The ExCEEd Teaching Model

Allen C. Estes, M.ASCE

Professor, Dept. of Civil and Mechanical Engineering, United States Military Academy, West Point, NY. E-mail: Allen.Estes@usma.edu

Ronald W. Welch, M.ASCE

Associate Professor, Dept. of Civil and Mechanical Engineering, United States Military Academy, West Point, NY. E-mail: Ronald.Welch@usma.edu

Stephen J. Ressler, M.ASCE

Professor and Deputy Head, Dept. of Civil and Mechanical Engineering, United States Military Academy, West Point, NY. E-mail: Stephen.Ressler@usma.edu

Introduction

While the first five articles in this *Journal of Professional Issues in Engineering Education and Practice* (JPI) series covered a variety of teaching tools and techniques such as the chalkboard, questioning, drama, board notes, physical models, and demonstrations, the previous issue took a broader view and introduced a model instructional strategy. This strategy provides a conceptual framework that an instructor can use to develop classroom instruction in an organized and coherent manner. The strategy reflects the way that students actually learn and prompts the instructor to make conscious decisions about allocating responsibility for student learning and sequencing the contributing activities. This article takes an even wider perspective and attempts to answer the question, What constitutes good teaching?

The ExCEEd Teaching Workshop strives to demonstrate and then develop good teaching skills. To do this, good teaching, at some point, must be defined. The ExCEEd Teaching Model represents our best attempt to do this. The ExCEEd Model was developed by examining what attributes make a good teacher, how students learn best, and what tools are available to assist the teacher. The model is based on teaching and learning theory from the literature, supported by years of practical experience from veteran instructors. This article traces the development process of the ExCEEd Teaching Model shown in Fig. 1. Once established, this model serves as a definition of good teaching that can then be used consistently throughout the workshop. Admittedly, many others have attempted to answer this same question, and no two answers are the same. Nevertheless, the ExCEEd Teaching Model is relatively simple; and if an instructor is doing everything in it, he or she is most likely teaching well.

Defining high quality teaching is a controversial and perilous task. Teaching is a very personal activity, and no two people do it the same way. Teaching effectiveness is often dependent on the personality and individual talents of the instructor. What works superbly for one teacher may totally flop for another. The answer often becomes, "I can't define good teaching, but I know it when I see it." Evidence of good teaching can be seen in the infectious enthusiasm of the teacher, the obvious engagement of the students, the clarity of the presentation, or the successful measured evaluation of what the students have learned. Although there are an infinite number of ways to teach well, there are some consistent elements, activities, and attributes that seem to be present with all good teachers. The ExCEEd Model attempts to capture these.

What are Attributes of a Good Teacher?

Seymour and Hewitt (1997) took an interesting approach to this question in their landmark study to determine why so many students were leaving math, science, and engineering programs. By interviewing hundreds of math, science, and engineering students from seven major U.S. institutions, they were able to compile a substantial list of practices that constituted bad teaching. The list includes such deficiencies as indifference to academic difficulty of the material, inadequate preparation, boring lectures, preoccupation with research, inability to communicate, presentation of material at too high a level, lack of practical application, grading on a curve, no concern for the intellectual needs of the students, a lack of structure or sequence to course material, no fit between homework and graded events, a sarcastic and degrading attitude toward students, and no awareness of how people learn. If these student comments are all reversed, the list becomes a reasonable compilation of what constitutes good teaching.

Lowman (1995) quantified what makes a good teacher by using teaching award nominations from more than 500 students and faculty members to collect descriptions of exemplary teach-

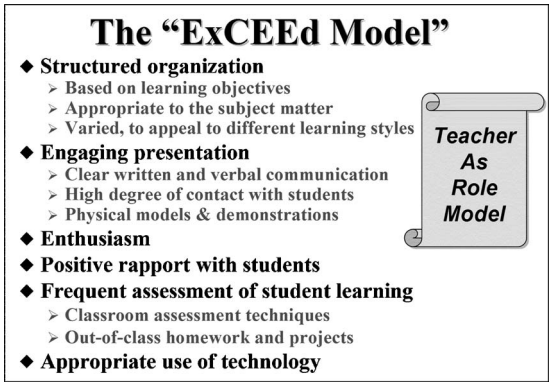

Fig. 1. ExCEEd Teaching Model used in ExCEEd Teaching Workshops as a description of what constitutes good teaching

