

book. Professor Felder's critique of the book led us to reorganize the order of presentation. Professor Phil Swain was extremely helpful in polishing Chapter 8. Without question, the work of Mary McCaulley in extending and explicating the ideas of Katherine Briggs and Isabel Briggs-Myers formed our thinking on psychological type and its relevance to engineering education. Catherine Fitzgerald and John DiTiberio provided first-hand exposure to Type theory in action.

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Finally, we dedicate this book to our families in appreciation for their patience and support: To our wives, Dot and Sherry, for listening to our complaints; and to our children—Charles and Jennifer, and John and Mary-Kate: With their future in mind we wrote this book.

INTRODUCTION: TEACHING ENGINEERING

It is possible to learn how to teach well. We want to help new professors get started toward effective, efficient teaching so that they can avoid the "new professor horror show" in the first class they teach. By exposing them to a variety of theories and methods, we want to open the door for their growth as educators. Since one goal is immediate and the second is long-term, we have included both immediate how-to procedures and more theoretical or philosophical sections. Written mainly for PhD students and professors in all areas of engineering, the book may be used as a text for a graduate-level class or by professionals who wish to read it on their own. Most of this book will also be useful to teachers in other disciplines. Teaching is a complex human activity, so it's impossible to develop a formula that guarantees excellence. But by becoming more efficient, professors can learn to be good teachers and end up with more time to provide personal attention to students.

1.1. SUMMARY AND OBJECTIVES

After reading this chapter, you should be able to:

- Discuss the goals of this book.
- Answer the comments of critics.
- Explain the two-dimensional model of teaching.
- Discuss some of the values which underlie your ideals of teaching.
- Explain some applications of learning principles to engineering education.

1.2. WHY TEACH TEACHING NOW?

Most engineering professors have never had a formal course in education, and some will produce a variety of rationalizations why such a course is unnecessary:

1. *I didn't need a teaching course.* Just because someone did not need a teaching course does not logically imply that he or she would not have benefited from one. And times have changed. In the past, young assistant professors received on-the-job training in how to teach. New assistant professors were mentored in teaching and taught several classes a semester. Now, mentoring is in research, and an assistant professor in engineering at a research university may teach only one course a semester. In the past the major topic of discussion with older professors was teaching; now it is research and grantsmanship. Thus, formal training in teaching methods is now much more important.

The problems facing engineering education have also changed. In 2009 (the most recent year for which data is available) 468,139 undergraduate engineering students were enrolled, which is 2.63% of the total of 17,778,741 undergraduates enrolled at all US institutions (NSF, 2013). If we look at only US citizens and permanent residents there were 440,791 undergraduates in engineering, which is 2.53% of the 17,404,882 total enrollment. The number of traditional new engineering students—white American male eighteen-year olds—is expected to drop slowly for at least the next 15 years (NSF, 2013). The 2010 population data in 5-year cohorts illustrates a slow decrease in numbers after the 15–19 bulge (Table 1-1). In 2014 the students in the 2010 15–19 cohort are currently in college. Cohort data by race and ethnicity is shown in Table 1-2. Since the cohorts do not match, the ratio calculations in Table 1-2 estimate the numbers for matching 7-year cohorts. The only groups that will have larger college age cohorts in the next 15 years are Hispanic or Latino, two or more races, and other races. Since the percentage of females does not change much, white male cohorts decrease at the same rate the white cohorts decrease. As the under-five cohort was 50.8% white in 2010 and the percentage of white babies continues to decrease, there will not be an increase in the percentage of traditional white male engineering students in the foreseeable future.

First, there is a moral imperative for reaching out to nontraditional students, including women, underrepresented minorities, veterans, low socioeconomic status, first generation college students, students of varying religions, and LGBTQ (lesbian, gay, bisexual, transgender, questioning) students. The 2011 enrollment of undergraduate students in engineering by race/ethnicity and by gender is given in Table 1-3. If all students had equal opportunity to study engineering, then the percentages of each group in engineering would be close to the corresponding percentages in the entire population. Clearly there are disparities. For example, if black or African American students studied engineering at the same percentage as the overall population there would be 2.4 times as many black or African American students as there are currently (assuming no change in the number of all other students. The largest disparity is in the number of female

