Maximizing Your Productivity as a Junior Faculty Member: Being Effective in the Classroom

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Abstract

The most distinguishing difference between "practicing" engineers (in industrial or government) and the university "faculty engineer" are instructional duties. In new engineering educators, inability or insecurities in instructional duties are by far the most common complaint [1]. Furthermore, these new educators face a classroom of students that are possibly hostile to learning and are usually much less prepared than the educator at the same point in their career. The results are low teaching evaluations and high discouragement for the new engineering educator. This paper gives seven simple and easy to remember "tricks of the trade" for new engineering educators to be effective instructors.

1 Introduction

While every Ph.D. engineering program prepares the student for a career in research, many programs fail to prepare, even superficially, the Ph.D. student for a career in instruction [1], [20]. Some universities identify students with aspirations to be engineering faculty and prepare them for the three main faculty duties: instruction, research, and service. Ideally, the future "new engineering educator" (NEE) is educated in, or at least exposed to, learning styles [5], [23], instructional methods [17], [18], basic cognition theory [23], and curriculum development [16]. However, this remains the exception rather than the rule. Other universities leave the majority of the Ph.D. student's skills development to the student's advisor and committee. If the student's committee does not actively direct the student to the necessary training, the motivated student must take the initiative. This student will ask the right people the right questions and ensures that he/she has instructional training and classroom experience before seeking a career in academe. Unfortunately, many students do not do this. As a result, a number of NEEs arrive at their first academic appointment with little to no instructional experience.

The Bagley College of Engineering at Mississippi State University hired twelve NEEs in six different departments during the academic year 2003-2004. Approximately two-third of these NEEs are in their first full-time academic appointment, and come to Mississippi State University with an average of 3.6 semesters of teaching experience in lecture, lab, or recitation. Since most teaching duties for tenure-track engineering faculty are lecture-based courses, it is important to note that MSU's average first-appointment NEE has 2.0 semesters of lecture class teaching experience. The NEEs who held previous academic appointments reported 8.5 semesters of teaching experience, all in lecture-based courses.

This paper arose from a request by the professional development coordinator in the Bagley College of Engineering at Mississippi State University. When NEEs are hired in the College, they are assigned mentors. Furthermore, the College sponsors a variety of workshops and brown bags seminars on instruction, grant proposal preparation, and professional development during the faculty members' critical first years. We were approached by the professional development coordinator to address the NEEs and specifically provide instructional "tricks of the trade". Mississippi State University, Mississippi's land-grant research university, places a great deal of emphasis on the research productivity of the engineering faculty, in addition to their instructional effectiveness. Therefore, we were charged with helping the NEEs become effective instructors without overly distracting them from building their fledging research programs. This paper should be read with this background in mind.

2 Effective new engineering educators

> *Educators should judge their performance by "what is learned" rather than by "what is taught".*

In [1], the author studied a collection of "quick-starting" or exemplary new faculty members (not exclusively NEEs). Boice defined "quick-starting " faculty as being "on track" toward tenure and promotion in both instructional and research duties. Boice found that quick-starting faculty did not experience extreme emotions due to their daily duties and found instructional activities enjoyable. In hopes of getting our NEEs off to a quick start, we attempt to provide NEE with seven broad guidelines to improve their instructional techniques and, hopefully, making the experience more interesting and enjoyable.

2.1 Design for learning

Consider your instructional activities like any other engineering activity. Effective instruction must be designed to be effective from the start. Long before the school term begins, determine the course's learning objectives. The authors in [16] recommend at least three months before the course starts. (We recommend reference [16] to NEE as the closest thing to a "faculty member user's guide" as exists.) If the course is already in existence, learning objectives may already exist. If the course is new or the learning objectives do not exist, your mentor or department chair can help you create the learning objectives. Learning objectives should be specific and observable [6], [12]. Learning objectives can be written at many different levels. We usually have two sets of learning objectives for a class. The first set has 3-8 objectives for the entire course. This set of learning objectives is those used in ABET assessment, degree program evaluations, and printed in the universities course catalog. The second set of learning objectives is much more detailed, often more than 100 for the entire course. Both learning objective sets are available to the students. We often encourage the students to use the more detailed set as exam study checklists. Learning objectives should address all levels of Bloom's Taxonomy, including the higher "process" levels, not just the lower "information" levels [23].