INTELLECTUAL EXCITEMENT	INTERPERSONAL RAPPORT: Low	Moderate	High
High	6. Intellectual Authority	8. Exemplary Lecturer	9. Complete Exemplar
Moderate	3. Adequate	5. Competent	7. Exemplary Facilitator
Low	1.Inadequate	2. Marginal	4.Socratic

Fig. 2. Lowman's (1995) two-dimensional model that categorizes teachers on the basis of their levels of intellectual excitement and interpersonal rapport

ing. The study collected adjectives and descriptive phrases from the award recommendations, divided them into like categories, and tallied the results. The descriptors fell neatly into two statistically independent categories, which Lowman defined as intellectual excitement and interpersonal rapport. Lowman described intellectual excitement as the clarity of the instructor's presentations, the instructor's disciplinary expertise, and the degree to which the students were stimulated emotionally by the classroom experience. The most common adjectives that described this intellectual excitement included enthusiastic, knowledgeable, inspiring, humorous, interesting, clear, organized, exciting, engaging, prepared, and energetic. Interpersonal rapport measures how much an instructor cares about his students and the degree to which they are effectively motivated by the teacher. The most common descriptive indicators were concerned, helpful, caring, encouraging, challenging, available, fair, friendly, accessible, demanding, approachable, and patient. Lowman created the two-dimensional matrix shown in Fig. 2 and divided the categories of intellectual excitement and interpersonal rapport into high, medium, and low capabilities. This two-dimensional model then describes nine categories of teachers on the basis of their relative strengths in these two areas. Teachers can range from those who are inadequate (low in both categories) to complete exemplar (high in both categories), with every possible combination in between. The numbers indicate a priority of development from (1) being the least effective to (9) being the most effective. The resulting conclusions are that the best teachers are highly skilled in both interpersonal rapport and intellectual excitement, but that the intellectual excitement dimension is the more important of the two.

How Students Learn

There is no shortage of studies in the literature that attempt to define how students best learn. Their relevance to quality teaching is that the best teachers will understand how students learn, account for the differing types of learners in the classroom, and then develop teaching strategies to best accommodate the learning process. Wankat and Oreovicz (1993), for example, developed a compendium of learning principles that reflect best practices in teaching. They include the need to guide the learner through lesson objectives, provide structure and organization, use images and visual learning, ensure that the student is active, require practice through problem solving and repetition, provide prompt and positive feedback, have positive expectations of students, challenge students but set them up for success, use a variety of teaching styles, make the class cooperative, ask thought-provoking questions, be enthusiastic, encourage students to teach one another, and care about what they are doing. Similarly, Chickering and Gamson (1991) compiled a list of seven principles of good practice that will enhance learning. The principles are to encourage contact between students and faculty, have students work together, encourage active learning, provide prompt feedback, emphasize time on task, communicate high expectations, and respect diverse talents and learning styles. Angelo (1993) offered a "teacher's dozen," which equates to 14 principles for improving higher learning. Some relevant examples from this list include an emphasis on active learning, focused attention from the student, student awareness of what is important, positive and reasonable goals for the learner, instructor feedback provided early and often, high expectations, frequent interaction between teachers and learners, and student understanding of the value of the learning. The principles also emphasize that learning requires time, practice, context, connections with knowledge, and the student's ability to organize information in personally meaningful ways. Still another list of learning principles is provided by Davis (2001), who emphasizes higher levels of cognitive development, sensitivity to student struggles, real-world experiences and applications of the material, meaningful structure to course material, connections with prior knowledge, active learning, cooperative learning among students, and frequent and specific feedback. Success comes when students know what they are supposed to learn, material is presented in ways that are meaningful to the student, students can organize the material to suit their individual framework, and teachers account for different learning styles.

