 participants, 11 were women and 2 were members of typically underrepresented groups. There were 8 civil, 3 mechanical and aerospace, 3 industrial, and 4 general engineering faculty in attendance as well as single representation from electrical, metallurgical, plastics, geological, naval architecture, and chemical engineering faculty. The short course had 13 professors from schools with graduate programs, 8 from undergraduate teaching schools, and 3 from engineering technology programs.

The short course was resource intensive. Conduct of the course required 1 week of dedicated time from 15 professors plus 5 total days between 3 consultants. The short course required the dedicated use of 24 classrooms as well as a larger conference room.

Participant teaching is the unique feature of this short course which sets it apart from other engineering teacher training programs. Participants were expected to arrive at the short course with 2 prepared lectures. Practice teaching was conducted in small groups composed of 4 participants and 2 short course mentors, one of which recently completed the USMA ISW. In the material which follows, the mentor who recently completed the USMA ISW is called the junior mentor while the other mentor is called the senior mentor.

3. Course Description

The core of the T4E short course was the Teaching Techniques Workshop. The schedule for this workshop is shown in Figure 1. This program of instruction reflects the authors' genuine belief that teachers learn to teach by:

→ Teaching.
→ Watching other teach.
→ Sharing ideas about teaching with others.
→ Receiving constructive feedback from:
  • other teachers.
  • students.
  • ourselves.

Thus the Teaching Techniques Workshop included a series of seminars, demonstrations, and labs that provided the participants with ample opportunities for each of these activities. Within the context of the workshop, these events are defined as follows:
**Seminar** – an interactive presentation on a focused topic and objective conducted by a T^4E faculty member with the entire group of 24 participants.

**Demonstration Class** -- a class taught by a T^4E faculty member to the entire group of 24 participants. During each of the 50-minute demonstration classes, the participants acted as students. Following each demonstration class, the participants were required to formally assess the class from the perspective of a student on a written class assessment form – and discuss their assessment with the entire group.

**Lab** -- an active learning session conducted in a small group setting. Each small group included six individuals: four T^4E participants, a senior mentor, and a junior mentor. The senior and junior mentors were T^4E faculty members – most recruited from USMA's military and civilian faculty.

In addition to the Teaching Techniques Workshop, the T^4E short course also included a series of seminars covering other topics of interest to new engineering educators. The workshop and the seminars are briefly described in the paragraphs below.

**The Teaching Techniques Workshop.**

Since the cornerstone (and uniqueness!) of T^4E was actual, get-up-and-do-it teaching, the majority of the short course time was devoted to organizational and presentation methods. These methods were identified, discussed, and practiced during the Teaching Techniques Workshop. The objectives of this 26 hour workshop were to --

- Demonstrate a structured methodology for organizing a class.
- Demonstrate effective skills and techniques for presentation of a class.
- Provide participants with an opportunity to
  - practice organizing and delivering classes.
  - receive feedback on their performance.
  - perform teaching assessments.

The manner in which Teaching Techniques Workshop was structured to accomplish these objectives is summarized in Figure 1. A brief chronological description of the events outlined in Figure 1 follows:

**Sunday afternoon.** After introductory and welcoming activities, a demonstration class was conducted on a non-engineering subject, i.e., the basic rules of soccer. This demonstration class served as an ice-breaker for the Teaching Techniques Workshop, while demonstrating some of the principal elements of an effective classroom presentation.

**Monday morning.** The first seminar (Seminar I) provided an introduction to the Teaching Techniques Workshop – emphasizing the workshop's objectives and conduct,
with particular emphasis on role-playing. After a second demonstration class (an elementary lesson in engineering mechanics), two seminars were conducted. Seminar II described a structured methodology for organizing an engineering class; Seminar III provided time-tested techniques for effective use of the blackboard. In Lab I every participant developed and wrote lesson objectives for a class of their choosing to complete the morning's activities.

**Monday afternoon.** After Seminar IV addressed the process of organizing a structured classroom presentation, participants developed and wrote a coherent package of material on the blackboard in Lab II. These activities were followed by the third demonstration class, an introductory lesson in mechanics of materials. Seminar V then addressed the fundamental elements of verbal communications, focusing on techniques for maintaining contact with students. Participants practiced delivery of a 5-minute segment of their first prepared class during Lab III -- the last formal activity of the first full day of T4E.