Consider your and your students' learning styles when designing a course. Several learning styles models exist [23], including Meyer-Briggs, Felder-Silverman, and Kolb. Have your students take a learning styles inventory exam. Try to present concepts from more than one learning styles preference. Ideally, each concept should progress through all four cycles (why?, what?, how?, what if?) in Kolb's model.

Be organized. Based on the learning objectives, the subject matter, and your abilities, select the most effective learning methods. (We will address a few of the more active learning methods later in this paper.) Carefully examine and select course references. Before the term begins, formulate your policies on attendance, grading, and contingencies, like student illnesses and family emergencies. Consult your mentor and/or department chair about the prevailing university, college, and department policies. Finally, spell out all policies in detail in your syllabus. The syllabus contains the course "ground rules" and is a contract between you and the student concerning expectations. We strongly recommend the NEE to refer to [16] for more details and citations about course design/preparation.

2.2 Classroom environment conducive for learning

Maintain a respectful classroom environment similar to acceptable profession practice. We have found that the single biggest contributor to student is personal contact or rapport with the students. Know your students by name and learn something about them as individuals. When a student knows that your know something about them, they perceive that you care about them as a person and a student. Once this relationship is established, they appreciate what you do more, and are more willing to respond to your efforts. Often, behavior and academic dishonesty problems are reduced when the class feels the instructor knows and cares about the students as individuals.

The predominant student attitude in the lecture hall at our university is more formal than other universities with which we've been associated. Students nearly always address professors with the title of "Doctor" or "Professor". Therefore, we have a reciprocal professional protocol with the students by addressing them as "Mr. Smith" or "Ms. Doe". Students often respond positively. They write in teaching evaluations that the classroom seems "professional" and "more like industry than college". If your university classroom environment is not so formal, address your students in a prevailing manner that is considered acceptable in professional practice. Regardless, learn the students' names and use them.

The classroom environment must be characterized by enthusiasm, dynamism, and movement. This energy will keep you and your students interested, alert, and learning. Do what it takes to keep the classroom energy levels high. A static classroom environment is the enemy of learning.

Move about the room during the period if your facilities allow. (If they don't, request that they be updated.) We have been known to walk to the rear of the lecture hall in the middle of a class period and have everyone turn his or her chairs 180 degrees. Then, we continue the instruction. Use voice levels and inflection to maintain the student's attention. If energy levels drop too low, especially in early morning or after meal periods, students may need to stand or move about the room. You don't have to give an Oscar winning performance during lecture. However, students must be able to see your excitement for the subject matter. If you are not interested in the subject, they definitely will not be.

Lectures need to be conducive to an open and free exchange of ideas. Obviously there are times when you must steer the classroom discussion back on scheduled topics, but students should have no fear in asking a question. Never discourage students who speak up in class or ask questions. No question is too "dumb" to answer. The old teacher's adage that "if one student has a question, then there are others with the same question." Be prepared and confident enough in your knowledge and abilities so that you do not appear defensive when students ask questions during the lecture.

Ultimately, NEEs need to balance the rigor, formalism, and authority given to them with the urge to become overly accommodating to or overly familiar with the students. NEEs should read Engelken's excellent paper on this balancing act [4].

2.3 Make learning more "active"

Learning psychologists have determined that knowledge retention declines precipitously from a maximum of about 70% to below 20% after a few minutes of traditional, or passive, lecturing [16]. (See Figure 1.) This passive lecture style, where the professor speaks and transcribes notes onto a blackboard for students to copy into their notes, is the primary engineering learning method used for decades. Effective learning requires pedagogy to keep students in their "retention groove". Active learning exercises (introspective high-level thinking skills problems, small-group exercises, "one-minute" reports, small-group brainstorming, etc.) interspersed through a "traditional" lecture do just that [14]-[17].

Active learning techniques have been used in K-12 education and general university education with great success since the 1970s. Starting about 1990, engineering educators initiated, measured, and published efforts and success with active learning techniques in the undergraduate engineering curriculum [2], [7]-[11]. Through studies in engineering education, much of it funded by NSF, active learning exercises have been shown to cater to various student learning styles [5], hone student communication skills [14], reinforce "learning communities" [2], [16], and effectively exercise higher thinking levels in Bloom's Taxonomy [17].

Active learning will keep students awake and engaged. Consider it the most "passive" learning method in your arsenal. Cooperative learning methods structure learning to occur outside of the classroom. It also develops teaming and communication skills. The literature is overflowing with its benefits and implementations. We encourage NEEs to read [14]-[17] for a start in deploying active learning techniques in the classroom.