Although all these lists were developed independently, some consistent themes run through them all. One is that students and teachers should understand the desired results of the learning process and that the approach to getting there should be structured. The use of clearly articulated learning objectives facilitates this and helps define the appropriate intellectual level of student achievement. Bloom's taxonomy (Bloom 1956) defines six levels of cognitive development (knowledge, comprehension, application, analysis, synthesis, and evaluation) and emphasizes the use of action verbs to describe them. Such quantifiable lesson objectives are useful for lesson planning, distinguishing between critical and extraneous material, communicating expectations, assessing student learning, writing exams, and assessing a course.

A second thread that appears throughout is that students learn in different ways and that teachers need to understand and accommodate these varied learning styles. Felder (1993) classified these differences on the basis of the various ways that students perceive, receive, organize, process, and understand information and concepts. With respect to how students perceive the vast array of information presented to them, learners are classified as either sensory, meaning that they favor information coming through their senses, or intuitive, where information comes through memory, reflection, or imagination. Students may prefer to receive information visually through pictures, graphs, and physical demonstrations or verbally through words and mathematical equations. Similarly, students process information with either an inductive or deductive preference, depending on whether they prefer to learn specific examples before they learn the overarching general theory or vice versa. Students process information with either an active or a reflective preference and understand material in either a sequential manner or a global manner. Most engineering instruction naturally favors the intuitive, verbal, deductive, reflective, and sequential learner. Different students can exhibit every possible combination of learning style preferences. The

teacher who desires to ensure that all students have an opportunity to learn in their preferred style should therefore occasionally prepare instruction designed to appeal to the sensory, visual, deductive, active, and global learners, who are often neglected in the normal course of instruction.

Technology: Tools of Teaching

Technology can be thought of as those tools that assist the teacher to teach and the learner to learn. Just as the carpenter relies on a hammer, saw, and tape measure, the teacher has a toolbox as well. Although they have been around for so long that many no longer think of them as technology, the textbook, chalkboard (Ressler 2004), pencil, and writing pad all qualify as instructional technology. These advances help the student learn a subject on his or her own, help the teacher enhance the classroom presentation, and help the learner record notes and thoughts so that they can be used again for further reflection. Understanding and appropriately using technology are important aspects of quality teaching. But technology also tends to be overrated and can easily be abused. The skilled hands of the carpenter are more important to a successful project than the hammer and chisel that he or she chooses to use. The same is true of teaching. Leamnson (1999) wrote that technologies are more "peripheral than central to the business of teaching" where the core of education remains "a personal interaction between teacher and student." Some technologies, if used ineffectively, will reduce rather than enhance that personal interaction.

Classroom technology has proliferated in the past few decades. Previously the viewgraph machine, opaque projector, copier machine, television set, calculator, and movie projector were examples of modern classroom technology. More recent advances include such presentation graphics as PowerPoint, engineering software packages, computer-aided instruction software (often included with textbooks), electronic textbooks, spreadsheets, math packages, simulation software, digital photographs, and the most significant source of information technology: the Internet. Course Web sites, e-mail, instant messaging, and such course management tools as Blackboard have altered the teacher-student relationship for better or worse, depending on how they have been used.

Software can be used in an effective manner or in an ineffective manner. Some packages serve as black boxes, allowing the student to obtain precise answers with little or no understanding of the underlying concepts that produced them. Jonassen (1996) distinguishes these types of programs, which rely on the computer to do the thinking, from such software as spreadsheets, programming languages, and math packages that require the learner to provide the algorithm and logic before the computer can perform the required calculations. Such software becomes a "mindtool" that engages and facilitates critical thinking. Mindtools cause learners to enhance, extend, amplify, or restructure the way that they think about content.

Like all computer software, PowerPoint presentations can be used and misused. PowerPoint is appropriate for showing charts, illustrations, and photographs that enhance instruction. PowerPoint files can be shared electronically and are easily modified for future presentations. However, there is a danger that such presentations may incorporate more material than students are able to absorb, provide an inflexible structure that can hinder spontaneity, and can cause passivity—especially when students are provided with hard-copy handouts of the PowerPoint slides in advance.