Table 1-1. 2010 Population of United States (NSF, 2013)

Cohort	Number	% Female
Total	308,746,000	50.8
<5	20,201,000	48.9
5–9	20,349,000	48.9
10–14	20,677,000	48.8
15–19	22,040,000	48.7
20–24	21,586,000	49.0

Table 1-2. 2010 US Population by Race/Ethnicity (NSF, 2013)

Race/Ethnicity	Total	<5	Ratio 1	5–17	Ratio 2	18–24
All	308,746	20,201	28,281	53,980	29,066	30,672
White	196,818	10,254	14,356	29,462	15,864	17,547
Asian	14,465	875	1,225	2,301	1,239	1,491
Black or African American	37,686	2,754	3,856	7,608	4,097	4,373
Hispanic or Latino	50,478	5,114	7,160	12,016	6,470	6,154
American Indian or Alaska native	2,247	175	245	472	254	262
Native Hawaiian/Pacific Islander	482	38	53	98	53	64
Two or more, not Hispanic	5,966	924	1,294	1,865	1,004	707
Other race, not Hispanic	604	67	94	156	84	73

Note: Numbers in thousands. Ratio 1 equals the number in the <5 cohort adjusted to 7 years: (# in group <5) × (7/5); ratio 2 equals the number in 5–17 cohort adjusted to 7 years: (# in 5–17 group) × (7/13).

Table 1-3. 2011 Undergraduate Enrollment of US Citizens and Permanent Residents in Engineering Programs by Race/ethnicity and Gender. Total US and permanent resident undergraduate engineering students was 439,827 which were 81.446% male and 18.554% female. The first row of data gives the % each race/ethnicity is of total number of engineering students. The 2nd row of data gives the % of each race/ethnicity in the total US population (2010 data from Table 1-2). Third and 4th rows are the % of each race/ethnicity that are male and female, respectively. Data is based on Table 2-10 in NSF (2013).

	White	Asian	Black or African American	Hispanic or Latino	Native American	Pacific Islander	> 1 Race/Ethnicity
% All US UG Engr. Students	69.696	8.643	5.508	10.574	0.530	0.225	1.897
% all US pop. (Table 1-2)	63.745	4.685	12.206	16.349	0.728	0.156	1.932
% Male	83.0	78.3	75.4	79.1	77.7	79.7	76.5
%Female	17.0	21.7	24.6	20.9	22.3	20.3	23.5

engineering students since parity with the overall population would require increasing the number of female engineering students by a factor of 4.2 (assuming no change in the number of male students). Of course, many students belong to two or more of these nontraditional groups.

Second, to remain internationally competitive, we must recruit, teach, and retain nontraditional students. They often have different experiences studying engineering (Table 1-4) and will often learn more with active learning methods than with lecture.

Table 1-4. Common Experiences of Non-Traditional Engineering Students (Modified from Susan Montgomery Lecture Material)

Women	<ul style="list-style-type: none"> • Faculty tend to interact more with men • Men interrupt more, women more hesitant • Women display a lack of confidence • Women cite lack of faculty contact • Women hide academic abilities • Women prefer a cooperative environment • Women feel sexualized
Under-represented Minorities	<ul style="list-style-type: none"> • Low faculty and peer expectations • Faculty don't care about us . . . or reach out • Faculty don't understand we are different • Faculty single us out as "spokesperson" for our group • Curriculum and faculty interactions exclude us • Faculty seem uncomfortable or cautious with us • Faculty sometimes take overt stances in class against diversity issues and initiatives • Out of class interactions with faculty are minimal and difficult
Veterans	<ul style="list-style-type: none"> • Alienation and isolation • Family adjustments • Loss of structure • Balancing multiple responsibilities • Academic concerns returning to school • Health and disability difficulties
First Generation College	<ul style="list-style-type: none"> • Embarrassment and guilt • Desire a sense of belonging • Overwhelmed by workload • Self-doubts about ability • Family pressure to succeed • Identity confusion • Financial difficulties • More familiar with oral than written communication
Low Socioeconomic Status	<ul style="list-style-type: none"> • Financial difficulties • Family pressure to drop out and help support family • Limited access to resources • Affordability of college, books, housing, etc. • Need to work while attending college
Varying Religions	<ul style="list-style-type: none"> • Lack of recognition of their religious holidays • Cultural differences • Differences in dress • Discrimination against some religions
LGBTQ (Lesbian, Gay, Bisexual, Transgender, or Questioning)	<ul style="list-style-type: none"> • Mental health concerns • Discrimination • Housing concerns • Questions of trust