Our experience is that active learning exercises during lectures are relatively easy for all NEEs. A simple way to create those first active learning exercises is to take an example exercise from the lecture notes that is typically worked and explained by the instructor. Place the example problem on the top of blank page and distribute to the class. Give instructions to the class on how to perform the active learning technique, i.e. think-pair-share, brainstorming, etc. While students work actively, the instructor should circulate around the classroom to give and get feedback. After several minutes, the instructor reacquires the attention of the energized, awake, and knowledge-retaining students to discuss the problem, its solutions, and related concepts. In subsequent exercises and with time, the NEE will become quite adept at switching student into and out of active learning exercises.

Cooperative learning is a pedagogic technique where students interact with one another while learning and applying course material [18]. Cooperative learning techniques can extend active learning beyond the course lecture period. Teams of three or four students work together on homework sets, lab experiments, course projects, and team-based exam questions. In short, cooperative learning is similar to team-based course projects common in many engineering courses, but cooperative learning is more formalized and structured to reinforce positive teaming and learning skills while avoiding common teaming problems [13], [15]. Cooperative learning must meet five criteria [18]:

- positive interdependence
  Team members must rely on each other to achieve the group's goals.

- individual accountability
  Members are held accountable for doing their part and mastery of the material.

- face-to-face interaction
  Some or all group members must work together to achieve the group's goals.

- appropriate use of interpersonal skills
  Group members learn and practice teaming, communication, conflict management and leadership skills.

- regular self-assessment of group functioning.
  Groups periodically reflect and evaluate their performance and identify ways to improve that performance.

Correctly applied, cooperative learning techniques increase the students' motivation to learn, material retention, depth of understanding, and teamwork/communication skills [18] by forcing students to work in the more effective (lower) levels in Figure 2.

Cooperative learning techniques may be the most thoroughly studied teaching method ever devised, and has been shown to be highly effective [5][18]. Many engineering educators who have adopted and studied active learning techniques have also tried cooperative learning techniques. Success in reducing attrition and improving academic performance, student motivation, and student satisfaction with engineering has been documented extensively [7]-[11], [13], [19], [22], [24]. Faculty observe and students self-report gains in complex problem solving skills, teamwork/communication skills, and design abilities [11], [21], [22]. NSF considers cooperative learning techniques a critical part of engineering education reform [2]. The cooperative learning references at the end of this paper have many effective activities. We have found team homework, team projects, and "jigsaw" exercises are particularly useful in engineering classes. The key is to ensure that all five criteria listed above are present to minimize problems. In our experience, NEEs should start with one or two cooperative learning exercises. Homework sets with challenging or open-ended problems or a team project are good candidates since many engineering courses already contain similar exercises. After the NEE achieves success in these smaller cooperative learning exercises, then the NEE should consider incorporating more cooperative learning techniques throughout his or her course. Of course, the NEE's mentor and department chair should be notified of the plans before starting.

2.4 Make learning relevant

Twenty-first century engineering students grew up with affordable PCs, video games, and hundreds of television channels, including MTV. They have been bombarded with a volume of information never before seen or imagined. These students want and need to see the relevance of a concept before they are willing to commit to them. Put another way, today's students learn in a top-down approach, i.e. generalities first, then details. This approach is the reverse learning order, bottom-up or details first, as the current crop of baby boomer engineering faculty.

Students want to know how a concept can be used before they learn. Tell them. Before you start a new derivation, introduce a new concept, or begin a new chapter, motivate the students with an applicable and relevant problem. Capture their interest by making the problem one that is close to a need or desire that affect them. During the derivations or discussions, reiterate the specifics of the problem at each point that desire for the students to retain.

The ultimate in making learning relevant is to use problem based learning (PBL) techniques [25]. PBL begins with a problem for the class to solve. The entire learning process centers on solving "the problem". In its purest form, the instructor does not have a list of concept to cover or any particular schedule. Students drive the pace and order of topical coverage based on their background or prior experiences, the current state of their solution, and their ability to learn independently. PBL can be considered the most extreme of the active learning techniques. PBL can be very effective in engineering, especially in design-oriented courses. NEEs comfortable and experience with active and cooperative learning should consider experimenting with PBL. However, our experience is that unless the students are experienced with active and cooperative learning, and properly prepared to be responsible fully for their own learning, a successful PBL course can be more challenging for NEEs. We currently recommend that NEEs study PBL techniques, get advice and mentoring from experienced faculty, and discuss their educational plans with their department chair before large-scale PBL courses are attempted.

