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3 **Engaging Engineering Students through**  
4 **Improved Teaching**  
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12  
13 **Abstract**  
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15 National enrollment statistics show that engineering programs historically lose more than 55% of  
16 their entering students to attrition of some form<sup>1</sup>. Whether this attrition is to other academic  
17 programs or from college altogether it is clearly a problem that must be reversed if we are to  
18 attract and retain the best and brightest minds to the engineering profession for the future. While  
19 there are a wide variety of reasons for the poor retention of math , science and engineering  
20 students, Seymour and Hewitt, in their seminal work, “Talking about Leaving: Why  
21 Undergraduates Leave the Sciences”<sup>2</sup>, discovered that the number one concern of students at  
22 institutions across the country; was the quality of instruction they received. Of the numerous  
23 reasons cited for leaving Mathematics Science and Engineering, (MSE), programs, pedagogical  
24 concerns dominated the top ten categories.

25 In an effort to improve the teaching of faculty in civil engineering programs across the US, the  
26 American Society of Civil Engineers has funded and promoted a teaching effectiveness  
27 workshop called the ExCEED Teaching Workshop for the past six years. Ostensibly for new  
28 faculty, this workshop focuses on some “nut and bolts” type teaching tools that help faculty  
29 members in preparing for a class, in developing a well choreographed classroom presentation  
30 and in logically connecting in-class and out-of-class work. The key element that separates this  
31 workshop from others of similar description is that participants are required to prepare and  
32 present three lessons to a group of peers and mentors, incorporating teaching tools gained in the  
33 workshop,. They receive immediate feedback on the effectiveness of their class and suggestions  
34 for improving the next class. The focus of this paper is divided into two parts. First a brief  
35 description of the objectives and conduct of the workshop will be presented. Then some data,  
36 both numerical and anecdotal, will be presented and discussed regarding the perceived and real  
37 effectiveness of the workshop.

38  
39 **Introduction**  
40

41 National enrollment statistics show that engineering programs historically lose more than 55% of  
42 their entering students to attrition of some form. When viewed in terms of 6-year graduations  
43 rates, this figure represents an overall 14% reduction in the 6-year graduation rate when  
44 compared to that rate for all disciplines combined<sup>1</sup>. In some engineering colleges, increases in

1 first year student retention rates from 34 to 50 percent are considered major victories<sup>3</sup> but fall far  
2 short of matching retention rates in other disciplines. Needless to say, retention rates in  
3 engineering programs is a serious issue in the United States. Whether this attrition results in  
4 students migrating to other academic programs or leaving college altogether it is clearly a  
5 problem that must be reversed if we are to attract and retain the best and brightest minds to the  
6 engineering profession for the future. While there are a wide variety of reasons for the poor  
7 retention of math, science and engineering students (MSE), Seymour and Hewitt, in their seminal  
8 work, "Talking about Leaving: Why Undergraduates Leave the Sciences"<sup>2</sup> discovered that the  
9 number one concern of students at institutions across the country; was the quality of instruction  
10 they received. Of the numerous reasons cited for leaving MSE programs, pedagogical concerns  
11 dominated the top ten categories of student responses. On the other hand, faculty members cite  
12 inadequate high school preparation or improper choice of discipline as the major factors  
13 affecting retention. Even though students point out factors that contribute to poor teaching in  
14 their end-of-semester evaluations, some faculty refuse to believe that these poor evaluations are  
15 really the result of poor teaching despite a large body of research<sup>4,5</sup> that supports the notion that  
16 student evaluations of teaching are reliable and valid.

17  
18 In light of all the negative publicity attributed to engineering education in the later part of the  
19 20<sup>th</sup> century, the American Society of Civil Engineers (ASCE), through its Committee for  
20 Education Activities Committee (EdAC), formally recognized the need to support the  
21 development of Civil Engineering faculty as effective teachers in 1998. Members of the  
22 committee reasoned that students perceive engineering faculty as representatives of the  
23 profession and, in many cases, it is engineering faculty that are the students first contact with the  
24 profession. As a result, faculty should be the front line in displaying a professional,  
25 knowledgeable and ethical image. It was clear that a program was needed that could facilitate  
26 the development of faculty who were:

- 27
- 28 • effective teachers, who can articulate complex technical concepts and ideas to diverse
  - 29 groups
  - 30 • effective teachers who can motivate students to think critically and creatively about
  - 31 engineering problems
  - 32 • role models of the civil engineering profession demonstrating leadership, teamwork, and
  - 33 communication skills.
- 34

35 While many in ASCE felt it was the responsibility of individual universities to deal with faculty  
36 development, the unfortunate fact was that many engineering educational communities had not  
37 implemented the faculty development programs necessary to improve teaching and learning.  
38 Few universities have implemented adequate programs for engineering graduate students that  
39 prepare them for academia. Additionally, reports from many sources, including the NSF  
40 coalitions<sup>6</sup> stressed the need for improvement of faculty teaching skills and pointed out that the  
41 desire by new faculty for this training appeared to be strong. ASCE's Educational Activities  
42 Committee (EdAC) tasked the Committee on Faculty Development (CFD) to develop a plan for  
43 an ASCE-sponsored faculty development program for C.E. faculty. The CFD was expected to  
44 create a high quality faculty development program to improve the teaching effectiveness of civil  
45 engineering faculty.

1 As a starting point for creating such a program, the CFD recommended that ASCE fund an  
 2 existing faculty development workshop called T<sup>4</sup>E (Teaching Teachers to Teach Engineering)  
 3 that was developed by the United States Military Academy through an NSF Grant. This week  
 4 long workshop was essentially a condensed version of a six week new instructor training  
 5 program that had been conducted in the Department of Civil and Mechanical Engineering for  
 6 over 40 years<sup>7</sup>. Under the auspices of ASCE, this work shop was called the ExCEED (Excellence  
 7 in Civil Engineering Education) Teaching Workshop, or ETW for short.

8  
 9 The ETW99 was designed by faculty of the U. S. Military Academy and delivered to 24 faculty  
 10 members with 1-4 years of teaching experience. This workshop was the first in what was  
 11 expected to be a series of annual teaching workshops for C.E. faculty. Concurrent with this  
 12 workshop nine senior faculty from engineering programs around the country formed a program  
 13 design team which was charged with to observing the ETW and making recommendations on  
 14 content and conduct of future teaching workshops that could be delivered in other venues. The  
 15 result of this design activity was the versions of ETW conducted in 2000 and subsequent yeas at  
 16 the University of Arkansas (2000-2005), Northern Arizona University (2002, 2003) and the U. S.  
 17 Military Academy (2000-2005).

### 18 19 **ExCEED TeachingWorkshop**

20  
21 ASCE established the following constraints and requirements for ExCEED Teaching Workshops:

- 22
- 23 • First and foremost, the program must be of very high quality.
  - 24 • The program must not run longer than 5 days.
  - 25 • The participants must have multiple times to practice effective teaching techniques.
  - 26 • The program must target civil engineering faculty with 1-4 years teaching experience.
  - 27 • The participants should learn principles of good practice in teaching and learning.
- 28

29 The workshop model utilized by the U.S. Military Academy incorporated the concept of a  
 30 learning team. The 24 participants were divided into 6 teams with each team having at least two  
 31 mentors who provided guidance and assessment of participant activities. The activities during  
 32 the week could be broken into three different categories: seminars, demonstration classes and  
 33 practice classes. Perhaps the defining feature of ETW99 over other workshops of similar  
 34 description was the fact that participants observed demonstration classes given by master  
 35 teachers and then had to teach three classes to their peers, incorporating concepts learned in the  
 36 seminars and demonstration classes. Seminar content for this workshop focused on providing  
 37 “nuts and bolts” details on how to plan and deliver engaging classroom instruction rather than  
 38 pedagogical theory.

39  
40 The final workshop format proposed by the program design team used the ETW99 format as a  
 41 basis for future workshops. All proposed changes kept the fundamental ETW99 program, with  
 42 its vital practice classes, demonstration classes, and stimulating environment, intact. The  
 43 proposed focus of the ETW continued to emphasize basic teaching improvements for junior  
 44 faculty. The program design team created objectives for the workshop that reflected this focus  
 45 and a set of expectations for participants that would help in selecting applicants for the  
 46 workshops. During the workshop:

- 1 • Mentors teach and demonstrate best methods of teaching and learning.
- 2 • Participants apply the best methods of teaching and learning in practice sessions.
- 3 • Mentors teach and demonstrate learning assessment skills.
- 4 • Program fosters a passion for teaching; and builds a learning community of civil engineering
- 5 educators.

