Getting Your Academic Career off to a Good Start

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September 20, 2010

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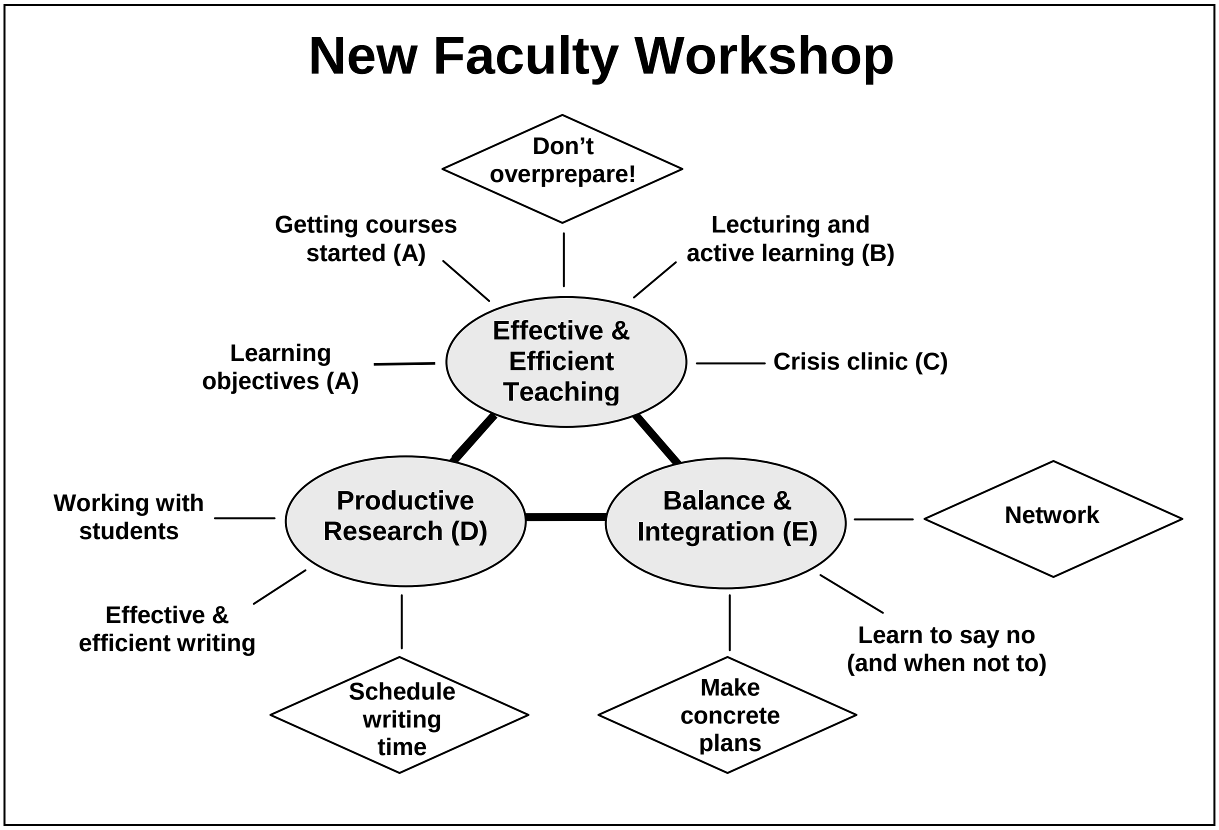

◇ R. Boice, *Advice for New Faculty*

Workshop Learning Objectives

At the conclusion of the workshop, the participants will be able to

- identify common mistakes made by new faculty members that hinder their advancement to promotion and tenure, and avoid making them.
- define learning objectives, write and classify them in terms of Bloom's Taxonomy levels, and list pedagogical and curricular benefits of writing them.
- devise preliminary course activities that capture students' interest and motivate learning.
- identify strategies for lecturing effectively and for obtaining active participation from most or all students in a class.
- deal with a variety of common classroom management, advising, and other student-related issues.
- interest graduate and undergraduate students in their research and work effectively with them.
- write articles and books in reasonable periods of time and maximize chances of getting them published.
- formulate strategies for balancing the competing demands of teaching, research, service, and personal life

Print Resources for New Faculty Members

- Boice, R. (2000). *Advice for new faculty members.* Needham Heights, MA: Allyn & Bacon. A practical book for new faculty members based on Robert Boice's experience with hundreds of new faculty. Sections deal with teaching, research, and fitting into the university.
- *Chronicle of Higher Education*, *<http://chronicle.com/section/Advice-Columns/144>*. Advice columns for college faculty members. Especially check out "Ms. Mentor" and "Balancing Act."
- Davidson, C. I., & Ambrose, S. A. (1994). *The new professor's handbook: A guide to teaching and research in engineering and science.* Bolton, MA: Anker Publishing. Sections on teaching and research offer useful guidance, especially for faculty in engineering and the sciences.
- Fink, L.D. (2003). *Creating significant learning experiences.* San Francisco: Jossey-Bass. An integrated approach to course and instruction design.
- Lang, J.M. (2005). *Life on the tenure track: Lessons from the first year*. Baltimore: Johns Hopkins University Press. An enjoyable personal narrative of an English professor's first year on the faculty, with useful hints to new faculty members of what may be awaiting them and what pitfalls to avoid.
- Menges, R. J., & associates. (1999). *Faculty in new jobs: A guide to settling in, becoming established, and building institutional support.* San Francisco: Jossey-Bass. An in-depth look at the problems facing new faculty and practical suggestions for dealing with them. Special suggestions aimed at women and faculty of color are also included.
- Svinicki, M., & McKeachie, W.J. (2011). *McKeachie's teaching tips: Strategies, research, and theory for college and university teachers* (13th ed.). Florence, KY: Cengage Learning. If you get only one book on teaching, make this the one.
- Toth, E. (2008). *Ms. Mentor's new and ever more impeccable advice for women and men in academia*. Philadelphia: University of Pennsylvania Press. Lots of practical advice, fun to read.