2.5 Give/get frequent feedback

Learning is a feedback system. In general, students and faculty perform better when the feedback evaluations are numerous and frequent. Problems are more quickly detected and corrected. Active classroom exercises give student and instructor the chance to evaluate the comprehension and retention just moments, hours, or days after the concept is covered. We use the results of an active exercise to make the most efficient use of classroom time – reviewing concepts when the exercise shows that the concepts have not be retained, or moving more quickly if the exercise shows that class is proficient and bored.

On the first day of class, students often dislike the idea of regular and frequent exams throughout the semester. However, our experience is that students appreciate the course grade being distributed over many exams and many days. The short frequent exams means that each exam covers less material. In addition, the student's grade is less likely to be affected by a single "bad" day, due to sickness, projects, or other exams. Our anecdotal experience is that class performance improves with the short frequent exams. The increase is more pronounced in the first and second year university students.

We also encourage more frequent student evaluation than the typical end-of-semester standardized form. Many of the "one minute papers" described in [16]-[18] are excellent at providing insight into what is effective and what the instructor may need to improve. Furthermore, these activities are often reflective for the students and push them into the higher levels of Bloom's taxonomy [14], [16], [23].

2.6 Guard against over-preparation

The natural tendencies of most engineering faculty is toward being an over-achiever and a perfectionist. Because of the extreme time demands on NEE to be successful quickly, these natural tendencies can lead NEEs into burnout, and worse, a negative tenure decision. NEEs need to take every possible step to avoid over-preparation in their instructional activities [1], [20]. Boice [1] advises new faculty to "moderate" their work toward instructional duties and gives several rules toward this end. His advice is excellent and with practice, NEEs can use them to guard against over-preparation. We repeat some of Boice's rules here with our comments on how NEEs can place them into practice.

- Wait
  Boice is not encouraging procrastination. But just as a good designer refrains from rushing to the design activities, so too should the NEE wait until a work plan is in place before starting preparation. Furthermore, NEEs should practice "waiting" while working. Take the time to work at a moderate pace. Do not rush or hurry which leads to mistakes and poor quality results. Do not work excessively so that you neglect your body, mind, soul, and relationships. Avoid waiting too long so that deadlines loom large and time pressures adversely affect quality of work and life.

- Prepare, and teach, in brief, regular sessions
  Learn how to be creative and accomplish meaningful work in brief sessions. It can be done. It must be done, because long, uninterrupted periods are rare for the NEE. Transfer this concept to your class activities too. Short, effective learning periods are more memorable and have higher retention than longer periods. (Recall the active learning research results in [14]-[17].) There are many excellent ways to break class time into brief sessions, many of which can be active or cooperative learning exercises. Some illustrative examples are to have students summarize the previous meetings key points, divide the class meeting into a few (2-4) main sections each with a memorable central point, one-minute papers, comprehension quizzes, think-pair-share discussion on complex or open-ended questions, and small discussion groups followed by one minute presentations of results. There are many others.

- Stop, before diminishing returns set in
  We can always make that one rough lecture a little bit better. However, the question to ask yourself is "why". Determine when your instructional preparation is good enough, then stop and go onto the next important task. A good plan formed in the "waiting" step should help the NEE know when to stop before the diminishing returns set in. Plan to stop in a timely manner in the classroom too. Leave a few minutes at the end of class to summarize, or better yet, have the students summarize, ask for questions, handle emergencies, or, simply, hold a few minutes of "office hours" for those student unwilling to visit your office.

- Moderate overattachment to content
  We remind the NEE of the principle that began this paper: *Educators should judge their performance by "what is learned" rather than by "what is taught"*. Many NEEs fall into the trap of trying to cover all of the material. Sure, you can lecture on every subject on the course outline, but if student don't comprehend the concepts, what productive work has been done? Student and faculty satisfaction is much improved if concepts are covered at a reasonable rate. Every class is different and some classes take longer to grasp the concepts than others. If time does not permit your class to learn that last chapter on the syllabus, then don't try to rush through it just to say that you did. Let the instructor teaching the next class in the program, the curriculum committee, and/or your department chair know that some students have not seen this material. If there never seems to be time to cover the material, your department may need to reexamine the course to see if the expectations are too high. Lastly, don't feel obligated to discuss, derive, or expound on a concept just because you prepared lecture materials. Our time with the students is precious. They have many other demands on their time. Include concepts only when they further the learning toward the course objectives.

