THE ABC'S OF ENGINEERING EDUCATION: ABET, BLOOM'S TAXONOMY, COOPERATIVE LEARNING, AND SO ON

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If you are like most university professors, you were not taught anything about how to teach in graduate school or when you began in your first faculty position. All you had to go on was how your professors taught, but nobody taught them anything about teaching either. It doesn't make a lot of sense, but that's our system.

Teaching is too complex and too important a profession to let people do it with no training or experience. Granted, some new faculty members are excellent the first time they get in front of a class, and I hope you're one of them, but the odds are against it. There are also a few who are poor teachers from the outset and never get better. Since you're taking the time now to read a paper about engineering education the chances are that you're not going to be one of those either. You are probably in the broad middle category of faculty members who have the potential to be excellent teachers but may take years learning how to do it by trial and error. Not that trial-and-error learning is always a bad thing, but in the case of teaching the ones paying the penalty for the errors are not the ones making them. Trial and error is also unnecessary. A lot is known about what makes teaching effective: spending some time in the literature learning about it can knock a couple of years off your learning curve.

The greatest initial barrier to learning new material is often jargon—unfamiliar terms that may denote easily learned concepts but whose unfamiliarity makes them sound esoteric and difficult. If you read ASEE conference proceedings or the *Journal of Engineering Education* or any other teaching-related journal, you will notice that a number of terms keep showing up, often with little or no explanation. If you don't know what they mean, the articles in which they appear may be difficult to decipher. The purpose of this paper is to help you over this hurdle. The few terms to be defined don't even begin to constitute an exhaustive glossary of educational jargon, but if you understand them you'll be off to a good start.

We first introduce *learning styles*—the different ways students characteristically use to take in and process information. Understanding what those ways are is a good first step toward designing instruction that can accommodate the learning needs of all of the students in a class. We then define three instructional approaches: *active learning* (getting students to do things in class that actively engage them with the material being taught), *cooperative learning* (putting students to work in teams under conditions that promote the development of teamwork skills while assuring individual accountability for the entire assignment), and *problem-based learning* and similar approaches (teaching material only after a need to know it has been established in the context of a complex question or problem, which increases the likelihood that the students will absorb and retain it).

Our focus next shifts to planning courses and measuring learning outcomes. We begin by defining and illustrating *learning objectives*—explicit statements of what students should be able to do when they have completed a segment of a course. A good set of objectives can be an invaluable resource for planning courses and individual lessons, creating assignments and tests, and defining the course in a meaningful way for other faculty members preparing to teach it, instructors of prerequisite and subsequent courses, and accreditation visitors. In the remainder of the paper, we introduce *Bloom's Taxonomy of Educational Objectives*, a system for classifying learning objectives according to the skill level required to meet them; define and distinguish the terms *assessment* and *evaluation*, two related processes that are vitally important in every aspect of both teaching and research; and discuss *ABET* and the engineering program accreditation process, in which the quality of every engineering department in the country is periodically assessed and evaluated.

Learning Styles

Students come with a wide variety of abilities, attitudes, interests, ambitions, and levels of motivation, and instructional methods that are effective for some students may be relatively ineffective for others. For example, one engineering student might be comfortable with relatively abstract theories and mathematical models and another might be much more receptive to concrete ("real-world") material such as lab experiments and industrial plant operations. A theoretical and math-intensive course would probably be much more effective for the first of these students, and a practical hands-on course would be a more positive experience for the second one.

A student's ***learning style*** is the way he or she characteristically takes in and processes information. Learning styles provide good clues to the instructional methods students are most and least comfortable with. If you know the range of styles that categorize the students in your class, you can design balanced instruction so that all students are taught sometimes in the manner they prefer, keeping them from becoming too uncomfortable to learn, and sometimes in their less preferred manner, forcing them to stretch and develop skills in areas that they might be inclined to avoid if given the choice.

Several learning style models have been developed and applied to engineering education. One formulated by Felder and Silverman [1988] involves four dichotomous dimensions. Students may be

- *sensing learners* (concrete, practical, oriented toward facts and procedures) or *intuitive learners* (conceptual, innovative, oriented toward theories and meanings).
- *visual learners* (prefer visual representations of presented material—pictures, diagrams, flow charts, etc.) or *verbal learners* (prefer written and spoken explanations).
- *active learners* (tend to learn by trying things out, working with others) or *reflective learners* (tend to learn by thinking things through, working alone).
- *sequential learners* (linear, orderly, tend to learn in small incremental steps) or *global learners* (holistic, systems thinkers, tend to learn in large leaps).