Unfortunately, women and underrepresented minority students see few women or underrepresented minority faculty members. In 2012, 14% (3515) of the 25,004 tenure-track engineering faculty in the United States were female (Berry, Cox, & Main, 2014). Although the percentage of female faculty in engineering has increased significantly since the 9% recorded in 2001, the percentage remains disappointingly low compared to the total population (Table 1: 50.8% female). Only 31.3% of the women were tenured full professors compared to 52.5% of the men (Berry et al., 2014). Underrepresented minority engineering faculty members have increased (black or African American from 2 to 3% and Hispanic or Latino from 3 to 4%), but from very low bases. African American female engineering faculty was 4% of all female engineering faculty in 2012. Approximately one-third of the African American female engineering faculty worked at one of the 12 Historically Black Colleges and Universities with an engineering program (Berry et al., 2014).

How do we encourage enough US citizens, particularly women and underrepresented minorities, to earn a PhD and then become educators? Many graduate students see the workloads of assistant professors as oppressive and do not want the tenure decision hanging over their heads. A course on efficient, effective teaching reduces the trauma of starting an academic career and will help these students to see the joys of teaching.

2. *I learned how to teach by watching my teachers.* Highet (1976), in simpler times, argued that a course on education during graduate study is not needed since students can learn by watching good and bad teachers. What if the teachers you watched were bad teachers? Even if you had good teachers, observing at best gives you a limited repertoire and does not provide for necessary practice. Observing also does not help you incorporate new educational technology into the classroom unless you have had the rare opportunity to take a course from one of the pioneers in these areas.

3. *Good teachers are born and not made.* Some of the characteristics of good teachers may well be inborn and not made, but the same can be said for engineers. We expect engineers to undergo rigorous training to become proficient, so it is logical to require similar rigorous training in the teaching methods of engineering professors. Experience in teaching engineering students how to teach shows that everyone can improve her or his teaching (see Section 1.5). Even those born with an innate affinity for teaching or research can improve by study and practice. Finally, in its extreme, this argument removes all responsibility and all possibility for change from an individual.

4. *Teaching is unimportant.* Teaching is very important to students, parents, alumni, accreditation boards, and state legislatures. Unfortunately, at many universities research is more important than teaching in the faculty promotion process. At undergraduate-focused institutions teaching is very important and faculty promotion and tenure depend heavily on teaching ability. An efficient teacher can do a good job teaching in the same or less time an inefficient teacher spends doing a poor job. Although sometimes less important for promotion, teaching is included in the faculty promotion process at all institutions. New professors who study educational methods will be better prepared to teach, will spend less time teaching, and will have more time to develop their research during their first years in academia.

5. *Teaching courses have not improved the teaching in high schools and grade schools.* There is a general trend toward reducing the number of courses in pedagogy and increasing the number of content courses for both grade school and high school teachers. However,

there is no trend toward zero courses or no practice in how to teach. The optimum number of courses in teaching methods undoubtedly lies between the large number required of elementary school teachers and the zero number taken by most engineering professors.

6. *Engineers need more technical courses.* The demand for more technical courses is frequently heard at the undergraduate level. At the graduate level some of the most prestigious US universities require the fewest number of courses. Thus, arguments that graduate students must cover more technical content lack conviction. Courses on teaching can be very challenging and can open up entirely new vistas to the student. Graduates who went into industry or government reported the communication and psychology portions of the course were very useful (Wankat and Oreovicz, 2005).

7. *If I am a good researcher, I will automatically be a good teacher.* Unfortunately, there is almost no correlation between effective teaching and effective research (see Section 17.4 for a detailed discussion). Frequently heard comments to the contrary are anecdotal. This is not a statement that engineering professors should not do research. Ideally, they should strive to do both teaching and research well, and they should be trained for both.

