Learning to Teach Engineers: The Applicability and Compatibility of One Approach

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Abstract

The American Society of Civil Engineers (ASCE) recently initiated a program that has **Ex**cellence in **C**ivil **E**ngineering **Ed**ucation (ExCEEd) as its goal. In 1999 the author attended the first ASCE ExCEEd Teaching Workshop (ETW) at the United States Military Academy in West Point, New York. The ETW participants consisted of 24 new (i.e., less than four years experience) civil engineering faculty. For this reason, the focus of the ETW was basic and effective teaching skills. It consisted of 12 seminars, three demonstration classes, and three classes that were prepared and taught by each participant.

This paper documents and summarizes several topics related to the author's ETW experience. First, the preconceptions of the author (who has attended a number of teaching workshops in the past several years) with respect to the ETW are described. Second, the format of the ETW and the main components of the "ExCEEd model" for teaching are summarized. Third, the "post-conceptions" of the author about the workshop in general and the overall applicability of the "ExCEEd model" are documented. In particular, the author's initial and ongoing experiences with the application of some techniques taught at the ETW are discussed. The results of a brief student survey are also summarized. Finally, the general compatibility of the "ExCEEd model" teaching approach with active and group learning techniques and the general requirements of the Accreditation Board for Engineering and Technology (ABET) are briefly discussed.

I. Introduction

Most new engineering faculty are expected to teach undergraduate and/or graduate classes from the first day on their appointment. The majority, however, have had almost no training or guidance about how to teach effectively, or how to assess that effectiveness. This results in a trial-and-error teaching approach that uses students as experimental subjects. It can also introduce the use of long-lasting teaching techniques that have questionable effectiveness.

The American Society of Civil Engineers (ASCE) recently initiated the **Ex**cellence in **C**ivil **E**ngineering **Ed**ucation (ExCEEd) program. One objective of this program is to fill the educational training gap for new civil engineering faculty. This paper documents several topics related to the author's attendance at the first ExCEEd teaching workshop (ETW). The following paragraphs summarize the author's preconceptions, the workshop content, the main components of the "ExCEEd model" for teaching, the author's post-conceptions, and some of the experiences the author has had with the application of some techniques and methods presented at the ETW.

II. Preconceptions

The first ETW took place in July 1999 at the United States Military Academy (USMA) in West Point, New York. The majority of the workshop was taught or presented by USMA faculty, and its content was primarily based on the USMA educational training program for new civil engineering faculty. These facts, combined with the author's experiences at other teaching workshops and during his first year of university teaching, produced some (admittedly cynical) preconceived expectations of the ETW. The author's main concerns with respect to the ETW included: 1) whether the "ExCEEd model" for teaching (used effectively by the military at an undergraduate academy) could be transferred to the world of "civilian" students, possibly at a large "research-oriented" university, 2) if the approach could work with graduate classes, 3) whether preparation for the "ExCEEd model" approach would take significantly more time, and 4) whether the techniques in the approach were compatible with some of the more recent teaching and assessment trends, and Accreditation Board for Engineering and Technology (ABET) expectations and requirements.

III. ExCEEd Teaching Workshop and "ExCEEd Model" Summary

A large amount of material was presented and discussed at the five-day ASCE ExCEEd teaching workshop. The following paragraphs represent a short summary of the ETW format and the main components of the "ExCEEd model" for teaching.

IIIA. The ExCEEd Teaching Workshop

As previously mentioned, the ASCE ETW took place in July 1999 at the USMA in West Point, New York. The number of participants in the workshop was limited to 24 new (i.e., less than four years experience) civil engineering and civil engineering technology educators from large and small universities throughout the country. The focus of workshop was basic and effective teaching skills, and the majority of the information presented appeared to be new to most of the participants. The stated objectives of the workshop were to help the participants: 1) improve their teaching skills, 2) learn and apply teaching and learning theory, 3) learn teaching assessment skills, 4) meet and interact with other civil engineering faculty interested in teaching, and 5) develop a passion for teaching.[1]

Overall, the five-day ETW consisted of 12 seminars, three demonstration classes (taught by the workshop instructors), and three classes prepared and taught by each participant. This produced a workshop approach that included: 1) the instructors explaining why and how to effectively teach (i.e., the seminars), 2) the instructors showing the ETW participants how to use the "ExCEEd model" for teaching (i.e., the model demonstration classes), and 3) the participants applying the "ExCEEd model" techniques and receiving constructive feedback (i.e., the classes prepared and taught by each participant). These three components for teaching new material (i.e., introduce/explain, show, and apply/use) also represent the core of the "ExCEEd model" for effective teaching (discussed in the next section). The content of the workshop seminars included[1,2]:

- Principles of effective teaching and learning,
- Learning styles,

- Communication skills,
- Learning objectives,
- Course and class organization,
- Developing interpersonal rapport with students,
- Teaching with technology, and
- Classroom and teaching assessment techniques.