Electronic Resources on Learning and Teaching

Resources in Engineering and Science Education is Richard Felder's homepage. From the page, you can browse or download:

- A bibliography of Richard Felder's and Rebecca Brent's publications with links to online versions of some of them
- *Index of Learning Styles* (an instrument students can take and self-score to give them information about their learning style on Professor Felder's learning style model)
- Reprints of all of the *Random Thoughts* columns from *Chemical Engineering Education* on specific topics relating to education and some additional articles
- Student handouts on a variety of topics
- Links to other web sites on engineering education

http://www.ncsu.edu/effective_teaching

Articles and Handouts with Teaching Tips

- **For Your Consideration** is part of the University of North Carolina Center for Teaching and Learning site and contains a series of short monographs designed for faculty and teaching assistants. Topics include among others the first day of class, writing to learn, teaching large lecture classes, evaluating student projects, problem-based learning, peer observation of teaching, and student evaluation of teaching.

  http:www.unc.edu/depts/ctl/fyc.html

- **How Stuff Works** is a comprehensive site with sections on engines and motors, electronics, around the house, things you see in public, basic technologies, computers and the Internet, digital technology, automotive, in the news, food, and your body.

  http://www.howstuffworks.com/

- **National Institute for Science Education** houses three web sites: Collaborative Learning, Field-Tested Learning Assessment Guide, and Learning through Technology. These sites are specifically designed for college-level science, mathematics, engineering and technology.

  http://www.wcer.wisc.edu/nise/cl1

- **Ted Panitz's Web Site** is a comprehensive resource for articles and links related to cooperative learning, writing across the curriculum, and problem-based learning.

  http://home.capecod.net/~tpanitz/

Digital Resource Libraries

- **Global Campus** is a collaborative multimedia database containing materials for business, fine arts, engineering, liberal arts, library, and science.

  http://www.csulb.edu/~gcampus/

- **MERLOT**, Multimedia Educational Resource for Learning and Online Teaching, is an open resource designed primarily for faculty and students of higher education. Links to online learning materials are collected along with annotations such as peer reviews and assignments.

  http://www.merlot.org/merlot/index.htm

- **MIT OpenCourseWare** is an educational resource containing MIT course materials. There is no registration requirement or fee for use. Courses from almost every conceivable discipline are included. You can access lecture notes and in some cases tests, online textbooks, visuals and simulations.

  http://ocw.mit.edu

- **National Engineering Education Delivery System (NEEDS)** is a digital library for engineering education. By searching the learning resources, you can locate and download many courseware tools and multimedia packages for all branches of engineering and the sciences.

  http://www.needs.org

- **National Science Digital Library (NSDL)** is a repository of resources and tools that support innovations in teaching and learning of science, technology, engineering, and mathematics education.

  http://nsdl.org/resources_for/university_faculty/

- **SMETE Digital Library** is an online community of digital collections for science, mathematics, engineering, and technology education.

  http://www.smete.org

- **World Lecture Hall** contains course materials in disciplines including engineering, sciences, mathematics, humanities, social sciences, business, and other professional schools.

  http://www.utexas.edu/world/lecture/index.html

Workshop Faculty Biographies

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B.A. Millsaps College
M.Ed. Mississippi State University
Ed.D. Auburn University

Rebecca Brent is President of Education Designs, Inc., a consulting firm in Cary, North Carolina. Dr. Brent has 30 years of experience in education and specializes in staff development in engineering and the sciences, teacher preparation, evaluation of educational programs at both precollege and college levels, and classroom uses of instructional technology. She holds a Certificate in Evaluation Practice from the Evaluators' Institute at George Washington University. From 1997-2003, she directed the NSF-sponsored SUCCEED Coalition faculty development program, and she currently coordinates new faculty development activities for the North Carolina State University College of Engineering. Prior to entering private consulting, she was an Associate Professor of Education at East Carolina University, where she received the University Outstanding Teacher Award.

Workshop Faculty Biographies

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Dr. Felder joined the N.C. State University faculty in 1969. He is a co-author of the book *Elementary Principles of Chemical Processes* and authored or co-authored over 200 papers on chemical process engineering and engineering education, and he has presented over 600 workshops and seminars on effective teaching on campuses throughout the United States and abroad. He has won the R.J. Reynolds Award for Excellence in Teaching, Research, and Extension, the American Society for Engineering Education Chester F. Carlson Award for Innovation in Engineering Education, the American Institute of Chemical Engineers Warren K. Lewis Award for Contributions to Chemical Engineering Education, the ASEE Chemical Engineering Division Lifetime Achievement Award for Pedagogical Scholarship, and a number of other national and regional awards for his contributions to engineering and science education. At North Carolina State he has won the Sigma Xi faculty research award and has been designated a University Outstanding Teacher and Alumni Distinguished Professor.

Resources in Engineering and Science Education is Richard Felder's Web site.

http://www.ncsu.edu/felder-public

From the site, you can browse or download:

- A bibliography of Dr. Felder's publications with links to online versions of many of them
- Reprints of all of the *Random Thoughts* columns from *Chemical Engineering Education*
- The *Index of Learning Styles* (an on-line instrument students can use to determine their learning style)
- Information on teaching workshops given by Dr. Felder
- Handouts for students on a variety of topics
- Links to other web sites on engineering and science education

A. How do I plan a course? How can I get it off to a good start?

Learning Objectives

Learning objective (or instructional objective): A statement of something *specific* and *observable* students should be able to do after receiving instruction, plus (optional) conditions under which they would do it and/or what would constitute acceptable performance.