Most engineering instruction in the past few decades has been heavily biased toward intuitive, verbal, reflective, and sequential learners, although relatively few engineering students fall into all four of these categories. The result is that most engineering students are taught in a manner at least partially mismatched to their learning styles, which could hurt their performance and their attitude toward engineering as a curriculum and career.

At <*http://www.ncsu.edu/felder-public/Learning_Styles.html*> you will find links to papers that provide extensive information on the Felder-Silverman model, including characteristics of students with different styles, teaching methods that address each style, suggestions for achieving the desired balance, and an on-line instrument to assess preferences on each of the four dimensions of the model. Other papers on the same site provide information on other learning style models and cite references to their applications to engineering education.

Active Learning

During a traditional lecture, the only one who is active is the lecturer—talking, writing on the board, showing transparencies, asking questions and often supplying the answers when there is no response from the class. The students are passive—watching and listening and taking notes (maybe), but seldom actively thinking about the material being presented.

Unfortunately, that's not how people learn. We know from cognitive science that information received passively with no attendant action or reflection is not retained in long-term memory. The cliché about something going in one ear and out the other is a good metaphor for what happens to material presented in traditional lectures. Compounding the problem is that students sitting passively in a lecture invariably take mental breaks in which their minds go elsewhere, and the longer they sit, the more frequently those breaks occur and the longer they last. If you're thinking about your homework in other courses or your email backlog or how long it still is to lunch, you're not hearing the lecture, and when you do get back to it, what you missed could make what you're hearing now incomprehensible. After a while, the lecture is just background noise.

Active learning is anything that happens in a class that engages students with the material being presented. Students might be called on to work individually or in small groups for brief periods of time to answer questions, start problem solutions, fill in steps in a problem solution or derivation, brainstorm lists, troubleshoot processes, or think of questions about the material just lectured on. At the end of the allotted period, the instructor calls on several individuals or teams for their responses, then collects more responses from volunteers, and moves on when the correct answer has been obtained and it seems clear that the students understand it.

Good things happen in a class when active learning is used, even if it's only for a few minutes out of an hour-long class. Activity refocuses students who have drifted off into mental breaks and energizes the entire class. If the activity requires the students to do something they will later have to do on homework and tests (such as draw and label a flowchart or free body diagram, outline the solution of a problem, estimate the value of a process variable, do some computations or parts of derivations, or come up with a theoretical interpretation of an experimental observation or a data set), there will be a much better chance that they will be able to do it on their own when the time comes.

When instructors first hear about active learning, many anticipate serious problems with it (*I'll never get through the syllabus if I do all that; the class will degenerate into chaos and I'll never get control back; some students will refuse to participate; some will resent being asked to do anything*…), and when they first use the method they may indeed encounter some student resistance and lack of participation. If you observe some precautions, however, and stay resolute for the first few weeks if you encounter resistance, those problems should become either nonexistent or inconsequential. For more ideas about what you might ask students to do in class and a rundown of what the precautions are, see Felder & Brent[1] and other papers you will find at <*http://www.ncsu.edu/felder-public/Cooperative_Learning.html*>

Collaborative/Cooperative Learning

Collaborative learning refers to two or more students working together on an assignment or project. There are several reasons for getting students to work collaboratively in lecture courses and not just in labs and the capstone design course, where collaboration is traditional. Engineering students will have to work in teams in their professional careers, and their performance evaluations could depend more on their ability to work well on those teams than on their technical skills. One of the mandated outcomes in the ABET Engineering Criteria is the ability to work in multidisciplinary teams, and students are unlikely to acquire high-level teamwork skills if they only work on teams in one or two courses. Perhaps most importantly, hundreds of research studies have shown that compared to students working individually, students working on well-functioning teams in a course learn more, learn at a deeper level, are less likely to drop out, and develop more positive attitudes toward the course subject and greater confidence in themselves.

Those benefits do not automatically occur whenever students work collaboratively, however, and most engineering graduates can tell horror stories about ineffective or dysfunctional teams. The most familiar problem involves "hitchhikers"—students who do little or nothing but get the same grade for the work as their more responsible teammates. Other common problems include dominant students who insist on doing everything themselves, students who are deliberately excluded for one reason or another, and interpersonal conflicts that arise because of different senses of responsibility, academic goals (high grades vs. passing grades), and personalities. When a team encounters those problems and cannot manage to resolve them, the members might well be better off working individually. Unfortunately, such situations frequently arise and quickly get out of hand when nothing is done to prevent them and to help students deal with them when they occur.