6

7 Faculty who attend ExCEED Teaching Workshops are expected to:

8

- 9 • Demonstrate, at the workshop, the principles of effective teaching.
- 10 • Apply, at the workshop, lesson assessment techniques.
- 11 • Implement, at their home institutions, concepts and strategies of effective teaching.
- 12 • Participate in future activities to enhance teaching and learning.
- 13 • Provide appropriate leadership at their home institutions to foster effective teaching and
- 14 learning.

15

16 A major concern of the program design team in exporting the program to other institutions was  
 17 the resource intensiveness of the workshop, both in terms of personnel and facilities. The  
 18 Military Academy supported this workshop with over 25 classrooms and at least as many  
 19 program faculty. It was unlikely that any other institution could support the workshop with the  
 20 same level of resources. The University of Arkansas was selected as the first site to test the  
 21 portability of the program. The College of Engineering at the University of Arkansas supported  
 22 the workshop with seven classrooms and the program director. The 12 mentors for the workshop  
 23 were either members of the program design team (6- senior mentors), or graduates of ETW99 or  
 24 previous T<sup>4</sup>E. workshops, (6- assistant mentors). The guidance of the program design team was  
 25 implemented by following the model instructional strategy illustrated in Figure 1. While specific  
 26 details of how the logistics and execution of that workshop were accomplished can be found in a  
 27 2001 paper by Dennis<sup>10</sup>, a brief description of the workshop content is provided here.

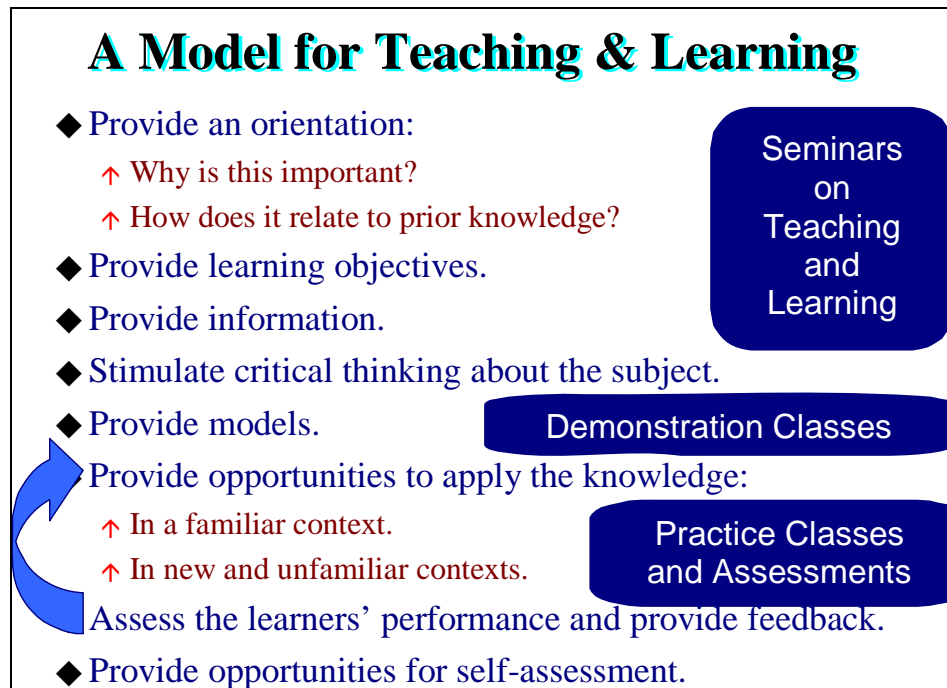
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29 All of the implied tasks from the program design team are assembled into a five-day schedule  
 30 shown in Figure 2. This schedule integrates 12 seminars, 3 demonstration classes, 3 practice  
 31 classes per participant and 2 social events into a logical sequence. The coordinator, mentors and  
 32 assistant mentors meet the day before the start of the workshop to iron out administrative details  
 33 and to conduct some “train-the-trainer” activities in preparation for a smooth kick-off of the  
 34 workshop.