By the end of this [course, section of the course, week, lecture], the student will be able to *** where *** begins with an action word (explain, calculate, design,...).

Examples grouped according to their levels on Bloom's Taxonomy (p. A4):

<u>Remembering</u>

- *list* [the steps in Jones' classroom management model]
- *identify* [five key provisions of the Clean Air Act]
- *outline* [the procedure for drawing an arterial blood sample]

<u>Understanding</u>

- *explain* [in your own words the role of each step in Jones' model]
- *describe* [each of the organelles found in animal cell cytoplasm]
- *interpret* [the output from a SPSS ANOVA calculation]
- *distinguish* [between conduction and convection]

<u>Applying</u>

- *apply* [Jones' model to a simple classroom scenario]
- *calculate* [the probability that two sample means will differ by more than 5%]
- *solve* [the compressibility factor equation state for P, T, or V from the other two]

<u>Analyzing</u>

- *diagnose* [reasons for a classroom breakdown using Jones' model]
- *predict* [the conflicts likely to arise when students with specified learning styles work on a cooperative learning team]
- *explain* [why we feel warm in 70°F air and cold in 70°F water]

<u>Evaluating</u>

- *decide* [whether Jones' model or Dreikurs' model is better suited to a specified classroom scenario and explain your reasoning]
- *critique* [an article in the popular press related to the content of this course]
- *select* [one of several alternative product designs and justify your selection]

<u>Creating</u>

- *formulate* [a classroom management model of your own, and specify the kinds of situations for which it would and would not be applicable]
- *design* [an experiment to determine the effect of temperature on information retention]
- *create* [a problem involving material we covered in class this week]

Non-learning objectives: … the student will

- *know*
- *learn*
- *appreciate*
- *understand…*

Critically important goals, but not ***directly observable*** *and therefore not learning objectives.*

Possible Scopes of Learning Objectives

- *Complete course*. Few, general—suitable to include on course syllabus. (See p. A9).
- *Section of course.* 1–2 pages, specific—suitable as study guide for an exam. (See p. A6).
- *Individual lesson.* 1–3 (maximum), very specific—put on board at the beginning of a lecture.

Taxonomies of Educational Objectives

Cognitive Domain[1] (intellectual outcomes including knowledge, understanding, thinking skills)

- *Remembering*—Retrieving, recognizing, and recalling relevant knowledge from long-term memory
- *Understanding*—Constructing meaning from oral, written and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing and explaining
- *Applying*—Carrying out or using a procedure through executing or implementing
- *Analyzing*—Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing and attributing
- *Evaluating*—Making judgments based on criteria and standards through checking and critiquing
- *Creating*—Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning or producing

Affective Domain[2] (emotional outcomes including interests, attitudes, appreciation)

- *Receiving*—attend to a stimulus [read a handout, listen attentively to a lecture]
- *Responding*—react to a stimulus [carry out an assignment, participate in a discussion, show interest in a subject]
- *Valuing*—attach value to an object, phenomenon, or behavior [demonstrate a positive attitude, appreciation, belief, or commitment through expression or action]
- *Organization*—organize (compare, relate, and synthesize) different values into the beginning of an internally consistent value system [recognize a need to balance freedom and responsibility, formulate a career plan, adopt a systematic approach to problem solving]
- *Characterization by a value or value complex*—internalize a value system and behave accordingly in a pervasive, consistent, and predictable manner [work independently and diligently, practice cooperation in group activities, act ethically]

Psychomotor Domain[3] (motor skill outcomes including operating equipment, sports)

- *Perception*—use sense organs to obtain cues about motor activity [relate labels to need for special handling of dangerous materials]
- *Set*—readiness to take a particular action [explain steps required to operate a piece of lab equipment]
- *Guided response*—early stage of learning a performance skill including imitation and trial and error [consciously follow a prescribed instrument calibration procedure]
- *Mechanism*—later stage of learning a performance skill when it can be performed with proficiency [follow the same procedure smoothly and effortlessly]
- *Complex overt response*—skillful performance of a complex movement pattern [repair electronic equipment quickly and accurately]
- *Adaptation*—skills that are so well-developed that the individual can modify them to fit the situation [alter a routine procedure to adapt to a novel situation]
- *Origination*—creating new movement patterns based on highly developed skills [develop a procedure for building an experimental prototype]

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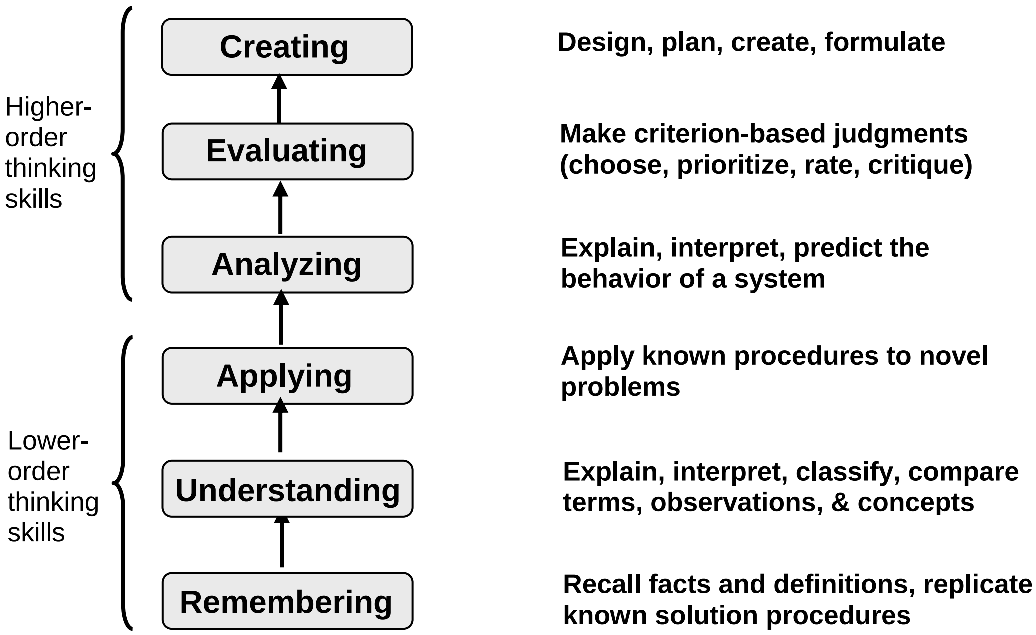
[1] Anderson, L. W. & Krathwohl, D. R. (Eds.). (2001) *A taxonomy for learning, teaching and assessing: A revision of Bloom's Taxonomy of educational objectives: Complete edition.* New York: Longman, pp. 67-68. Original reference: Bloom, B. S., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals by a committee of college and university examiners. Handbook 1. Cognitive domain.* New York: Addison-Wesley.