The way to maximize the benefits of teamwork is to use ***cooperative learning***, a subset of collaborative learning in which the instructor builds in measures to assure that five conditions are met:

1. *Positive interdependence.* The students have to rely on one another for the effort to be successful.
2. *Individual accountability.* Each team member is held accountable for everything in the assignment or project, and not just the part for which he or she may have had primary

responsibility. If students hitchhike and don't understand what the team did, they do not get credit for the work.

3. *Face-to-face interaction, at least part of the time.* Much of the learning in team projects takes place when the team meets to discuss, debate, and reach consensus on solutions to problems. If the team simply divides the work and staples the individual parts together without discussion, it is not cooperative learning.
4. *Facilitation of interpersonal skill development*. Students are not born with the project management, time management, communication, leadership, and conflict resolution skills needed to work effectively on a team. For team assignments to qualify as cooperative learning, the instructor must take steps to help the students develop those skills.
5. *Periodic self-assessment of team functioning.* At regular intervals, the teams must be required to reflect on what they are doing well as a team, what they need to work on to improve the team functioning, and what if anything they will do differently in the future.

Implementing cooperative learning effectively is not trivial. It requires knowing how to form teams and equip them to deal with the problems that commonly arise in teamwork, when to allow teams to dissolve and how to form new ones, how to structure assignments to assure both positive interdependence and individual accountability, and how to minimize or eliminate the resistance—and occasionally, the hostility—that some students feel toward instruction that requires them to work in teams. Suggestions regarding all of these points and links to the research base supporting cooperative learning may be found at <*http://www.ncsu.edu/felder-public/Cooperative_Learning.html*>. The monograph *Cooperative Learning in Technical Courses: Procedures, Pitfalls, and Payoffs*[2] is a good place to start learning about the approach. Felder and Brent[3] describe how the proper implementation of cooperative learning can equip students with all of the learning outcomes mandated by the ABET Engineering Criteria.

Problem-Based Learning/Project-Based Learning and other Inductive Approaches

The traditional approach to engineering instruction is deductive, proceeding from the general (principles and theories) to the specific (applications). In most courses, the instructor lectures on theories, principles, and mathematical methods and algorithms; gives assignments in which students practice the methods and algorithms; and later (sometimes much later) gets to applications. Engineering curricula work in much the same way. The students spend the first year learning basic science and math, then the next two learning mostly engineering science, and as seniors take the capstone design course in which they apply some of the fundamentals taught in the preceding three years to design a process or product.

The main problem with the deductive approach is that it is not how people normally acquire and retain new knowledge and skills. Rather, they do so by confronting problems that they need or want to solve; trying to accomplish their goal using what they already know and can do; discovering that more knowledge or skill is needed than they currently have and identifying what it is; gaining the required information (from books, classes, or observations of others solving similar problems) and adding it to their existing knowledge base; and practicing the required skills repeatedly and observing and reflecting on the outcomes of each attempt. In other words, people learn new material most effectively when they perceive a clear need to know it in order to solve a problem or meet a challenge. If they are simply presented with a body of new material and told that in a month or in two or five years they'll be shown why they need to know it, they are likely to learn it at best superficially.

An alternative and more effective instructional approach is to teach *inductively*, presenting students with problems before they have been taught everything they need to know to solve them and then teaching the required material once the students can clearly see why they need to know it. There are many variations of this approach with different names and somewhat different emphases, including ***problem-based learning***, ***inquiry-based learning***, ***discovery learning***, ***need-to-know learning***, and ***just-in-time learning***. These methods are initially less comfortable for instructors than straightforward deductive presentation of material, and they can at first be distressing to students, who may not appreciate having to deal with problems they have not been taught to solve beforehand. Since induction is how people actually learn, however, the students taught this way are likely to end up with a much greater mastery of the knowledge and skills the instructor wishes to impart.

Formal problem-based learning calls for giving students significant problems whose solution requires the knowledge and skills normally taught in the course, and then having them work through the following steps, usually in teams:

1. Define the problem.
2. Build hypotheses to initiate the solution process.
3. Identify what is known, what must be determined, and what to do.
4. Generate possible solutions and decide on the best one.
5. Complete the best solution, test it, and either accept it or reject it and go back to Step 4.
6. Reflect on lessons learned.