8. *Even if a teaching course might be a good idea, none is available.* There are courses in teaching in engineering colleges (e.g., Heath et al., 2013; Stice, 1991; Wankat and Oreovicz, 1984, 2005). At the University of Texas at Austin the teaching course has been offered since 1972 (Stice, 1991). The Ohio State course is online and students are paired with a faculty mentor (Heath et al., 2013). In addition, the University of Delaware, University of Alberta and Northwestern University have similar teaching fellow programs that provide a supervised practicum in teaching engineering (Russell et al., 2014). Many universities have focused their efforts into campus-wide courses often as part of a Preparing Future Faculty program. Many, if not most, universities offer teaching workshops either before the semester starts (e.g., Felder et al., 1989) or during the semester (e.g., Wentzel, 1987). Professors who missed a course in graduate school can sign up for the American Society for Engineering Education (ASEE) National Effective Teaching Institute (NETI) (e.g., Felder and Brent, 2009).

9. *If I need to adopt a new teaching method during my career, I will do it on my own.* Adopting a totally new teaching method on your own is possible but quite difficult. McCrickerd (2012) notes that one important but usually hidden reason professors hesitate to improve their teaching is fear of failure. It is much easier to try new methods as part of a course or workshop where there is a mentor to provide assistance and other students to provide support.

A large number of reports have called for training engineering professors how to teach. Both the Mann and the Wickenden reports of SPEE (the precursor of ASEE) call for teacher training (Kraybill, 1969). The ASEE Grinter report (Grinter, 1955) states, "It is essential that those selected to teach be trained properly for this function." The ASEE Quality of Engineering Education Project concluded, "All persons preparing to teach engineering (the pre-tenure years) should be required to include in their preparation studies related to the practice of teaching" (ASEE, 1985, p. 156). The Institution of Engineers Australia (1996, p. 61) recommended engineering schools develop policies to "ensure that staff undertake formal courses in learning and teaching." Simon (1998, p. 343) noted that athletic coaches in college are trained in coaching, which is a form of teaching, and then stated "we should ask seriously whether we, too, should not be paying explicit attention to the techniques of learning and teaching." Wankat (2002) recommended that institutions hiring assistant professors should

require candidates to have taken an education course or to attend an extensive teaching workshop. The 2009 ASEE phase I report (Jamieson and Lohmann, 2009, p. 11) stated, "It is reasonable to expect students aspiring to faculty positions to know something about pedagogy and how people learn when they begin their academic careers." This sentence is repeated in the ASEE final report *Innovation with Impact* (Jamieson and Lohmann, 2012, p. 19), and the first recommendation of the report is "Value and expect career-long professional development in teaching, learning, and education innovation for engineering faculty and administrators, beginning with pre-career preparation for future faculty" (Jamieson and Lohmann, 2012, p. 46). Wankat (2013) concluded that training professors how to teach was necessary to successfully reform engineering education.

There is one additional very good reason: Teaching when you don't know how may be considered unethical! Canon 2 of the engineering code of ethics states, "Engineers shall perform services only in the areas of their competence" (see Table 12-1). Since teaching is a professional service, teaching when one is not competent is probably unethical.

1.3. THE COMPONENTS OF GOOD TEACHING

A good teacher is characterized as stimulating, clear, well-organized, warm, approachable, prepared, helpful, enthusiastic, fair, and so forth. Lowman (1995) synthesized the research on classroom dynamics, student learning, and teaching to develop a "two-dimensional model" of good teaching. The more important dimension is intellectual excitement, which includes content and performance. Since most engineering professors think content is most important, making this dimension most important agrees with common wisdom in the profession. Included in intellectual excitement are organization and clarity of presentation of up-to-date material. Since a dull performance can decrease the excitement of the most interesting material, this dimension includes performance characteristics. For great performances professors need to have energy, display enthusiasm, show love of the material, use clear language and clear pronunciation, and engage the students so that they are immersed in the material.

Lowman's second dimension is interpersonal rapport. Professors develop rapport by showing an interest in students as individuals. In addition to knowing every student's name, does the professor know something about each one? Encourage them and allow for independent thought even though they may disagree with the professor? Make time for questions both in and out of class? Students consistently include this dimension in their ratings of teachers (see Section 16.4.2). At times the content and rapport sides of teaching will conflict with each other.