[2] Krathwohl, D.R., Bloom, B.S., Massia, B.B. (1984). *Taxonomy of educational objectives. Handbook 2. Affective domain.* New York: Addison-Wesley.

[3] Simpson, E. J. (1972). *The psychomotor domain. Vol. 3.* Washington: Gryphon House.

Bloom's Taxonomy of Learning Objectives: Cognitive Domain*



- Each skill involves the skills below it
- Usually, undergraduate education deals almost exclusively with Remembering, Understanding and Applying.
- Ideally, all Bloom levels should be addressed in every course (need not be sequential).

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* Levels revised by Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching and assessing: A revision of Bloom's Taxonomy of educational objectives: Complete edition.* New York: Longman, from levels originally developed by Bloom, B. S. and Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals by a committee of college and university examiners. Handbook 1. Cognitive domain.* New York: Addison-Wesley.

Illustrative Detailed Objectives

<u>Example 1</u>. By the end of Chapter 4 of the course text, you (or "the student") will…

Unacceptable: …**learn** how to design and conduct experiments.

Weak: …be able to **design** an experiment to measure *** and **analyze** the results

Good: …be able to

(a) **design** an experiment to measure *** as a function of *** (*Creating*) and **perform** an error analysis (*Applying or analyzing*)
(b) **explain** in terms a bright high school senior could understand the meaning of the results (*Understanding*).
(c) **rate** the applicability of different empirical correlations for *** vs. ***. (*Evaluating*)

<u>Example 2</u>. By the end of this course, you (or "the student") will…

Unacceptable: …**understand** the requirements of multidisciplinary teamwork.

Weak: …be able to **function** effectively on a multidisciplinary project team.

Good: ...be able to

(a) **function** effectively as a team member on a multidisciplinary project team, with effectiveness being determined by peer ratings and self-assessment (*Applying & affective*)
(b) **judge** the relative importance of the different disciplines in the project (*Evaluating*)

Reasons for writing objectives

- *Identify & classify course material*. Use objectives as a basis to
  - construct syllabus
  - plan lessons
  - identify and delete obsolete or extraneous course material
  - make sure all Bloom levels are being addressed
  - minimize time spent in class on low-level material. *Suggestion: If Level 1 material is important, put it on a study guide for exams but don't spend any time on it in class*. Reserve class time for things the students need a teacher for: writing definitions on a board to be copied and memorized doesn't qualify.
- *Make lectures, in-class activities, assignments, and exams coherent*. When objectives are used as the basis for designing all of them, it helps avoid the common disaster of teaching one thing and testing on something else. It also helps assure that adequate practice and feedback is provided on high-level skills before the skills are assessed.
- *Provide a study guide for students* (see next two pages). If you don't give your objectives to the students, the course becomes an exercise in guessing what you think is important for them to know. If you give all of your objectives to the students on Day 1, they will never look at them again. Giving them as study guides for tests helps assure that the students will pay attention to them, and maximizes the likelihood that the students capable of meeting the objectives will end up doing so.
- Tell faculty colleagues what they can expect students who pass this course to be able to do
  - teachers of follow-on courses, new instructors, adjunct instructors
  - curriculum planning committees
  - accreditation coordinators

Illustrative Study Guide*

In order to do well on the next test, you should be able to do the following:

1. Explain in your own words the terms *separation process, distillation, absorption, scrubbing, extraction, crystallization, adsorption*, and *leaching*. (What are they and how do they work?)
2. Sketch a phase diagram (P vs. T) for a single species and label the regions (solid, liquid, vapor, gas). Explain the difference between a vapor and a gas. Use the phase diagram to define (a) the vapor pressure at a specified temperature, (b) the boiling point at a specified pressure, (c) the normal boiling point, (d) the melting point at a specified pressure, (e) the sublimation point at a specified pressure, (f) the triple point, (h) the critical temperature and pressure. Explain how the melting and boiling point temperatures vary with pressure and how P and T vary with time (increase, decrease, or remain constant) as a specified path on the diagram is followed.
3. 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 for water.
4. Use data in the text to speculate on whether distillation and/or crystallization might be a reasonable separation process for a mixture of two given species. **List the additional information you would need to confirm your speculation.**
5. Distinguish between intensive and extensive variables, giving examples of each. Use the Gibbs phase rule to determine the number of degrees of freedom for a multicomponent multiphase system at equilibrium, and state the meaning of the value you calculate in terms of the system's intensive variables. Identify a feasible set of intensive variables to specify that will enable the remaining intensive variables to be calculated.
6. In the context of a system containing a single condensable species and other noncondensable gases, explain in your own words the terms *saturated vapor, superheated vapor, dew point, degrees of superheat*, and *relative saturation*. Explain the following statement from a weather report in terms a first-year engineering student could understand: "*The temperature is 75°F, barometric pressure is 29.87 inches of mercury and falling, the relative humidity is 50%, and the dew point is 54°F*."
7. Given an equilibrium gas-liquid system with a single condensable component (A) and liquid A present, a correlation for $p_A^*(T)$, 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.
8. Given a mixture of a single condensable vapor, A, and one or more noncondensable gases, a correlation for $p_A^*(T)$, and any two of the variables y_A (mole fraction of A), temperature, total pressure, dew point, degrees of superheat, and relative, molal, absolute, and percentage saturation (or humidity), use Raoult's law for a single condensable species to calculate the remaining variables.
9. 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. **Make up and solve your own problem involving such a system.**
10. **After completing your analysis of a vapor-liquid phase change process, identify as many possible reasons as you can for discrepancies between what you calculated and what would be measured in a real process. Include any assumptions made in the calculation.**
11. Explain the meaning of the term "ideal solution behavior" in the context of a liquid mixture of several volatile species. Write and clearly explain the formulas for Raoult's law and Henry's law, state the conditions for which each correlation is most likely to be accurate, and apply each one to determine

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* Higher-level objectives in boldface.

any of the variables *T*, *P*, x_A, or y_A (temperature, pressure, and mole fractions of A in the liquid and gas phases) from given values of the other three. *Make up and solve your own problem involving such a system*.

12. Explain in your own words the terms *bubble point*, *boiling point*, and *dew point* of a mixture of condensable species, and the difference between vaporization and boiling. Use Raoult's law to determine (a) the bubble point temperature (or pressure) of a liquid mixture of known composition at a specified pressure (or temperature), and the composition of the first bubble that forms, (b) the dew point temperature (or pressure) of a vapor mixture of known composition at a specified pressure (or temperature), and the composition of the first liquid drop that forms, (c) whether a mixture of known amount (moles) and composition (component mole fractions) at a given temperature and pressure is a liquid, a gas, or a gas-liquid mixture, and if the latter, the amounts and compositions of each phase, (d) the boiling point temperature of liquid mixture of known composition at a specified total pressure.
13. Use a *Txy* or *Pxy* diagram to determine bubble and dew point temperatures and pressures, compositions and relative amounts of each phase in a two-phase mixture, and the effects of varying temperature and pressure on bubble points, dew points, and phase amounts and compositions. Outline how the diagrams are constructed for mixtures of components that obey Raoult's law. Construct a diagram using a spreadsheet.
14. For a process system that involves liquid and gas streams in equilibrium and vapor-liquid equilibrium relations for distributed components, draw and label the flowchart, carry out the degree-of-freedom analysis, and perform the required calculations. **Make up and solve your own problem involving such a system.**
15. Explain in your own words the terms *solubility of a solid in a liquid*, *saturated solution*, and *hydrated salt*. Given solubility data, determine the saturation temperature of a feed solution of given composition and the quantity of solid crystals that precipitate if the solution is cooled to a specified temperature below the saturation point. Perform material and energy balance calculations on a crystallizer, and identify sources of error in your calculation.
16. Given a liquid solution of a nonvolatile solute, estimate the solvent vapor pressure lowering, the boiling point elevation, and the freezing point depression, and list the assumptions required for your estimate to be accurate. Give several practical applications of these phenomena. Identify sources of error in your calculation.
17. **Given the description of a familiar phenomenon involving more than one phase, explain it in terms of concepts discussed in this chapter. Given an explanation of such a phenomenon, evaluate its scientific soundness.**

Choosing a Text

General

- How well does the text match your course syllabus?
- Pick a couple of topics you don't know cold, and read the text on them. Is it clear to you? Would it be clear to the students? The average ones?
- Are there lots of visuals—pictures, schematics, charts, plots?
- Are "real-life" examples or applications included?
- Are there self-tests or chapter-end questions to help students with studying?
- What support materials are available to you and/or the students? Instructor's manual? Masters for transparencies? A test bank? Software? CD-ROM? What is the quality of the support material?
- How much would the text cost the students? If the cost is out of line, can quantity discounts be obtained?

Technical

- Are all major points, methods, etc., illustrated by clear worked-out examples?
- How are the text problems—mostly simple drills, long and difficult skullcrackers, or a graded blend?
- Are there enough problems for you to vary the assignments from term to term?
- Does the text deal with real processes and systems or purely hypothetical ones?

Course Syllabus

What <u>should</u> be included?

- Course number, course name, semester
- Instructor's name, office number, office hours
- Teaching assistants' names offices, office hours
- Prerequisites, departmental restrictions
- Required text
- Policies and procedures for assignments and grading
- **Note:** Be sure to check for university syllabus requirements on B-9.

What <u>may</u> be included?

- Course description
- Topical outline or concept map
- Course-level learning objectives *(recommended!)*
- Dates for tests *(recommended!)*, drop date
- Assignment schedule
- Supplementary references

<u>Sample Syllabus</u>

NCSU Department of Chemical Engineering
CHE 205: Chemical Process Principles

Instructor (Section 1): Dr. Lisa G. Bullard (*lisa_bullard@ncsu.edu*), 2012 EB1, (919)515-7455
Office Hours: M 1:30 – 3PM, T 10 – 11:30AM

Instructor (Section 2): Dr. Richard Felder (*rmfelder@mindspring.com*), 2088D EB1, (919)515-2327
Office Hours: T H, 2:30 – 4PM

Teaching Assistants: ...
Graders: ...