**Tuesday morning.** Lab IV was the sole activity. Each participant presented the first 25 minutes of an engineering class. This lab (and Labs VI and VII) was videotaped so that participants could analyze and self-critique their presentations – and have a historical record of their T4E experience. A twenty minute teaching assessment followed each presentation, with all participants evaluating the class from a student's perspective. The "learning by doing" model of T4E was now understood by the participants.

**Tuesday afternoon.** Seminar VI addressed the fundamental elements of using questioning to maintain contact with students in the classroom. Participants practiced these questioning techniques in Lab V. Seminar VII discussed the use of training aids and demonstrations in the engineering classroom, and the effective use of vu-graph slides to communicate technical information. A review of the fundamental principles of the "T4E Model" of conducting engineering instruction (Seminar VIII) concluded the day's formal activities.

**Wednesday morning.** Each participant presented a 50 minute engineering class during Lab VI. A twenty minute teaching assessment followed each presentation.

**Wednesday afternoon.** The use of technology in the engineering classroom was the primary focus of the afternoon's Teaching Techniques Workshop activities. The fourth demonstration class was a repeat of the third, but with an increased use of technology. Afterward, participants assessed the effectiveness and efficiencies of classroom technology using the demonstration class as a vehicle for discussion.

**Thursday morning.** Lab VII was the final event of the Teaching Techniques Workshop. Each participant presented another extended engineering class. A twenty minute teaching assessment followed each presentation.

It is appropriate to remark on the nature of the teaching assessments during the Teaching Techniques Workshop. As previously mentioned, participant teaching was conducted in six-
person lab groups composed of four participants and two short course mentors. Except for the participant teaching the lesson, all group members assumed the role of an undergraduate engineering student during these lab sessions. Consequently, all teaching assessments were conducted from a student perspective -- not the perspective of a colleague with subject-matter expertise. A conscious effort was made to focus on assessing organizational and presentational methods – not the technical expertise of the participant.

**Other Seminars.**

While T^4E emphasized classroom organizational and presentational skills in a "learning by doing" environment, other seminars were conducted to explore other critical issues of importance to success as a college-level engineering faculty member. The scheduling of these seminars is portrayed in Figure 2 and explained below.

**Learning Styles.** This seminar explored and discussed fundamental teaching techniques and how they related to the learning styles of typical undergraduate students.

**Gender Issues.** This event was conducted by Dr. Mary Sansalone, Associate Director of the School of Civil & Environmental Engineering, Cornell University. Dr. Sansalone discussed the challenges and rewards for female faculty members in academia.

**History of Engineering Education.** Dean Emeritus William B. Street of Cornell University presented a review of the history of engineering education in the United States – with special emphasis on the military influence on the educational institutions.

**Student-Teacher Relations.** A guided group discussion was conducted on the sensitive issues related to formal and informal associations between faculty and their students.

**Teaching With Technology.** This seminar was conducted by the faculty of the United States Military Academy's Center for Teaching Excellence to demonstrate some specific computer-based technologies being investigated by the Academy for possible use in the education process.

**Success in Academia.** Charles Wise of the Community of Science of Baltimore, Maryland summarized the research funding opportunities available to engineering faculty – especially through the Community of Science.

**Promotion and Tenure.** This seminar discussed the many paths toward (and away from!) tenure.

### SHORT COURSE SCHEDULE

<table>
<thead>
<tr>
<th>SUNDAY</th>
<th>MONDAY</th>
<th>TUESDAY</th>
<th>WEDNESDAY</th>
<th>THURSDAY</th>
<th>FRIDAY</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Lab IV</td>
<td>Lab VI</td>
<td>Lab VI</td>
<td>Lab VII</td>
<td>Lab VII</td>
</tr>
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<td>8:00 a.m.</td>
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<td>Lab IV Participant</td>
<td>Lab VI Participant</td>
<td>Lab VII</td>
<td>Lab VII</td>
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Success in Academia
4. Course Assessment

Four instruments were used in assessing the short course. Two were collected on the final day of the course to gather the participants’ and senior mentors’ immediate reactions. Input was then sought from each participant, and the individual from their institution who supported their participation, at the end of the subsequent fall semester.