The details of the information discussed in each of the 12 seminars will not be presented in this paper, but the presentation material for each of the ETW seminars is on the ASCE webpage, and can be used for educational purposes.[1] The seminar content provided the why and how of effective teaching.

Three demonstration classes were taught by ETW instructors that had years of experience with the "ExCEEd model" (see the next section) teaching approach. These classes provided models of how the seminar material could be used to teach: 1) a normal-sized undergraduate class with relatively basic subject material, 2) a normal-sized undergraduate class with more advanced material, and 3) how the approach could be adapted to large lecture hall classes. In general, they showed the ETW participants that "ExCEEd model" techniques could be applied and adapted to classes of varying subject difficulty, student/learner diversity (typically the ETW participants or "students" were participating in classes outside their specialty area of civil engineering), and physical settings or requirements. The ability to do the latter (i.e., adapt to different physical settings) was very important because the ETW participants would each have to apply the "ExCEEd model" at their own university. In addition to showing how the "ExCEEd model" for teaching could be applied, the model classes also provided an example or goal for the participants and the classes they would prepare and present as part of the ETW.

The three classes prepared and taught by the ETW participants was a vital learning component of the workshop. This "learn by doing" approach limited the number of people that could participate in the workshop, but it was critical to the effectiveness of the program in the author's opinion. The classes prepared and taught by the participants allowed them to apply the theories, teaching techniques, and assessment tools discussed in the seminars and demonstrated in the model classes. The classes were also videotaped, and assessed by the participant, their peers, and the ETW mentors. In the author's opinion, a large amount of learning took place at the ETW during the application of the techniques taught (much like a typical engineering classroom).

IIIB. The "ExCEEd Model"

The majority of the information presented at the ETW represented explanations and demonstrations of the techniques used to apply the "ExCEEd model" for teaching. These techniques, and the "ExCEEd model" itself, are consistent with the educational training provided to new USMA civil engineering faculty and accepted teaching and learning research results and methodologies.[1, 2, 3, 4, 5] The "ExCEEd model" contains the following six components[1]:

1. A planned and structured organization for the course and each class (i.e., learning objectives and lesson outlines or "board notes" that plan course and class content and activities);

2. The use of an engaging presentation style (i.e., the effective use of voice, chalk, questioning, and physical demonstrations and models);

3. An obvious enthusiasm for the particular subject and civil engineering in general (i.e., the faculty as a role model);

4. A positive rapport with the students (i.e., the creation of an environment that allows a free exchange of ideas and questions);

5. The frequent assessment of student learning (i.e., the use of classroom assessment techniques and appropriate homework/projects); and

6. The appropriate use of technology (i.e., deciding when technology improves the learning environment).

The following paragraphs briefly summarize some of the techniques presented at the ETW for the application of the "ExCEEd model" for teaching.

One of the more important characteristics of the "ExCEEd model" is its structured and efficient approach to class (and course) organization. The basic requirements of the approach are the creation of learning objectives and a lesson outline (through the use of "board notes") for each class.[6] Usually, one to five learning objectives should be identified for each class. These objectives must be measurable and describe what the student should be capable of **doing** after attending class, and completing the reading assignments, assigned homework, and/or projects. They should be visible to the student and referred to throughout each class. The construction of learning objectives assists with lesson planning, but also provides direction and flow to each class, indicates to the student the material they need to know, assists with the writing of exams, helps students study for exams, and allows the assessment of student learning and overall course effectiveness. In addition, the accomplishment of learning objectives is measurable because they all represent what students must **do** after a class, reading, homework or project.