The instructor serves primarily as a consultant, lecturing only when the need for new material arises in the context of the problem.

A related but less formal instructional approach is ***project-based learning*****,** which means that most of the learning in a course takes place in the context of projects, with lectures playing a subsidiary role or not taking place at all. The way the capstone design course is usually taught is project-based learning, as is the engineering laboratory in which each experiment can be considered a project. Several engineering departments have shifted some of their traditional lecture courses to project-based courses, and a few universities have made the switch for all of their courses, the best known of which is the University of Aalborg in Denmark. Whether project-based learning or one of the forms of problem-based learning is adopted, if student teams are involved, all of the methodologies of cooperative learning can be used to maximize the effectiveness of the approach.

Woods,[4] Wankat,[5] and Duch, Groh, and Allen[6] provide guidance on designing and implementing problem-based learning (Woods and Wankat are both engineering professors), and a collection of papers on engineering applications of the approach was recently published in the *International Journal of Engineering Education* (vol. 19, #5, 2003). Felder and Brent[3] describe how the proper implementation of PBL can equip students with all of the learning outcomes mandated by the ABET Engineering Criteria.

Learning (Instructional) Objectives

Learning objectives (aka ***instructional objectives***) are statements of what students should be able to do if they have acquired the knowledge and skills the course is supposed to teach them. A learning objective takes one of the two following forms:

1. At the end of this [*course, topic, chapter, lecture*], the student should be able to…
2. To do well on the next test, you should be able to…

What follows either of these stems is a list of tasks that demonstrate mastery of the desired knowledge and skills. Each task statement includes one or more key action words [such as *list, explain, calculate, estimate, derive, model, design, choose,* and *critique*] along with a definition of the task and possibly a specification of the conditions under which the task is to be performed.

Following are examples of learning objectives that might appear on a study guide for an engineering test, with the key action words italicized.

<u>To do well on the next test, you should be able to</u>

1. *Explain* the statement, "The vapor pressure of pure water at 100°C is 760 mm Hg," in terms that a bright high school student could understand.
2. *Estimate* the vapor pressure of a pure substance at a specified temperature or the boiling point at a specified pressure using (a) the Antoine equation, (b) the Cox chart, (c) the Clausius-Clapeyron equation and vapor pressures at two specified temperatures, (d) Table B.3 of your text. *Rank-order* your estimates in descending order of accuracy (best to worst), and briefly *justify* your ordering.
3. Given an equilibrium gas-liquid system with a single condensable component (A) and liquid A present, a correlation for the vapor pressure $p_A^*(T)$, and any two of the variables y_A (mole fraction of A(v) in the gas phase), temperature, and total pressure, *calculate* the third variable using Raoult's law. *List* reasons why the calculated value might differ significantly from a measured value, assuming that the measurement is accurate.
4. For a process system that involves a gas phase containing a single condensable component and specified or requested values of feed or product stream saturation parameters (temperature, pressure, dew point, relative saturation or humidity, degrees of superheat, etc.), *draw* and *label* the flowchart, *carry out* the degree-of-freedom analysis, and *perform* the required calculations.

The action words in a learning objective must refer to *observable* actions—things an instructor could in principle watch the students doing. The words in the illustrative objectives just given meet this criterion, but words like *learn, know, understand,* and *appreciate* do not. You can't watch someone understanding or appreciating something. If you want to know whether students understand a concept you have attempted to teach, you must ask them to do something observable that demonstrates their understanding. The things you might ask them to do would be your learning objectives for that concept.

All course instructors routinely write learning objectives, although most don't call them that—they call them exams. Unfortunately, the first time many instructors seriously confront the question of what knowledge and skills they want their students to acquire is when they sit down to write the exams. That's too late. The result is frequently that too much time is spent in lectures on material of secondary importance and too little is spent on things the instructor decides to emphasize on the tests—and students justifiably do not appreciate being taught one thing and tested on something else.

Having a good set of learning objectives in advance helps an instructor select course content and decide on how much time to allocate to each topic; plan lectures (talk about, illustrate, and give students active learning exercises in the things the instructor wants them to be able to do); create relevant assignments (give the students practice in those things); and write relevant tests (ask them to do some of the things). The objectives also do a much better job than the syllabus of defining the course to instructors preparing to teach it for the first time, instructors of prerequisite and subsequent courses in the curriculum, curriculum planning committees, and program accreditation visitors.