Immediate Participant Feedback

Feedback from the participants was collected on the final day of the course via a short course assessment form that sought numerical scores on value and conduct of the various components of the course, with comments welcomed. This form had been given out at the start of the week with the request that it be filled in as the week progressed. Participants spent some 26 out of roughly 37.5 hours of programmed activity teaching, watching others teach, critiquing other’s teaching, or working on various aspects of developing and presenting a good class. This aspect of the short course was given high ratings by the participants, 4.6 in value (1 = low, 5 = high) and 4.7 in conduct (1 = unsatisfactory, 5 = excellent).

Other major aspects of the short course were rated from 2.6 (Student-Teacher Relations) to 3.9 (Women’s Issues in Academia) in value and 3.4 to 4.4 in conduct, respectively. Data on administration and logistics, and conduct of instruction were also captured in this survey for use in planning and conducting future courses.

Two short open-ended questions were handed out, and collected, on the final day that sought an overall self-assessment of participant’s improvement in teaching, if any. A sampling of the participants’ comments follows:

“Yes, my teaching has improved. I think the greatest improvement is in my ability to organize a lecture, know how long it’s going to take...At first I was skeptical about how transportable this would be ... Once we started doing it, though, I could see things I could use and I may find more.”

“Assessment techniques are key. Self-assessment - if I can do this, I can continue to improve. Realized the absolute #1 status of KNOWLEDGE.”

“Yes. Improved energy and excitement.”

“Yes. -- Identifying my deficiencies & assets as a teacher was very valuable. I know the things I need to work on and the priorities. Knowing that I have assets & what they are gives me confidence to work on the deficiencies & risk falling flat on my face.”

“I believe my teaching will improve via constant contact. I expect my ability to keep the class engaged throughout a class will improve because of the many questioning techniques/objectives/board tech(s) we have been exposed to, this week”

“Yes! I have learned some very specific proven techniques that I can start to incorporate into my teaching. My teaching has improved as measured by the assessments of the practice sessions. The “board” concept has made that possible.”
“I believe this is the best seminar I have ever been to related to teaching.”

**Immediate Senior Mentor Feedback**

Feedback from the “senior mentors” was also gathered on the final day of the course to capture their point of view on various aspects of how the course was run and how they felt the participants’ teaching had improved. Although opinions on how the course ran were inconclusive, the unanimous opinion was that the participants had improved their teaching.

**Subsequent Participant Feedback**

At the end of the following fall semester, a questionnaire was sent out to gather feedback on the short course from the participants after they had had a chance to incorporate what they had seen and practiced in the summer. A sample of the questions with the participants’ averaged responses are shown in Figure 3. At the time of writing, 16 of 24 participants had responded.

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### TEACHING SELF ASSESSMENT

**Professor:** ____________________________________________________________  **Date:** __________

Please provide a rating of each aspect of your teaching on a scale of 1 to 5 in accordance with the criteria given, and provide any comments you have on that aspect directly below it.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Self Assessment</th>
<th>Contribution of T²E to current status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before T²E</td>
<td>Current</td>
</tr>
<tr>
<td></td>
<td>1 = unsatisfactory</td>
<td>5 = excellent</td>
</tr>
<tr>
<td>OVERALL ASSESSMENT of your teaching</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LESSON ORGANIZATION</td>
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<td>Comments</td>
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</tr>
<tr>
<td>PRESENTATION OF MATERIAL</td>
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<td>4.0</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERACTION WITH STUDENTS in class</td>
<td>3.2</td>
<td>4.1</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEMONSTRATION &amp; VISUAL AID USAGE</td>
<td>2.6</td>
<td>4.0</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY AND ENTHUSIASM</td>
<td>3.2</td>
<td>4.2</td>
</tr>
<tr>
<td>Comments</td>
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</tbody>
</table>

**Figure 3 - Portion of participant survey with averaged responses**
**Subsequent Sponsor Feedback**

Feedback from the person at the participant’s home institution who had recommended the applicant and agreed to pay their travel expenses was also sought. The first page of questions on this survey were identical to the participant survey, except for minor changes to make the questions read appropriately. Results for the first, third, fourth, sixth, seventh, and eighth questions, those shown in Figure 3, are presented graphically in Figure 4. In this case, the results represent an average of 8 responses.