In addition to the creation of learning objectives for each class, the "ExCEEd model" also requires the preparation of a lesson outline for each class. These outlines should identify the topics and activities included in each class, and specify the structure and sequence of how these topics and activities will be presented. The structure and sequence is defined through the use of "board notes".[6] In fact, the use of the chalkboard and "board notes" is an integral part of the "ExCEEd model" teaching approach. Each "board note" typically, but not always, represents a three to four foot section of chalkboard, and includes headings, topics, and sub-topics organized in a short and concise outline format (this structure can also be supplemented by the organized and deliberate use of colored chalk, and is described in more detail in a paper by Ressler, Meyer, and Lenox).[6] Each group activity or demonstration in the class is also contained in its lesson outline (i.e., they are planned into the class), and may be equivalent to one or more board notes. Typically, there might be five to eight topics or activities in the set of "board notes" for a particular class (but this depends on the rate of instruction for the individual). The overriding goal of the material contained in the "board notes" is to accomplish the class learning objectives (which should represent the first "board note" and remain on the chalkboard throughout the

class). However, "board notes" also have several other uses. For example, "board notes" should be used to rehearse and organize a class, and identify appropriate transition points. They should also be used as a reference throughout the class (but not transcribed), and kept as a record of what was covered in each particular class. In turn, this allows improvements in scheduling and syllabus organization from semester to semester. The development of activities outside-of-class (versus the in-class focus above) can take a similar approach and should also be constructed to meet learning objectives.

In addition to a suggested organizational approach, the ETW also included techniques to improve the presentation skills and student/faculty interaction of the participants. The use of chalkboards in an organizational outline format (as described previously) can decrease the amount of contact between the instructor and student. This loss of contact, however, goes almost unnoticed if the techniques presented at the ETW and the "ExCEEd model" for teaching are properly applied. The demonstration classes at the ETW and the author's initial experiences with the "ExCEEd model" approach support this fact. For example, the lesson outline "board notes" should not just be member transcribed. When presenting material the instructor needs to be enthusiastic, write and talk, explain what they are writing, and then step back and see if it makes sense (e.g., walk around the classroom and see what the student is seeing). The characteristics or style of the presentation also need to vary (e.g., volume, pitch, instructor location), and group activities (whenever possible) and questions planned into the lesson outline "board notes". This presentation approach, along with planned activities and questions, will actively engage the student during a large portion of an "ExCEEd model" class. Overall, this approach to teaching only advocates the use of technologies when they improve student learning. Classroom contact time is considered a limited and important commodity, and it should typically focus on effective human communication and interaction with the student (e.g., getting to know your students - their names, capabilities, and outside interests).

One method of engaging and interacting with students during class (besides group activities) is the use of planned questions. In fact, in the author's opinion, active questioning of students during class is an essential component of the "ExCEEd model". Several different methods of questioning were discussed at the ETW. For new faculty, however, a high level of comfort should first be acquired with the most basic form of questioning. This method involves asking a planned question, waiting, and then calling on an individual student by name for an answer. The author has found that this method of questioning (when established early in the class) can be adjusted to the capabilities and learning styles of the students (e.g., the type of question can be changed). Students also appear to come to class prepared to both listen and interact. They understand that during an "ExCEEd model" class there will be faculty/student and student/student interaction and that there is a need to be aware of the material being covered. Planning questions into a lesson outline also requires an understanding of why the question is really being asked, and usually helps lead the class discussion in a cooperative manner. Finally, for new faculty, this type of questioning also establishes who is in charge of the classroom. The questioning does not have to be done in an all-imposing manner, but it does show the student that there is a structure to the class and a planned direction or flow.

Finally, the ETW introduced several classroom assessment techniques (CATs) to the participants.[5] CATs are designed to assess and understand the level of student knowledge with

respect to a particular class/course objective. They should be planned directly into the organizational structure previously described as one or two "board notes". The CATs used at the ETW included: 1) a background knowledge probe (i.e., three questions with simple answers that are quickly assessed to evaluate class knowledge), 2) the muddiest point paper (i.e., what was the muddiest point in the class), 3) a preconception check (i.e., testing what they think they know and showing them what is really true), 4) the minute paper (i.e., what is most important thing learned, and what is still important but was not answered), and 5) the approximate analogy (i.e., produce an analogy in your terms equivalent to a given analogy of class material). These are just some of the techniques available for classroom assessment, but they allow early, efficient, and effective feedback to/from the students/faculty. There is an entire handbook about classroom assessment techniques written by Angelo and Cross.[5]

IV. Student Survey Results

The author has applied several of the techniques and some of the "ExCEEd model" teaching approach to a small senior/graduate-level course. He has made a concerted effort to show enthusiasm for the subject material and civil engineering in general, used learning objectives for the course and each class, and applied the "ExCEEd model" lesson outline/"board notes" approach to class communication, activities, and questioning. The class has included high levels of student/student and student/faculty interaction through planned periodic questioning/answering and group activities. CATs have also been used to explore and assess student knowledge with respect to learning objectives, and the class and out-of-class content adjusted appropriately.