Learning objectives can be particularly valuable if they are shared with the students in the form of study guides for tests and then used as the basis of the test preparation. When students have a clear understanding of what is expected of them, there is a much greater chance that they will meet the expectations than if the expectations are muddy (as in, "Here is your 538-page text…you're responsible for all of it…guess what I think is important enough to put on the test.") Even if the study guides and tests include high-level thinking and problem-solving skills (as they should), the clarity of the expectations almost invariably leads to better student performance. A fringe benefit is that the instructor no longer has to deal with the ever-popular "Are we responsible for this on the test?" Once the students have the study guide, they know.

For more information on why and how to write learning objectives, see Felder and Brent,[3,7] Gronlund,[8] and Mager.[9]

Bloom's Taxonomy

When you start writing learning objectives, you quickly discover that different tasks call for dramatically different knowledge and skill levels, with some tasks requiring only rote memorization to complete and others calling for sophisticated analytical skills and creativity. A system of classifying learning objectives according to their required skill levels can help instructors make sure they are teaching and testing at an appropriate level for their students.

In the 1950s Benjamin Bloom and colleagues formulated such a system, called ***Bloom's Taxonomy of Educational Objectives***. Categories were formulated for cognitive (thinking and problem-solving skills), affective (attitudes, value systems), and psychomotor domains. The categories or *levels* for the cognitive domain and illustrative action words for each level are as follows:[7,10]

1. **Knowledge** (repeating verbatim): *list* [the first ten alkanes]; *state* [the steps in the procedure for calibrating a gas chromatograph].

2. **Comprehension** (demonstrating understanding of terms and concepts): *explain* [in your own words the concept of vapor pressure]; *interpret* [the output from an ASPEN flowsheet simulation].
3. **Application** (applying learned information to solve a problem): *calculate* [the probability that two sample means will differ by more than 5%]; *solve* [the compressibility factor equation of state for *P, T*, or *V* from given values of the other two].
4. **Analysis** (breaking things down into their elements, formulating theoretical explanations or mathematical or logical models for observed phenomena): *derive* [Poiseuille's law for laminar Newtonian flow from a force balance]; *explain* [why we feel warm in 70^{o}F air and cold in 70^{o}F water].
5. **Synthesis** (creating something, combining elements in novel ways)**:** *formulate* [a model-based alternative to the PID controller design presented in Wednesday's lecture]; *make up* [a homework problem involving material we covered in class this week]; *design* [anything].
6. **Evaluation** (making and justifying value judgments or selections from among alternatives): *determine* [which of the given heat exchanger configurations is better, and explain your reasoning]; *select* [from among available options for expanding production capacity, and justify your choice]; *critique* [an essay, report, or article for accuracy and style].

Levels 4–6 are known as the ***higher-level*** (or ***higher-order***) ***thinking skills.***

All engineering instructors would say that they want their students to master higher-level thinking skills, but in many cases their lectures and homework assignments focus almost exclusively on Level 3. Then, if they put a high-level question on an exam (to see if the students "know how to think") and the students do poorly on it, they blame it on the students' lack of ability or poor study habits.

Their criticism is misdirected. The only way people acquire skills is through practice and feedback. If we teach at Level 3, it is unfair for us to require students to figure out for themselves how to work at Levels 4, 5, and 6, and especially unfair to expect them to figure it out on a calculation-packed 50-minute test. The best way to facilitate the development of higher-level skills is to include high-level tasks in learning objectives, share them with the students in study guides for exams, give illustrations and practice in class and more practice on assignments; and *then* put the high-level questions on the exams. If all that is done, most of the students who are capable of functioning at the high levels will be able to do so—and if engineering instructors collectively do it in every engineering course from the freshman through the senior year, our graduates will come out able to do modeling, design, and critical and creative thinking at a level that we can barely imagine now.

For information on writing learning objectives at all levels of Bloom's Taxonomy, see Gronlund,[8] Mager,[9] and Besterfield-Sacre *et al.*[11]

Assessment and Evaluation.