Course Text: R.M Felder and R.W. Rousseau, <u>*Elementary Principles of Chemical Processes*</u>, 2005 Edition with Integrated Study and Media Tools, Wiley (2005). *You will need the workbook that comes with the new edition.*

Course prerequisites: C– or better in MA 241, PY 205, and CH 201 or the transfer equivalent. This requirement is strictly enforced. If you have questions, see one of your instructors.

Course purpose: CHE 205 prepares you to formulate and solve material and energy balances on chemical process systems and lays the foundation for subsequent courses in thermodynamics, unit operations, kinetics, and process dynamics and control. More fundamentally, it introduces the engineering approach to problem solving: breaking a process down into its components, establishing the relations between known and unknown process variables, assembling the information needed to solve for the unknowns, and finally obtaining the solution using appropriate computational methods.

Course Objectives: By the end of the course, you should be able to do the following things:

- **Basic engineering calculations.** Convert quantities from one set of units to another quickly and accurately; define, calculate, and estimate properties of process materials including fluid density, flow rate, chemical composition variables (mass and mole fractions, concentrations), fluid pressure, and temperature.
- **Material and energy balance calculations**. Draw and label process flowcharts from verbal process descriptions; carry out degree-of-freedom analyses; write and solve material and energy balance equations for single-unit and multiple-unit processes, processes with recycle and bypass, and reactive processes.
- **Applied physical chemistry**. Perform pressure-volume-temperature calculations for ideal and non-ideal gases. Perform vapor-liquid equilibrium calculations for systems containing one condensable component and for ideal multi-component solutions. Calculate internal energy and enthalpy changes for process fluids undergoing specified changes in temperature, pressure, phase, and chemical composition. Incorporate the results of these calculations into process material and energy calculations.
- **Computation**. Use spreadsheets (EXCEL) and an equation-solving program (EZ-Solve) to solve material and energy balance problems.
- **Teamwork**. Work effectively in problem-solving teams and carry out meaningful performance assessments of individual team members

CHE 205: Chemical Process Principles
POLICIES AND PROCEDURES

- **Academic integrity.** Students should refer to the University policy on academic integrity found in the Code of Student Conduct (found in <u>Appendix L</u> *of the Handbook for Advising and Teaching*). It is the instructor's understanding and expectation that the student's signature on any test or assignment means that the student contributed to the assignment in question (if a group assignment) and that they neither gave nor received unauthorized aid (if an individual assignment). Authorized aid on an individual assignment includes discussing the interpretation of the problem statement, sharing ideas or approaches for solving the problem, and explaining concepts involved in the problem. Any other aid would be unauthorized and a violation of the academic integrity policy. This includes referring to homework from previous semesters. (Note that the instructors will provide all students with sample exams from previous years). Any computer work submitted must be completed on your own personal computer or from your own NCSU account to avoid confusion about the origin of the file, and no sharing of files in any way is allowed. All cases of academic misconduct will be submitted to the Office of Student Conduct. If you are found guilty of academic misconduct in the course, you will be on academic integrity probation for the remainder of your years at NCSU and may be required to report your violation on future professional school applications. It's not worth it!
- **Homework.** Students will submit homework individually for the first few assignments. Early in the semester, the instructors will designate teams of 3-4 individuals, and all subsequent assignments should be submitted by those teams unless otherwise specified. The assignment schedule will be posted on the course web site.
- **Homework format**. Use green (Bullard section) or yellow (Felder section) engineering paper (available in the Student Supply Store), one side of each page (clear side, not grid side); begin each problem on a new page; and box all final answers. Each completed assignment should be in one person's handwriting (the recorder's for group assignments). The problems should be submitted in the same order as in the homework assignment. Staple the pages and fold them vertically with the fold on the left hand side when you hand them in. Put your name and problem set number (individual assignments) or the names and roles (coordinator, recorder, checker, and monitor) of the *participating* team members (team assignment), and the problem set number on the outside. The problem numbers should be written vertically on the opposite side as your name. *If a student's name appears on a solution set, it certifies that he/she has participated in solving the problems.* In order to encourage you to follow the instructions given above, standard point deductions will be assigned for not stapling, no name, etc. (refer to the course web site for specifics).
- **Late homework**. Completed assignments should be turned in at the beginning of the class period. You may choose to turn in the homework in early in the CHE 205 homework box in the CHE student lounge. If it's your job to turn in the homework and you're late, so is the homework. Late assignments will receive a point deduction of -20. Late solution sets will be accepted up to 8:15AM on the Monday after the due date, turned in to Dr. Bullard's mailbox in 2009 EB1, which is inside the main office suite (2001 EB1). *However, once an individual or a group hands in two late assignments, they will no longer be accepted.*
- **Posted solutions.** *Complete problem set solutions will not be posted, but the final numerical solution to each problem will be posted on Dr. Bullard's bulletin board.* It is your responsibility to make sure you find out how to solve the problems by asking about them in class, during office hours, or in the problem session after they have been handed in.
- **Individual effort assessments for team homework**. Teams will periodically be asked to submit individual effort assessments with completed assignments. These assessments will be incorporated into the assignment of homework grades. *If repeated efforts to improve team functioning (including faculty intervention) fail, a non-participant may be fired by unanimous consent of the rest of the team, and a team member doing essentially all the work may quit.* (Details of the required procedures are given in the handout on team policies and expectations.) Individuals who quit or are fired must find a team unanimously willing to accept them; otherwise they will receive zeros for the remainder of the homework.
- **Exams**. There will be three exams during the semester and a comprehensive final exam. *All tests will be open-book, closed-notes.* The lowest test grade will count half as much as each of the other two. Tests will be given as a common exam on scheduled Fridays from 3-5PM (see detailed course schedule for dates and locations). Students who are unable to take the test at those times (with a documented excuse—not just that you don't want to) will schedule an alternate time to take the exam.
- **Test and homework grading**. If you believe that an error was made in grading the homework, you should write a short justification of your claim and attach it to the original homework assignment in question. Put the justification

and homework paper (stapled together) in Dr. Bullard's mailbox in 2009 EB1 or in the red homework box. Put the name(s) of the TA(s) who graded the problem(s) in question as well as your contact email. The TA or one of the instructors will review your concern and respond to you directly. The "statute of limitations" for submitting such claims is one week after the homework is returned.