35

36 At the beginning of the workshop an assessment vehicle called a Background Knowledge  
 37 Probe<sup>11</sup> is administered to determine the general level of participant knowledge in topical areas  
 38 relating to teaching and learning. Some important feedback from this vehicle that has remained  
 39 relatively constant over the past 6 years is that; fewer than 25 percent of the participants have  
 40 participated in a formal teaching and learning development activity that lasted more than 4 hrs:  
 41 only 20 percent of the participants have heard of or used fairly common techniques to improve  
 42 teaching and learning, and fewer that 2 percent of the participants have internalized these  
 43 concepts to the point where they could explain them to others. As a result, it has not been  
 44 disappointing to participants that the first three bullets of the Model Instructional Strategy are  
 45 accomplished in the 12 seminars that focus on these areas. The two major references for the  
 46 workshop are Joseph Lowman’s *Mastering the Techniques of Teaching*<sup>8</sup> and Wankat and

1 Oerovicz's *Teaching Engineering*<sup>9</sup>. Each participant is given a copy of these books and the  
 2 seminar content refers frequently to information in each. The seminars are highly interactive and  
 3 have many collaborative and active learning pieces in each. Through the seminars participants  
 4 are exposed to Lowman's Two Dimensional Model for Effective Teaching<sup>8</sup>, and are required to  
 5 cite and develop in and out-of-class activities that contribute to the two dimensions of the model,  
 6



26 Figure 1. Teaching and Learning Model used in the Exceed Teaching Workshop  
 27  
 28

29 intellectual excitement and interpersonal rapport. The use of learning objectives for lesson  
 30 planning is stressed and Blooms Taxonomy for the cognitive domain<sup>12</sup>, is used as a focal point  
 31 by the participants in developing quantifiable and meaningful lesson objectives for their practice  
 32 classes. Felder's Index of Learning Styles<sup>13</sup> is used as theory to convey the variety of ways our  
 33 students receive and process information. Wankat and Lowman are the major references used to  
 34 develop the importance of good communication skills, organization and enthusiasm.  
 35

36 The demonstration classes given by the "master teachers" reinforce all of the concepts presented  
 37 in the seminars and follow what is referred to as the ExCEED Model, illustrated in Figure 3.  
 38 Participants act as students in a sophomore level class and are required to take notes, respond to  
 39 questions and perform calculations, just like a regular student. Through these classes  
 40 participants observe an engaging presentation which uses chalk and the blackboard as the  
 41 primary classroom prop. Each class is laced with physical models and active learning exercises  
 42 and an appropriate use of technology. The instructor always demonstrates enthusiasm for the  
 43 material and conveys material in a very logical and organized manner. At the conclusion of each  
 44 class an assessment process is conducted which is identical to the process the participants will be  
 45 subjected to in their practices classes. Mentors and participants alike cite strengths and areas for  
 46 improvement. The modeling of this assessment process in the demo classes makes the

COURSE SCHEDULE						
	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8:00		Admin	Admin	Admin	Admin	Admin
		Demo Class I	Demo Class II	Demo Class III	Lab IV Practice Class 3	Seminar XII Syllabi/Testing
10:00		Seminar II Teaching & Learning	Seminar VII Questioning	Seminar IX Building Rapport		Seminar XIII Making It Work
		Seminar III/IV Communication	Seminar VIII Learning Styles			ASCE Ed.
12:00		Lunch	Lunch	Lab III Practice Class 2	Lunch	ETW Assessment & Wrap-Up
2:00		Seminars V,VI Performanced Based Learning	Lab II Practice Class 1		Seminar X Managing Teams	
4:00	Intro to ETW				Seminar XI Non-Verbal Communication	
	Seminar I Learning to Teach					
6:00	Ice Breaker Team Building	Lab I Organizing a Class			Banquet	

Figure 2. ExCEED Teaching Workshop Schedule

assessment of participants classes more useful in that they are trained in what to look for in a class and how to tie the behavior to the teaching models they have been exposed to. Seeing a seasoned instructor who presents a remarkably well done class get both positive and negative feedback also helps them buy into the assessment process.