ExCEEd Teaching Model

The ExCEEd Teaching Model (Fig. 1) incorporates the most relevant of these concepts into a single framework that defines effective teaching, based on what makes a good teacher, how students best learn, and what technological tools are applicable to the desired learning outcomes. A key feature of the model is that the teacher is the role model and the leader throughout this entire process. The responsibility for learning lies with the student, but the teacher guides the process and sets the example to be followed.

Structured Organization

Structured organization is derived from the intellectual excitement dimension of Lowman's (1995) two-dimensional model and is a continuing theme throughout the various lists of learning principles that were previously described. The model instructional strategy (Welch et al. 2005) attempts to apply structure and sequencing to classroom instruction. The framework is based on well-articulated, lucid learning objectives that are appropriate to the subject matter. The objectives need to target the appropriate cognitive level, and the students need to understand the relevance of the topic. The instruction should allow the student to make connections with previous learning and organize the material in a personally meaningful way. Because every student is different, teaching methods need to be varied to accommodate and appeal to the diverse needs of all students. The goal should be for each student to occasionally use his or her favored learning style and for all students to eventually be comfortable in learning with all learning styles.

Engaging Presentation

Clarity of presentation is one of the two elements associated with the intellectual excitement dimension of Lowman's (1995) model. Obviously, a major component of a clear presentation is the instructor's subject matter expertise and mastery of the content. The ability to explain concepts clearly and willingness to prepare in advance are also key. Poor presentation skills were listed prominently as an element of bad teaching by the students in the Seymour and Hewitt study (1997). An engaging presentation begins with the instructor's clear verbal and written communication (Ressler et al. 2004). Effective communication starts with clear handwriting, voice articulation, and adequate volume but also extends to varying the pitch and speed of the instructor's voice, avoiding idiosyncrasies, and using gestures effectively. The exemplary presentation will often incorporate humor, drama (Estes 2005), and good storytelling.

Students cannot be passive observers; teachers need to maintain a high degree of contact and engagement. Physical position and movement around the classroom will help, and any presentation can be enhanced through effective questioning of the students (Estes et al. 2004). Contact can also be improved through spontaneity and the willingness to take the class in a direction in which the students want to go. Ironically, this can only be achieved when the instructor is so well prepared that she or he can take that journey and still successfully return to complete the lesson objectives.

In engineering classes, physical demonstrations enhance almost any lecture and are also a form of instructional technology. Textbooks do an excellent job of describing physical phenomena in words, equations, graphs, and even pictures on the page. A

physical demonstration appeals to the visual and sensory learner who might not otherwise appreciate the deflected shape of a beam, the strength of concrete, or the path of a projectile until she can see it, touch it, and feel it in the real world. Vander Schaaf and Klosky (2005) present a variety of demonstrations that are appropriate for the engineering classroom and that will stimulate critical thinking in students.

Enthusiasm

The second element of intellectual excitement in Lowman's (1995) model involves the stimulation of positive emotion in students. If the instructor demonstrates passion for the material, such emotion tends to be contagious. Another consistent theme throughout the learning principles involves attaching an importance and real-world context to the course material. If the teacher is excited about the lesson, then that alone helps make it relevant—especially if the teacher is viewed as a role model. A natural enthusiasm brings focused energy and a strong sense of presence to the classroom. Students are more likely to remain awake. They become more excited about the material, and this excitement increases the chance that they will study it on their own. Students will experience the positive emotions of laughter, suspense, and dramatic tension and may ultimately share the instructor's joy of discovery—all of which will cause them to remember some aspect of the material.