- **Missed tests**. If you miss a test without either a certified medical excuse or prior instructor approval, you will take a makeup test at a designated time during the last week of the semester. The makeup exam will be fair but comprehensive (covering all the course material) and challenging. Tests missed with certified medical excuses or prior instructor approval will be dealt with individually. Only one missed test can be made up. *Note: if you show up to take the test, you must take the grade – you cannot decide mid-way through to walk out and take the makeup exam.*
- **Problem session.** *All 205 students must be registered for one of the weekly problem sessions* (205P). Several computer applications will be taught during the problem sessions. 10% of your grade is based on problem session quizzes and in-class exercises. Attendance is expected and is included as part of your problem session grade. You should not float between problem sessions; stay in the one in which you are registered. However, if it is necessary to miss a problem session, you may attend another session that week to make up the time as long as you notify the TA of the problem session you attend so that your attendance can be recorded.
- **Attendance.** Students who miss class due to an excused absence should work with the instructor or problem session TA to make up any missed work or tests. Documented medical excuses should be presented to the instructor. For a full statement of the university attendance policy see
  <w*ww.ncsu.edu/provost/academic_regulations/attend/reg.htm*>.
  Examples of <u>anticipated</u> situations where a student would qualify for an excused absence are:
  a. The student is away from campus representing an official university function, e.g., participating in a professional meeting, as part of a judging team, or athletic team. These students would typically be accompanied by a University faculty or staff member.
  b. Required court attendance as certified by the Clerk of Court.
  c. Religious observances as verified by Parents & Constituent Services (515-2441). For more information about a variety of religious observances, visit the <u>Diversity Calendar</u>.
  d. Required military duty as certified by the student's commanding officer
- **Calculation of course grade.** A weighted average grade will be calculated as follows:
  - Exams (3) = 40%
  - Final examination = 30%
  - Homework = 20%
  - Problem session quizzes and in-class exercises = 10%.

  The lowest exam grade counts half as much as the other two (lowest exam counts 8%, other two count 16%). ***The homework grades will only count if the average grade on class exams and the final exam is 60 or above—in other words, if you can't pass the individual tests, then you can't pass the course.***

  The course grades will be determined as follows:

Score	>97	93 – 96.9	90 – 92.9	87 – 89.9	83 – 86.9	80 – 82.9	77 – 79.9	73 – 76.9	70 – 72.9	67 – 69.9	63 – 66.9	60 – 62.9	< 60
Grade	A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F

Note: We do not curve grades in this course. It is theoretically possible for everyone in the class to get an A (or an F). Your performance depends only on how you do, not on how everyone else in the class does. It is therefore in your best interests to help your classmates, while acting within the bounds of the stated academic integrity policy.

- **Instructors' commitment**. You can expect your instructors to be courteous, punctual, well-organized, and prepared for lecture and other class activities; to answer questions clearly; to be available during office hours or to notify you beforehand if they are unable to keep them; to provide a suitable guest lecturer when they are traveling; and to grade uniformly and consistently according to the posted guidelines.
- **Consulting with faculty**. We strongly encourage you to discuss academic or personal questions with either of the CHE 205 course instructors during their office hours or by email.

- **Students with disabilities.** North Carolina State is subject to the Department of Health, Education, and Welfare regulations implementing Section 504 of the Rehabilitation Act of 1973. Section 504 provides that: "No otherwise qualified handicapped individual in the United States. . . shall, solely by reason of his handicap be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." This regulation includes students with hearing, visual, motor, or learning disabilities and states that colleges and universities must make "reasonable adjustments" to ensure that academic requirements are not discriminatory. Modifications may require rescheduling classes from inaccessible to accessible buildings, providing access to auxiliary aids such as tape recorders, special lab equipment, or other services such as readers, note takers, or interpreters. It further requires that exams actually evaluate students' progress and achievement rather than reflect their impaired skills. This may require oral or taped tests, readers, scribes, separate testing rooms, or extension of time limits.

What to Do During the First Week[1]

Note: Select one or more of these activities in each category—don't attempt to do them all.

Introduce yourself

- *Introduce yourself & talk briefly about your background, experience, and interests.* The better the students get to know you and vice versa, the better the class will work.

Establish expectations (yours and the students')

- Summarize your expectations of the students and what they can expect from you.
- Hand out the syllabus. Review critical rules and procedures likely to be unfamiliar to the students (e.g., rules for groupwork).
- Have students in pairs read through the syllabus and raise questions.
- Distribute advice collected from students at the end of the previous offering of the same course.
- Have students write their goals for the semester.
- Have students anonymously hand in rumors they've heard about the course or about you. Next class period, address them.

Establish student-instructor and student-student communication mechanisms

- *Learn the students' names.* Use a seating chart and quiz yourself during exercises and tests, or take and label digital photos or photocopy their ID's and study them after class**.** This may be the single most effective way to motivate them to learn.
- Set up a class e-mail alias or list server or chat room or Web site. Require their use at least once or twice.
- In very large classes, designate student representatives to collect and relay feedback from constituent student groups.