A short survey of the students in the class was conducted about five weeks into the semester. They represented a group with relatively diverse backgrounds (at least for an engineering senior/graduate-level course). There were three senior civil engineering students, three non-engineering students, and four graduate engineering students. Three of the ten students were also first-semester internationals. The goal of the survey was to determine what the students liked and disliked about the teaching approach (i.e., the "ExCEEd model").

The survey answers were surprisingly similar, despite the diverse backgrounds (and learning styles) of the students. First, almost all of the students liked and used the learning objectives that were presented at the beginning of each class. They also liked the fact that they stayed on the chalkboard throughout the class. Other characteristics of the approach that they liked were the well-organized notes/lecture, the interaction and discussion produced by the planned questioning, the energy and enthusiasm shown for the subject, and the organized use of colored chalk. Some of the characteristics that the students did not like included the amount of material covered in a 50-minute class period (e.g., one student commented that the approach was "too efficient"). This, however, is probably more a function of the syllabus than the approach. Other students felt the class was too structured and wanted more free-flow discussion. These responses made it clear that there was a diversity of the learners in the class. Some the students liked the organization, but others didn't like the structure. Therefore, the results of the survey were used to plan more free-flow discussion activities into the class organization (e.g., a hot-topic or current event of the day discussion). The "ExCEEd model" approach allows adjustments that take into account the diversity of the learners in a class. Of course, using the chalkboard as a

medium of communication also requires good handwriting, and the author is still working on efficient and effective writing. In addition, the use of colored chalk was discontinued because of the generally unclean nature of the “black” boards after the first few weeks of class. This issue, however, will be resolved next semester.

V. Post-Conceptions

In summary, the author did have some concerns about the applicability of the “ExCEEd model” approach before he attended the ETW. These concerns or preconceptions were related to how this approach might transfer to the "civilian" world and graduate classes, whether it would take significantly more class preparation time, and whether it was compatible with some of the more recent trends in teaching and assessment. For the most part, almost all of these preconceptions were unfounded. An initial application by the author of some of the techniques taught and demonstrated at the ETW indicates that the “ExCEEd model” for teaching can be adjusted to different institutional class organizations, student populations, and classroom settings. The preparation time to apply the approach appears to be somewhat longer. This additional time requirement, however, is significantly outweighed by the improvements in student learning and future organizational benefits provided by the approach. In fact, organizational changes and improvements to the class in the future will be easier, and the notes directly transferable. This allows the construction of more realistic syllabi and class schedules. My preconceptions of the approach and its compatibility with current trends in teaching and assessment were also unfounded. The techniques used in the “ExCEEd model” for teaching are based on accepted teaching and learning principles. The model includes a student focus, planned and measurable learning objectives, group activities, class and course assessment, and direct student/faculty and student/student interaction. In addition, it can be used to recognize different learning styles (through classroom assessments), and be adjusted for those differences. The method (when applied properly), therefore, also meets the general expectations and requirements of the Accreditation Board for Engineering and Technology (ABET).

VI. Conclusion

The success of the author’s first attempt at what he refers to as a “hybrid” active-lecturing approach (i.e., the “ExCEEd model”) has been a success. The author is a better teacher (i.e., more students learn more) because of the ASCE ETW, and his application of the “ExCEEd model” techniques. The results from a short survey of his students support this conclusion of success. My author’s impressions from his initial attempt at the “ExCEEd model” approach -- students adjust to the presentation style, like and understand the overall approach, and appreciate being challenged if the subject material and instructor expectations are clearly explained.

VII. Acknowledgement

The majority of this paper is a summary of the presentation notes produced by the ASCE ETW instructors. Additional information on the ASCE ExCEEd program content and a summary of the ETW can be found on the ASCE webpage.[1] The summary, opinions, and viewpoints expressed in this paper, however, are solely those of the author. The author would like to thank

ASCE and the ETW instructors for the opportunity to take advantage of the ETW in its inaugural year. The author of this paper is a member of the ASEE and ASCE.

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