## The “ExCEED Model”

- ◆ Structured organization
  - Based on learning objectives
  - Appropriate to the subject matter
  - Varied, to appeal to different learning styles
- ◆ Engaging presentation
  - Clear written and verbal communication
  - High degree of contact with students
  - Physical models & demonstrations
- ◆ Enthusiasm
- ◆ Positive rapport with students
- ◆ Frequent assessment of student learning
  - Classroom assessment techniques
  - Out-of-class homework and projects
- ◆ Appropriate use of technology



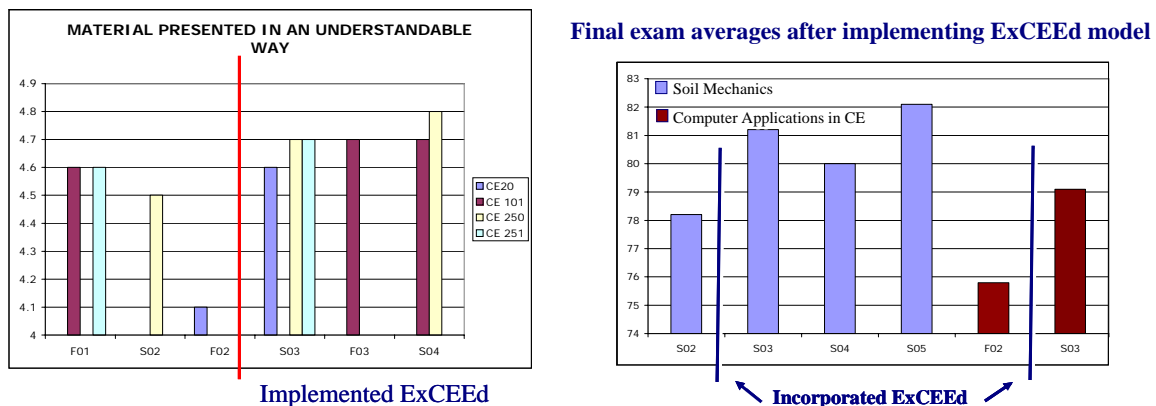
Figure 3. Presentation concepts emphasized in demonstration and practice classes

1 The goal is to have participants, within the confines of their own personalities, model the  
 2 behavior of the master teacher in their practice classes. Each practice class is considered a  
 3 laboratory with specific learning objectives. For example, the first practice class only requires  
 4 the participants to present material in an organized fashion following well crafted lesson  
 5 objectives using clear verbal and written communication. In the second class they are required to  
 6 ask well formed questions and incorporate activities or techniques that appeal to different  
 7 learning styles. In the final class they are required to integrate active learning activities. The  
 8 idea is not to overwhelm them with implementing too many concepts at one time.

9  
 10 A defining feature of the Arkansas workshop over workshops held at West Point is the  
 11 icebreaker, held on Sunday evening. This event integrates some team building competitions into  
 12 a relaxed social atmosphere. All mentors who have experienced both the Arkansas and West  
 13 Point workshops are in agreement that, as a result of this activity, the participants really come  
 14 together into teams and seem more relaxed during their first practice teaching session than those  
 15 at the West Point workshops. The actual workshop is an intense 12-14 hr per day experience.  
 16 While formal activities are scheduled for only 8 hours per day, informal mentoring and class  
 17 preparation went on well into the evening hours everyday. Even though the workshop was  
 18 intense, few participants complained. On the contrary, most felt the pace of instruction was right  
 19 on track and every participant felt they took something from the workshop that would improve  
 20 their teaching.