How do these two dimensions interact? The complete model is shown in Table 1-5. Lowman (1995) divides intellectual development into high (extremely clear and exciting), medium (clear and interesting), and low (vague and dull). He divides the interpersonal rapport dimension into high (warm, open, predictable, and highly student-oriented), medium (relatively warm, approachable, democratic, and predictable), and low (cold, distant, highly controlling, unpredictable). To interpersonal rapport we have added a fourth level below low—punishing (attacking, sarcastic, disdainful, controlling, and unpredictable)—since we have observed professors in this category.

The numbering system in Table 1-5 indicates that professors improve their teaching much more quickly by increasing their intellectual excitement than by developing greater rapport with students. A professor who is high in interpersonal rapport and low in intellectual excite-

Table 1-5. Two-Dimensional Model of Teaching (Lowman, 1995)

Intellectual Excitement	Interpersonal Rapport			
	Punishing	Low	Moderate	High
High	6 ¹ . Intellectual Attacker	6. Intellectual Authority	8. Masterful Lecturer	9. Complete Master
Moderate	3 ² . Adequate Attacker	3. Adequate	5. Competent	7. Masterful Facilitator
Low	1 ³ . Inadequate Attacker	1. Inadequate	2. Marginal	4. "Warm fuzzy"

ment (position 4) will be considered a poorer teacher than one who is high in intellectual excitement and low in interpersonal rapport (position 6). Because their strengths are very different, these two will excel in very different types of classes. The professor in position 4 will do best with a small class with a great deal of student participation, whereas the professor in position 6 will do best in large lecture classes. Our impression is most engineering professors are in the broad moderate level of intellectual excitement and are at all levels of interpersonal rapport. The difference between these teachers and those at the high level of intellectual excitement is that the latter either consciously or unconsciously pay more attention to the performance aspects of teaching. Fortunately, all engineering professors can improve their teaching in both dimensions, and position 5 (competent) is accessible to all. Although becoming a complete master is a laudable goal to aim for, teachers who have attained this level are rare.

Hanna and McGill (1985) contend that the affective aspects of teaching are more important than method. Affective components which appear to be critical for effective teaching include:

- Valuing learning
- A student-centered orientation
- A belief that students can learn
- A need to help students learn

These affective components are included in the model in Table 1-5. High intellectual excitement is impossible without valuing the learning of content and a need to present the material in a form that aids learning. High interpersonal rapport requires a student-centered orientation and a belief that students can learn.

A few comments about the punishing level of interpersonal rapport are in order. Since most students will fear such a professor, they will do the course assignments and learn the material if they remain in the course and aren't immobilized by fear. However, even those who do well will dislike the material. In our opinion and in the opinion of the American Association of University Professors (see Table 17-6), this punishing behavior is unprofessional. The only justification is to train students for a punishing environment such as that confronted by boxers, POWs, sports referees, and trial lawyers. Professors who stop attacking students immediately move into the level of low interpersonal rapport and receive higher student ratings.

One can add a number of additional components to the definition of good teaching. Wankat and Oreovicz (1998) added:

- High ratio of student learning to student time
- High ratio of student learning to instructor time

The first is student efficiency while the second is instructor efficiency, which makes the teaching sustainable. Students appreciate an efficient instructor. There is a high correlation between the fraction of their preparation time that students considered to be valuable and the student ratings of the instructor (Theall and Franklin, 1999).

1.4. PHILOSOPHICAL APPROACH

Teaching is an important activity of engineering professors, both in regard to content and in relation to students. New professors are usually superbly trained in content, but often have very little idea of how students learn. Our (revolutionary) hypothesis: Young professors will do a better job teaching initially if they receive education and practice in teaching while they are graduate students or when they first start out as assistant professors. They will be more efficient the first few years and will have time for other activities.

The teaching methods covered here go beyond the standard lecture format, although it too is covered. Unfortunately, for too many teachers teaching is lecturing. To broaden the reader's repertoire of teaching techniques, we include other teaching methods. Because advising and tutoring are closely tied to teaching, we also include these one-to-one activities. We also cover methods for teaching students to become good problem solvers and to learn how to learn. Since engineering professors must be involved in many other activities in addition to teaching, we emphasize both effectiveness and efficiency. We believe people want to learn. Therefore, we search for ways to stop demotivating students while realizing that a few discipline problems always exist.