Positive Rapport with Students

This element of the ExCEEd Teaching Model is clearly linked to the interpersonal rapport dimension of Lowman's (1995) model. The quality of the relationship between student and faculty appears several times in the various lists of learning principles. The deficiencies of being haughty, unapproachable, unconcerned, and unavailable cited by the students in the Seymour and Hewitt study (1997) clearly deal with lack of interpersonal rapport. Unlike an engaging presentation, the effects of which are immediate, interpersonal rapport is developed over time and is cultivated throughout the semester and even longer. An effective relationship with students can begin in the classroom by learning students' names, investigating something about their interests, implementing policies that are perceived as fair, soliciting and then responding to student feedback, demonstrating some flexibility in the scope and timing of requirements, being available for questions, and displaying a warm and friendly demeanor. Rapport is just as effectively established outside the classroom by answering student e-mail promptly, welcoming students when they attend office hours and using the one-on-one time to get to know them, attending student activities such as ASCE student chapter events or athletic events in which they might be participating, and recognizing students around campus or in the local community and greeting them with a smile and a handshake. Lowman (1995) identifies a key attitude necessary for establishing a relationship with students when he states that a great classroom instructor "must genuinely like college-age students and identify with their interests, both serious and foolish." Highet (1966) adds, "It is easy to like the young because they are young. They have no faults, except the very ones they are asking you to eradicate: ignorance, shallowness, and inexperience."

Frequent Assessment of Student Learning

The most prevalent theme throughout the lists of effective learning principles was that students must practice what they are taught and receive prompt feedback to effectively learn a subject. The model instructional strategy (Welch et al. 2005) contains a feedback loop that involves student practice in a familiar context and then in an unfamiliar context followed by performance feedback—and new opportunities to practice. Active learning requires hand-on applications both in and out of class through in-class examples and out-of-class homework and projects. The in-class examples allow for the practice of skills in a nonthreatening environment. Out-of-class problems and projects allow the students to apply their skills in a new situation where time is not as great a factor. The out-of-class assignments provide the best opportunities for students to teach and learn from one another, to accept an active learning role, and to devote the high-quality time on task necessary for genuine learning to take place.

The frequent assessment element of the ExCEEd Teaching Model unfortunately necessitates substantial grading, which is widely considered a thankless task. Engineering students are both perceptive and busy; they will allocate their time to those tasks that offer the highest payoff. If students don't receive feedback in a timely manner, they will typically stop doing the assignments. Cross (1996) uses an archery analogy to emphasize the importance of feedback. A student could purchase the highest-quality bow, hire the most accomplished archery instructor, and understand completely the theoretical dynamics of flight; but if that student never received feedback as to whether the arrows were hitting the target, it would be impossible for him or her to learn and improve.

Grades are clearly not the only way to attain feedback on student learning. An interactive classroom environment in which the instructor is asking directed questions and students feel free to ask their own questions will provide a limited basis for assessing student understanding. Angelo and Cross (1993) proposed a number of classroom assessment techniques that assess student learning in a nonthreatening manner. A few examples include the minute paper, muddiest point paper, and the approximate analogy. In these techniques, students are asked to summarize the main learning point, identify the topic that needs the most clarification, or make a connection between the new material and something that they have seen before. A teacher should plan the assessment technique to target specific feedback and then share the results with the students. The feedback and corresponding lesson adjustments can help develop rapport with students.

Appropriate Use of Technology

There has never been more technology available to assist both the teacher and the learner than currently exists. Instructional technology is neither inherently good nor bad. It is a set of tools that can be used appropriately or inappropriately. If these tools are used in a manner that supports the other tenets of the ExCEEd Teaching Model, they are probably being used appropriately. The danger is that technology will be used simply because it is available, rather than because it enhances the quality of either teaching or learning. With the increased availability of such new technologies as wireless networks and laptops for every student in the classroom, the challenge to use technology appropriately has never been greater.

Conclusion

Although a single universally accepted definition or model of what constitutes good teaching will remain elusive, the ExCEEd

Teaching Model presented herein is supported by the literature, has been tested by veteran instructors, and has been used effectively in 7 years of ExCEEd Teaching Workshops. Such a framework, once accepted, becomes a useful validation tool for deciding whether to try something new. If the new method is supported by an element of the model, it has a higher likelihood of being beneficial. The model is similarly helpful as a checklist for the inexperienced instructor: "If I am doing all these things, I am probably teaching effectively." Furthermore, if this model is valid, then it can be used the basis for assessing effective teaching—the subject of the next article in this series.

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