## 21 Assessment of the Workshop

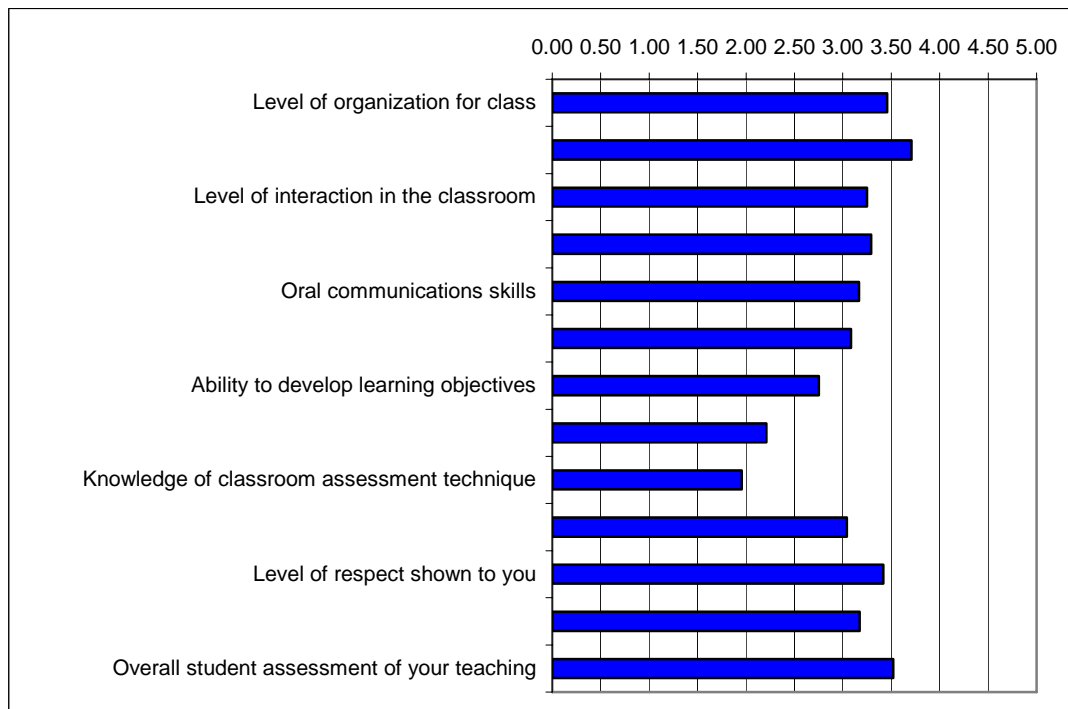
22  
 23 A great deal of anecdotal evidence exists to support the notion that the ExCEED teaching  
 24 workshop has improved the teaching of past participants from the winning of local and national  
 25 teaching awards to improvements in teacher ratings. The ratings shown in Figure 4 are typical of  
 26 some of the unsolicited feedback received from past participants. The affect of ETW on  
 27 evaluations and student performance are dramatic.



42 Figure 4. Student Evaluations and Test Scores for a Past ETW Participant

43  
 44  
 45 The formal workshop assessment was conducted in three phases. A pre-workshop questionnaire  
 46 was distributed prior to the actual workshop in an attempt to get some baseline data on the

1 participants' self-assessment of their teaching abilities. The results of that survey are illustrated  
 2 in Figure 5. An interesting aside from this data is that is that participants at the Arkansas  
 3 workshops have higher self assessment scores on every question than the participants at the West  
 4 Point workshops.



27 Figure 5. Results from the Pre-workshop Assessment Questionnaire.

28  
 29 A score of three in Figure 5 represents acceptable knowledge or performance in a particular area.  
 30 The only areas which participants felt a particular weakness were in addressing student learning  
 31 styles, developing lesson objectives and using classroom assessment techniques. In fact, many  
 32 participants had never heard of learning styles or classroom assessment technique (as  
 33 distinguished from quizzes or examinations). These baseline data were collected only to obtain  
 34 participant perceptions of their teaching preparedness prior to any exposure to teaching and  
 35 learning concepts presented in the workshop.

36  
 37 Participants also completed an assessment vehicle at the conclusion of the workshop in which  
 38 they rated each major activity of the workshop in terms of its value to them in improving their  
 39 teaching and how well the activity was actually executed by the content provider. The results of  
 40 that assessment are given in Figure 6. Participants uniformly rated all activities high, however,  
 41 the defining features of the ExCEED workshops, practice classes and demonstration classes  
 42 received the highest overall ratings.

43  
 44 The lowest rated activity was the participant skits in which they were asked to model the worst  
 45 teaching they had ever been exposed to. The intent was to add some levity to the workshop by  
 46 interspersing these skits between seminars, but the archetypical engineer participants did not



1 appreciate humor. So they were removed from subsequent workshops and replaced by five-  
 2 minute demonstrations of the use of various physical models to promote the understanding of  
 3 principles in various sub-disciplines of civil engineering. As part of the workshop assessment  
 4 the participants were asked the question; “Has your teaching improved as a result of attending  
 5 this workshop? If so, please characterize that improvement for us. If not, please tell us the major  
 6 reason you were unable to improve your teaching.”