![Graph showing sponsor's assessment of participant](image)

The close correspondence between participant and sponsor responses is worth noting. It indicates that our program is on track from all perspectives. Data on student reaction to the faculty member’s teaching was not available at the time of writing.

**5. Lessons Learned**

The most important lesson is that there is a need for some form of concentrated teacher training for engineering professors, and for that matter, most college professors. The 121 inquiries, 61 applications, and the response of those in attendance illustrate the urgent need for something to help teachers learn to teach. Much time and effort has gone into the technological classroom, the advancement of learning models and teaching techniques, and distance learning. MOST of the students today still see a professor, in the classroom, three times a week. Unfortunately, it is the neglect of those teachers by the developmental programs in this country that necessitated this course.

The course is unique in that the participants are put in front of a class of their peers to be evaluated on their teaching skills. The majority of participants responded well to this situation and learned a great deal. Since most were inexperienced instructors, they felt comfortable with their personal weaknesses and basked in their strengths. Originally there was concern with the group dynamics, but because this was stressed as a sensitive area, it was almost devoid of problems.
Feedback on the short course indicates the need to do a better job tying the program together when addressing learning models, technology, and student-teacher relations. Since these are high priority areas in most schools, how these areas fit in our teaching scheme must be demonstrated. It is important that the participants realize that this tie exists so they can “defend” their teaching methods when there is pressure to change.

The concerns of those from other universities where there are other demands on time need to be more thoroughly addressed so that the participants can use the “T4E Model” and remain on track for tenure and promotion. Institutional missions differ, thus requiring modification of the passion for teaching before all else.

In general, we are on target with our program. It is especially useful to the new instructor with no experience. With modification, it can be exported to almost any environment to assist teachers at all levels who want to do better in the classroom. Unfortunately, we can only reach 24 per year, but these 24 will affect thousands of students in their teaching lifetime.

6. Future of the Short Course

Funding for a second offering of the short course was awarded by the NSF. This offering will run from July 27 through August 1, 1997. In anticipation of reduced funding from NSF in future years, other sources of support are being explored, as is the possibility of exporting the program to other institutions.

The West Point/USMA environment offers advantages in that all participants are on equal ground with no one present who would be potentially involved in their promotion/tenure reviews. Also, the teaching model that is presented was developed at USMA and is most easily illustrated there due to relatively unique classroom resources, and the human resources that can be devoted to the effort at little or no cost. On the other hand, we have succeeded in developing a teaching model that is transportable.

The short course would work well as a program required of new faculty at individual institutions, or within university/college systems. An appropriately sized group could be gathered in several ways. New engineering faculty could be brought together from several institutions within a system, or the program could be adjusted to work for new faculty within Mathematics, Science, and Engineering (MSE) departments in a single institution. An obvious advantage of running a program involving faculty from MSE departments within a single school is the potential for increased interaction among these faculty to include the planting of seeds for future interdisciplinary efforts.

Several of these schemes are being explored, knowing that the dynamics of the group are critical to the success of the program, and that group size and background effect the group dynamic. Getting up and teaching in front of ones peers, being critiqued on that teaching, and critiquing others within the group does much to break down barriers and develop bonds, and clearly helps educators improve their teaching.
References


Author Biographies

JERRY W. SAMPLES is Professor of Engineering and Director of Engineering Technology at the University of Pittsburgh at Johnstown. He holds a BS ChE from Clarkson College, and MS and PhD in ME from Oklahoma State University. He taught at the United States Military Academy for 12 years, has extensive experience in the development of inexperienced faculty members, and was the PI on a 1995 NSF Grant entitled “Teaching Teachers to Teach Engineering”.

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