Engineering professors invariably serve as models of proper behavior. Thus, an engineering professor should be a good engineer both technically and ethically, not using his or her position to persecute or take advantage of students. We agree with Hight (1976, p. 79) that in general students are likely to be immature and that "our chief duty is not to scorn them for this inability to comprehend, but to help them in overcoming their weakness." A well-developed sense of fairness is almost uniformly appreciated by students.

1.5. WHAT WORKS: A COMPENDIUM OF LEARNING PRINCIPLES

Throughout this book we will base teaching methods on known learning principles. Many comments on what works in teaching are scattered throughout. In this section we will list many of the methods that are known to work. The ideas in this section are based on Chapters 13 to 15, papers by Carberry and Ohland (2012); Chickering and Gamson (1987); Keeley, Smith, and Buskist (2006); Ripley (2010); and Roksa and Arum (2011); books by Farr (2010), Lang (2013), Lowman (1995), and Svinicki and McKeachie (2014); and the government brochure *What Works* (1986).

1. Guide the learner. Be sure that students know the objectives. Tell them what will be next. Provide organization and structure appropriate for their developmental level.
2. Develop a structured hierarchy of content. Some organization in the material should be clear, but there should be opportunities for the student to do some structuring. Content needs to include concepts, applications, and problem solving.

3. Use images and visual learning. Most people prefer visual learning and have better retention when this mode is used. Encourage students to generate their own visual learning aids.
4. Ensure that the student is active. Students must actively grapple with the material. This can be done internally or externally by writing or speaking.
5. Require practice. Learning complex concepts, tasks, or problem solving requires a chance to practice in a nonthreatening environment. Some repetition is required to become quick and accurate at tasks. Most students and faculty underestimate the amount of practice needed to learn new skills (Ambrose et al., 2010).
6. Check for understanding frequently. Question, listen, observe.
7. Provide feedback. Feedback should be prompt and, if at all possible, positive. Reward works much better than punishment. Particularly in communication, in addition to telling what is wrong, give some direction on how to do it correctly. Students need a second chance to practice after feedback in order to benefit fully from it.
8. Communicate your expectations that students will behave professionally, and professors should model professional behavior at all times. Engineering students are preparing for professional careers. They should start behaving professionally as first year students.
9. Have positive expectations of students. Positive expectations by the professor and respect from the professor are highly motivating. Students learn more from faculty who have high expectations. This important principle cannot be learned as a "method." Master teachers truly believe that their students are capable of great things.
10. Provide means for students to be challenged yet successful. Be sure students have the proper background. Provide sufficient time and tasks so that everyone can be successful but be sure that there is a challenge for everyone. Success is very motivating. The combination of items 9 and 10 can be stated succinctly. "I am going to challenge you," and "you are capable of meeting that challenge" (Lang, 2013, p. 157).
11. Individualize the teaching style. Use a variety of teaching styles and learning exercises so that each student can use his or her favorite style and so that each student becomes more proficient at all styles.
12. Make the class more cooperative. Use cooperative group exercises. Stop grading on a curve and either use mastery learning or grade against an absolute standard.
13. Ask thought-provoking questions. Thought-provoking questions do not have to have answers. Questions without answers can be particularly motivating for more mature students.
14. Be enthusiastic and demonstrate the joy of learning. Emphasize learning instead of grades. Enthusiasm is motivating and will help students enjoy the class.
15. Encourage students to teach other students. Students who teach others learn more themselves and the students they teach learn more. Students who tutor develop a sense of accomplishment and confidence in their ability.
16. Care about what you are doing. The professor who puts teaching "on automatic" cannot do an outstanding job.
17. Track student performance. Share the results with students. Students can make informed decisions about study if they know how they are doing in class.
18. Develop efficient routines for transitions, disseminating materials, collecting assignments, and so forth. Efficiency at these tasks leaves more time for student learning.

19. If possible, separate teaching from evaluation. If a different person does the evaluation, the teacher can become a coach and ally whose goal is to help the student learn. These ideas can be stated succinctly: *engaged students learn* (Astin, 1993).