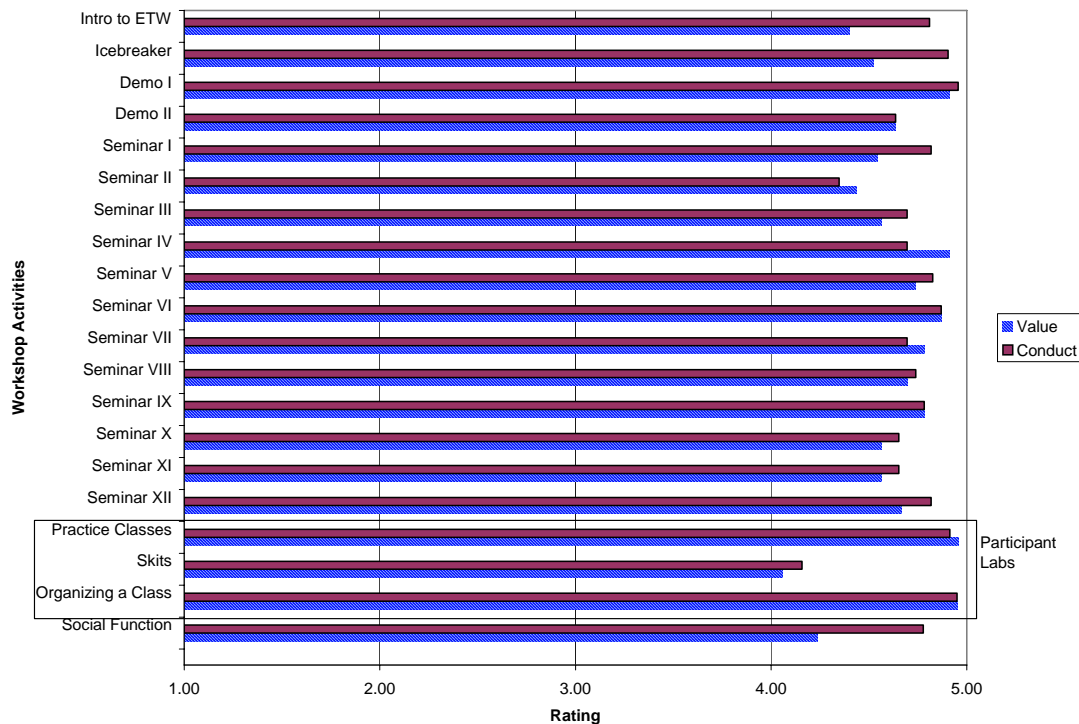


Figure 6. Assessment of Workshop Activities.

Since 1999 over 300 participants have completed this assessment and none have ever answered this question negatively. Comments like those give below are typical.

- “Before attending the workshop I was wondering if I could become an effective teacher. Now I believe I can. The workshop has given me the tools to succeed.”
- “My attitude changed from total frustration [with teaching] to excitement. Life changing experience as an educator I’m a “reborn” teacher.”
- “Having someone finally explain a proven way how to organize a class and engage students is the single most significant event in improving my professional career (10 years). I am only sorry I did not find the information sooner.”

Finally a post workshop questionnaire is administered at the end of the semester following the workshop (approximately 7 months out). In that questionnaire the same questions posed in the pre-workshop questionnaire are asked again. The participants were requested to rate on a scale

1 of 1 to 5 their abilities before attending ETW and after attending ETW and to assess the  
 2 contribution of ETW to their current status. A sample response to that questionnaire is  
 3 appended. An interesting note from this post workshop assessment data is that the participants'  
 4 self assessment of their Pre-ETW skills was frequently one to two points lower than when they  
 5 answered the same question in the Pre-workshop questionnaire. This reinforces Wankat's notion  
 6 that college professors often over rate their own teaching until they have something to compare it  
 7 to<sup>14</sup>. Typical responses on preparation time for class have participants spending from 10 to 60  
 8 minutes less for each class, a significant improvement in efficiency. Participants felt the most  
 9 useful feature from the workshop that they could incorporate into their teaching was; writing  
 10 learning objectives, questioning techniques and the use of "board notes".