In engineering education it is frequently necessary to judge whether and how well students have learned a body of material or mastered a skill, or how well an instructor has taught a course, or how well a product or process has met its design specifications, or how well an instructional program has met its educational objectives. A two-step process should be used to make the judgment rationally:

- ***Assessment***. Decide on the data that will be used as a basis for making the judgment and the procedures (observations, measurements, experiments, surveys,…) that will be used to obtain the data, then carry out the procedures and perform whatever analytical operations are needed to put the data into a form suitable for the next step.
- ***Evaluation***. Using the assessment outcomes and pre-established criteria, draw inferences and make evaluative judgments. (*What grade does the student's work deserve? Is the new laboratory course an improvement over the old one, and does the improvement justify the cost? Are the program graduates' communication skills satisfactory? Should the paper be accepted for publication as is, or should it be rejected, or should it be sent back to the author for revision?*)

Assessment and evaluation have become extremely important in engineering education in the past decade—or to put it more accurately, their importance has become widely recognized. Program accreditation and the ABET Engineering Criteria are all about assessment and evaluation of learning. In addition, if you develop a new course or instructional software package or try an alternative teaching strategy in a class and you propose to submit a paper about it to the *Journal of Engineering Education,* the reviewers will immediately look for your assessment and evaluation plan. If it isn't there or doesn't stand up to their scrutiny, the paper will almost certainly be rejected no matter how clever your idea may be. "*We tried this method and we liked it and so did the students*" may have been acceptable ten or even five years ago, but it won't cut it today. The same outcome will follow if you apply to the National Science Foundation for a CAREER Award or a grant to study new teaching materials or methods and you don't have a solid assessment and evaluation plan built into the proposal. Funding agencies are not interested in financing ideas unless the principal investigator has a realistic plan to determine whether or not they work.

For a good introduction to assessment and evaluation of learning, see McKeachie,[12] and for specific details on the assessment of engineering learning outcomes, see Felder and Brent[3] and Besterfield-Sacre *et al*.[11]

ABET

The ***Accreditation Board for Engineering and Technology*** (ABET) is the body that periodically reviews every engineering program (departments and interdisciplinary course programs) in the United States and determines whether they meet certain standards. Prior to a review of a program, the faculty assembles key information about the program's educational goals, course offerings, faculty qualifications, and student products (homework, tests, reports, etc.) into a ***self-study***. An ABET ***visitor*** (usually a faculty member from another institution) reviews the self-study, interviews the faculty and administrators, and decides whether the program should receive full (6-year) or probationary (3-year) accreditation or whether it should be denied accreditation.

The criteria ABET uses to make this determination (known as the ***Engineering Criteria***) are both complex and flexible, and self-studies may vary considerably from one institution to another. The program is responsible for formulating its own goals or ***program educational objectives***, making sure they reflect the mission of the university and the needs of the different program constituents (including students, faculty, and hirers of program graduates); ***program outcomes***, or attributes of program graduates (knowledge, skills, values) that reflect the degree to which the program has met its objectives; ***outcome indicators***, the assessment instruments and procedures that will be used to determine whether the graduates have achieved the outcomes; ***course learning objectives*****,** statements of the things students should be able to do (define, explain, calculate, derive, model, design, evaluate,…) when they have completed each core course in the program curriculum; and a ***continuous improvement process*** that will be used to remedy any shortcomings revealed by the outcome assessments and continue to raise the program quality. The ABET visitor evaluates the appropriateness of the educational objectives, the extent to which the specified outcomes map onto the objectives and whether they incorporate eleven specific attributes specified by ABET (***Outcomes 3a–3k***), the extent to which the course learning objectives map onto the outcomes, the feasibility of the specified outcome assessment and continuous improvement processes, and the seriousness with which the program is implementing those processes.

The last paragraph only scratches the surface of the accreditation process and its jargon. For more details, see Felder and Brent.[3]

Last Words

The methods defined here only represent a start on all there is to know about effective teaching. Articles by the authors of this paper on many different aspects of engineering education can be found at <*http://www.ncsu.edu/effective_teaching*>, and two excellent general references on teaching and learning are McKeachie[12] and Wankat.[5] If you pick up either of those books and randomly read a page, you are almost guaranteed to pick up a useful tip about some aspect of teaching along with information about the research that supports the tip.

The important thing to remember, though, is that learning how to teach as well as you're capable of teaching is the work of a career—it's not something to try to do in your first year. If you begin your next course determined to write a full set of instructional objectives before the first day of class and do a full-scale implementation of cooperative and problem-based learning, you will probably not be happy with the results. The time you need to devote to your research will be compromised, you'll feel awkward and overstressed, and the students are likely to go into full-scale rebellion. Instead, pick one or two new methods (such as giving students study guides containing your instructional objectives and incorporating some active learning into your lectures), use them until you feel comfortable with them, and then gradually increase their use and add other new methods in subsequent courses, never venturing too far from your comfort zone. If you do that, your teaching will make a rapid initial improvement and will continue to improve thereafter, and that's all you need.

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