1.6. EFFECTIVENESS OF TEACHING COURSES AND WORKSHOPS

Extensive teaching workshops and courses improve teaching. The organizers of engineering teaching workshops at West Point (Conley et al., 2000) found that former students believed that they had improved because of the intensive one-week summer workshop. When asked, "Has your teaching improved as a result of attending this course?" 90% answered yes. The first edition of this book was used as the textbook. Brawner et al. (2002) found a self-reported increase in use of active learning methods by attendees of teaching workshops. The effectiveness of the American Society for Engineering Education (ASEE) National Effective Teaching Workshop (NETI) was studied by sending surveys to attendees from 1993 to 2006 (Felder and Brent, 2009). They found that 67% of the respondents reported an increase in teaching

Table 1-6. Survey Results of How to Teach Course (Wankat and Oreovicz, 2005)

Scale for questions 2 and 5: Negative = 1, Slightly Negative = 2, Neutral or No effect = 3, Slightly positive = 4, and Positive = 5. n = number of responses

Q. 2. Impact of the How-to-Teach course during job search for academic position? Score: 4.55, n = 25

Comments: "Writing the teaching statement and knowing what to expect as a professor has helped tremendously."

"It never came up in my interview. I assumed everyone had a course like this. Little did I know, that I was ahead of the curve on this."

Q. 5. "Impact of course on your academic career? Score 4.80, n = 17

Comments: "Improved my delivery skills on university lectures and training offerings to industry."

"Gave me a foundation on which to build a research program and continue to develop as a teacher."

Scale for question 3: Harmful = 1; Slightly harmful = 2; Neutral = 3; Slightly helpful = 4; Helpful = 5.

Q. 3. Effect of course on your first 2 years or less as an assistant professor. Score: 4.90 n = 17

Comments: "It was *immensely* helpful. I feel that I was very well prepared for what I would face."

"Made teaching a relatively easy task, which freed my time for research."

Scale for question 8: Strongly not recommend = 1; Not Recommend = 2; Neutral = 3; Recommend = 4; Strongly recommend = 5.

Q. 8. "Would you recommend a similar course to PhD students planning academic careers?"

Score: 4.90, n = 42

Comments: "Should be a *required* course."

"The belief that the possession of a PhD gives you some innate ability to teach is ridiculous."

"Strongly recommended for those seeking positions at a teaching institution."

ratings, 29% reported no change, and “fewer than 6% reported a drop.” (The sum does not add to 100% in the original paper.) They add “Also, inspection of individual responses shows that many who reported negative or negligible changes in their ratings had high ratings to begin with, so there was nowhere to go but down.” This comment points to a problem with voluntary workshops: excellent teachers attend, and professors who would probably benefit the most from attending often do not. Walczyk et al. (2007) showed that a single, three-credit course for professors in science is sufficient to result in significant increases in teaching effectiveness, and the increase in effectiveness was retained several years later.

Wankat and Oreovicz (2005) conducted a longitudinal study of alumni from their 3-credit graduate course, “Educational Methods in Engineering.” They received 42 useful responses (40%). Although a 40% response rate is low for a valid analysis (Felder and Brent, 2009), the authors analyzed the results. The primary research hypothesis was: “The course on educational methods would have a significant impact on graduates who followed academic careers.” Impact included having an easier time finding a position, becoming a better teacher as shown by student ratings, and faster start-up as an assistant professor. Survey results from the questions focused on academic careers are summarized in Table 1-6. Based on these responses the course was considered very valuable for graduates who chose academic careers. A survey of teachers of similar courses indicated that these results should generalize to other how-to-teach courses.

Supervised teaching internships, which are also effective, can be organized several different ways. First, they can be modeled after formal programs in education and psychology. In this model the students sign up for a supervision “course” with a professor who supervises four to six students. Second, in Preparing Future Faculty (PFF) programs interns serve at another institution, such as a community college, working with a professor at that institution (Lewanowski and Purdy, 2001). Third, professors can formally (Baber et al., 2004; Russell et al., 2014) or informally (Sherwood et al., 1997) share a course with a selected graduate student. The professor attends class when the graduate student teaches and provides feedback. This model could be employed at any university, and since it is less structured, can be adapted to unique circumstances.

1.7. CHARACTERISTICS OF GREAT TEACHERS

We do not focus on creating great teachers because being great requires characteristics that are very difficult to teach. However, professors who are already good teachers often want to know what separates the great teachers from the merely good.