## 11 **Conclusions**

- 14 • Based on participant responses and assessment data it is clear that the ExCEED Teaching  
 15 Workshops are making a difference in the quality of instruction civil engineering students are  
 16 receiving in classrooms all across the country.
- 17 • The key to creating a successful workshop is in assembling a seasoned group of mentors who  
 18 subscribe to the basic precepts of ExCEED.
- 19 • Participants agreed with the program design team in that the defining features of this teaching  
 20 workshop over all other teaching workshops are the demonstration classes, given by  
 21 exemplary teachers, and the practice classes which force participants to employ concepts  
 22 taught in the workshop in their classes that are presented to an audience of their peers in a high  
 23 challenge-low threat environment.
- 24 • The improvement in clarity and enthusiasm displayed in practice classes vary from  
 25 participant to participants, but all 300+ participants in the program have had a positive and  
 26 quantifiable improvement
- 27 • While no direct evidence has been uncovered that links improved student retention to the  
 28 ETWs, improvements in teaching evaluations and improved student performance post ETW  
 29 suggest that these workshops are indeed reversing the notion that the quality of teaching in  
 30 civil engineering programs is a matter of concern.

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### ExCEED Teaching Workshop (ETW) POST-COURSE ASSESSMENT

NAME: \_\_\_\_\_

DATE: 02/20/2005

Please provide a rating of each aspect of your teaching on a scale of 1 to 5 (as shown), and provide any additional comments directly below each rating.

Aspect	Self Assessment		Contribution of ETW to current status 1 = none 2 = small 3 = moderate 4 = high 5 = very high
	Before ETW	Current	
	1 = unsatisfactory 5 = excellent		
<b>OVERALL ASSESSMENT of your teaching</b>	2	4	5
Comments <i>ETW opened my eyes to a new range of teaching tools.</i>			
<b>LESSON ORGANIZATION</b>	2	4	5
Comments			
<b>PRESENTATION OF MATERIAL</b>	2	4	5
Comments <i>I have incorporated more activities into the lecture which seems to enhance student learning and interaction.</i>			
<b>VOICE</b>	2	3	5
Comments <i>I still have to work on this to break old habits but I am aware of its effects and potential.</i>			
<b>INTERACTION WITH STUDENTS (IN CLASS)</b>	2	4	5
Comments <i>using digital pics. really does help <del>them</del> learn student names quick(ly) (with name cards)</i>			
<b>USE OF DEMONSTRATIONS &amp; VISUAL AIDS</b>	2	5	5
Comments			
<b>ENERGY AND ENTHUSIASM</b>	2	4	5
Comments			
<b>CONFIDENCE (AS A TEACHER)</b>	2	5	5
Comments			
<b>LEVEL OF STUDENT LEARNING</b>	2	4	4
Comments			
<b>TEACHING EVALUATION BY STUDENTS</b>	3	?	N/A ?
Comments <i>Still waiting on last semester's evaluations.</i>			
<b>TEACHING EVALUATION BY PEERS</b>	3	?	?
Comments <i>Only have comments before ETW. Expected better this year.</i>			

PROFESSOR: \_\_\_\_\_ DATE: \_\_\_\_\_

Please provide answers to the following questions.

I spend approximately 50 minutes preparing for a typical hour of class, not including grading; this is approximately 30 minutes more (less (please circle one) than prior to ETW. Please comment.

I have a better system of lesson and class organization, plus better ~~of~~ lecture/classroom/instruction ~~that~~ skills which have helped reduce time necessary for prep.

What one aspect of the short course has helped you the most?

Interacting with students during classroom lecture/teaching. (Asking questions, learning each student's name, "drawing out the answer" technique, etc.)

What one aspect of the short course has helped you the least?

While the whole course was helpful, the aspect least helpful is probably that which I use the least, i.e. colored chalk! I prefer to use colored markers. 😊

What single addition or improvement would you incorporate into the short course?

more fruits and veggies for breakfast!

Based upon your experience during the previous academic year, what is your overall assessment of the ExCEED Teaching Workshop: Was it worth your time?

I absolutely enjoyed the workshop. I can't say enough good things about it. It touched on a broad range of topics to increase teaching effectiveness. All filler and no fluff.

Would you recommend ETW to others?

Absolutely!

Please describe any activities you have undertaken as a result of ETW to further the cause of high-quality teaching.

More frequent student assessment of ~~the~~ course, which is generally positive. Attended ~~work~~ other workshops that stress student-centered teaching, i.e. P. Fink, "Creating Significant Learning Experiences", among other things.