- Let other do some of the work
  Just as research results are shared in our academic communities, so too should we consider sharing instructional results and materials. Ask you mentor or colleagues to give you copies of their syllabi and/or lecture notes. All educators, not just NEEs, can learn from others. Your colleagues lecture style may not be similar to yours, but there is likely something you can learn or "borrow" from their approach. Ask for advice from faculty who are known for their classroom excellence. Ask your mentor, department chair or an experienced educator to evaluate a few of your lectures at random. Find time to read the engineering education literature about "best practices". Join the ASEE and any education-oriented societies in your professional organizations. Attend workshops on education methods sponsored by your college, ASEE, NSF, and others.

Try out and practice the rules above. It will take time to learn how long to wait (plan) before starting activities. It will take time to learn how to be productive in those fifteen minutes between meetings. It will take time to learn when to stop before your efforts give little value-added to the results. It will take time to learn to lose attachment to that material. It will take time to learn how to work with others. However, mastery of these rules will make you a more effective instructor with less preparation.

2.7 Publish

Satisfaction with instruction comes more easily with research success. Schedule a regular time during your week for writing proposals and papers. Only miss this time if you would miss a lecture for the same reason. Also, consider ways to measure your instructional effectiveness quantitatively and qualitatively. View your classes like a research experiment. Form a hypothesis about what will create effective learning. Then test this hypothesis. Publish your findings in the conferences and journals of the ASEE or the educational society in your professional organization.

3 Summary

The authors' experience is that students respond positively, in teaching evaluations and instructional effectiveness, in response to efforts toward these "tricks of the trade", especially one through six. With the exception of the active, cooperative, and problem-based learning techniques, these "tricks" can be employed by NEEs immediately. The NEE needs to keep his/her mentor and department chair aware of their use of active, cooperative, and problem-based learning techniques. The key here is to try these techniques slowly and deliberately. With thoughtful preparation and guidance from faculty experienced with these techniques, the NEE can increase the energy levels in the classroom and affect better learning. We think the "tricks" presented here will help NEEs to start their instructional careers quickly and positively.

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Figure 1: Student learning retention rates [16]

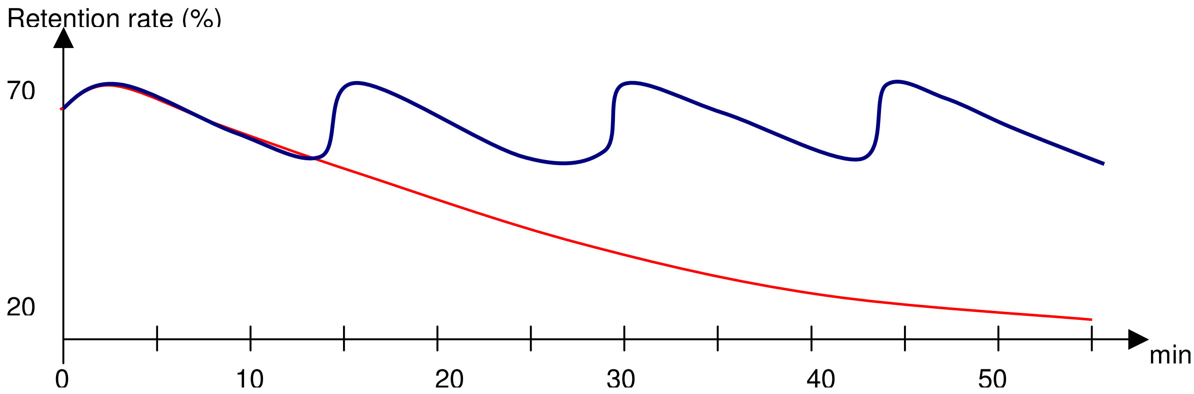

Figure 2: Student learning retention rates [3]

After two weeks, people tend to remember…

10% of what they read	Reading	Passive Learning
20% of what they hear	Hearing	
30% of what they see	Seeing pictures	
50% of what they see and hear	Seeing a movie	
	Looking at an exhibit	
	Watching a demonstration	
	Seeing it done on location	
70% of what they say	Participating in a discussion	Active Learning
	Giving a talk	
90% of what they do	Performing a dramatic reenactment	
	Simulating the real experience	
	Doing the real thing	