Teach for America asked: What differentiated the great teachers from the good ones? Over a number of years Steven Farr studied this question and developed the following list of six characteristics (Farr, 2010; Ripley, 2010):

1. Set big goals for students. Since few students will go beyond the goals that are set, modest goals lead to, at best, modest results. With big goals even the students who do not reach their goals will probably perform well. However, the teacher has to believe that the students can meet their goals.
2. Invest in students and their families. Involve students and family in the process of learning.
3. Plan purposely. Start with the desired outcome and plan backwards to the actions necessary to get the students to this outcome.

4. Execute effectively. Maintain focus on student learning. All other secondary goals should be handled as routinely and efficiently as possible.
5. Continuously increase effectiveness. Keep changing teaching methods with the goal of always getting better. “Good enough” is not good enough to become great.
6. Work relentlessly to reach goals. Refuse to let difficulties stop the students from learning and reaching their goals. Every institution has disadvantages, policies, and personalities that can be used as reasons for not doing better. Find a way around these difficulties.

Although developed for grade, middle school and high school teachers, these characteristics, with the exception of involving families in item 2, all apply to college teaching. Items 2, 3, and 4 can be taught in a course and are covered in this book. The What Works list in Section 1.4 will satisfy these three items. Unfortunately, we do not know how to teach instructors to believe that their students can meet big goals. We also do not know how to teach instructors to never be satisfied—and we doubt we should even try. Finally, we do not know how to instill the relentless drive and resilience that will allow a teacher to overcome all obstacles.

Bain (2004), Barrett (2012), Hight (1976), and Stice (1998) consider other characteristics of great teachers and distill additional lessons that may help teachers become better.

1.8. CHAPTER COMMENTS

At the end of each chapter we will step aside and look philosophically at the chapter. These “meta-comments” allow us to look at teaching from a viewpoint that is outside or above the teacher. In class we use metadiscussion to discuss what has happened in class. Section 1.1, Summary and Objectives, gives readers an advance idea of what will be covered in the chapter. Advance organizers are particularly useful for readers who prefer a global learning style (see Section 15.3.3). In this chapter we set up a straw man who argued against courses on teaching methods, and then we knocked him down. The straw man is real, and we have met him many times. This book is written in a pragmatic, how-to-do-it style. The philosophical and spiritual aspects of teaching are given little attention. We recommend Palmer’s (2007) book for readers interested in these aspects.

HOMework

1. Develop a critical comment about the need for a teaching course and your response.
2. Good teachers must remain intellectually active. Brainstorm at least a dozen ways a professor can do this during a 35 to 40 year career.
3. Discuss the values that influence your teaching.
4. Determine the positions in Table 1-5 of engineering professors you know. What could these professors have done to improve their teaching? (Do not identify the professor.)

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EFFICIENCY

Professors are more effective if they learn to be efficient. Ideally, this learning would be done in school (it is helpful to be an efficient student). Most new professors work long hours and still feel they don't have time to do everything they want or need to do. By being more efficient they could do more research and do a better job of teaching in less time. Being efficient requires both an attitude and a bag of tricks. This chapter draws upon Lakein (1973, 1997), Griessman (1994), Morgenstern (2004), and Covey (1989, 2004, 2013) for many of the basic ideas. Reis (1997), Boice (2000), and Deneef and Goodwin (2007) have written guides for increasing the performance of new professors while Wankat (2002) and Robinson (2013) consider all professors.

2.1. SUMMARY AND OBJECTIVES

After reading this chapter, you should be able to:

- Set goals and develop activities to meet those goals.
- Prioritize the activities and use to-do lists.
- Improve your work habits with respect to people interactions and other activities.
- Analyze your travel patterns and improve your time use during travel.
- Explain how time spent preparing to teach affects course effectiveness, and use methods to improve your teaching efficiency.
- Improve your research efficiency and apply approximate cost-benefit analyses.
- Use methods to control stress.
- Discuss situations when a strict application of efficiency principles may not be the most efficient in a global sense.

2.2. GOALS AND ACTIVITIES

Clarifying your motivation for being more efficient will help provide the energy and drive to become more efficient (Covey, 2004; Morgenstern, 2004). Often, you know what you should