Find out what students know and want to know

- Have students list (1) things they know about the course content, and (2) questions they have about it.
- Schedule a test on course prerequisites sometime in the next 1–2 weeks; hand out a summary of key learning objectives covering the prerequisites to be used as a study guide; hold an optional review session, and give the test. Count it toward the final grade. (This is an alternative to spending weeks re-teaching things they should have learned before taking your course.)

Motivate the students' interest in the course.

- Show a graphic organizer for the course.
- Do a demonstration. Get the students to predict the outcome first.
- Survey (or get students to brainstorm) real-world applications of the course topics.
- Show photos & videos of real-world connections to course material (experiments, maps, geological faults, wind turbines, bridges collapsing, equipment burning or exploding, roads buckling, period plays, conversations in foreign languages, current news stories about economics, geopolitics, epidemics, infrastructure breakdowns,….)
- Use the integrated inquiry-based learning strategy described in the middle of page B16.

[1] Brent, R., & Felder, R. M. (1999). It's a start. *College Teaching, 47* (1), 14–17, <*www.ncsu.edu/felder-public/Papers/Getting_started.html*>.

HOW TO PREPARE NEW COURSES WHILE KEEPING YOUR SANITY*

Richard M. Felder
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Rebecca Brent
Education Designs, Inc.

Think of a two-word phrase for a huge time sink that can effectively keep faculty members from doing the things they want to do.

You can probably come up with several phrases that fit. “Proposal deadline” is an obvious one, as are “curriculum revision,” “safety inspection,” “accreditation visit,” and “No Parking.” (The last one is on the sign posted by the one open space you find on campus minutes before you’re supposed to teach a class, with the small print that says “Reserved for the Deputy Associate Vice Provost for Dry Erase Marker Procurement.”)

But the phrase we have in mind is “new prep”—preparing for and teaching a course you’ve never taught before. This column describes the usual approach, which makes this challenging task almost completely unmanageable, and then proposes a better alternative.

Three steps to disaster, or, how not to approach a new course preparation

1. *Go it alone.* Colleagues may have taught the course in the past and done it very well, but it would be embarrassing to ask them if you can use their materials (syllabi, learning objectives, lecture notes, demonstrations, assignments, tests, etc.), so instead create everything yourself from scratch.

2. *Try to cover everything known about the subject in your lectures and always be prepared to answer any question any student might ever ask.* Assemble all the books and research articles you can find and make your lecture notes a self-contained encyclopedia on the subject.

3. *Don’t bother making up learning objectives or a detailed syllabus—just work things out as you go.* It’s all you can do to stay ahead of the class in your lectures, so just throw together a syllabus that contains only the course name and textbook, your name and office hours, and the catalog description of the course; invent course policies and procedures on a day-by-day basis; and decide what your learning objectives are when you make up the exams.

Here’s what’s likely to happen if you adopt this plan. You’ll spend an outlandish amount of time on the course—ten hours or more of preparation for every lecture hour. You’ll start neglecting your research and your personal life just to keep up with the course preparation, and if you’re unfortunate enough to have two new preps at once, you may no longer have a personal life to neglect. Your lecture notes will be so long and dense that to cover them you’ll have to lecture at a pace no normal human being could possibly follow; you’ll have no time for interactivity in class; and you’ll end up skimming some important material or skipping it altogether. Your policies regarding late homework, absences, missed tests, grading, and cheating will be fuzzy and

* *Chem. Engr. Education, 41*(2), 121–122 (Spring 2007).

inconsistent. Without learning objectives to guide the preparation, the course will be incoherent, with lectures covering one body of material, assignments another, and tests yet another. The students' frustration and complaints will mount, and the final course evaluations will look like nothing you'd want to post on your blog.

There's a better way.

A rational approach to new course preparation.

1. *Start preparing as soon as you know you'll be teaching a particular course*.

Dedicate a paper file folder and a folder on your computer to the course and begin to assemble ideas and instructional materials. While you're teaching the course, continue to file ideas and resources as you come up with them.

2. *Don't reinvent the wheel.*

Identify a colleague who is a good teacher and has taught the course you're preparing to teach, and ask if he/she would be willing to share course materials with you. (Most faculty members would be fine with that request.) In addition, try finding the course on the MIT OpenCourseWare Web site (*<http://ocw.mit.edu>)* and download materials from there. Open courseware may contain visuals, simulations, class activities, and assignments that can add considerably to the quality of a course and would take you months or years to construct from scratch. The first time you teach the course, borrow liberally from the shared materials and note after each class what you want to change in future offerings. Also consider asking TA's to come up with good instructional materials and/or inviting students to do it for extra credit.

3. *Write detailed learning objectives, give them to the students as study guides, and let the objectives guide the construction of lesson plans, assignments, and tests.*

Learning objectives are statements of observable tasks that students should be able to accomplish if they have learned what the instructor wanted them to learn. Felder and Brent recommend giving objectives to students as study guides for tests[2,3] and show an illustrative study guide for a midterm exam.[4]

Before you start to prepare a section of a course that will be covered on a test, draft a study guide and use it to design lessons (lectures and in-class activities[5]) and assignments that provide instruction and practice in the tasks specified in the objectives. As you get new ideas for things you want to teach, add them to the study guide. One to two weeks before the test, finalize the guide and give it to the students, and then draw on it to design the test. The course will then be coherent, with

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[2]R.M. Felder and R. Brent, "Objectively speaking," *Chem. Engr. Education, 31*(3), 178–179 (1997), <*http://www.ncsu.edu/felder-public/Columns/Objectives.html*>.
[3]R.M. Felder and R. Brent, "How to teach (almost) anyone (almost) anything," *Chem. Engr. Education*, *40*(3), 173–174 (2006), <*http://www.ncsu.edu/felder-public/Columns/TeachAnything.pdf*>.
[4]R.M. Felder, Study guide for a midterm exam in the stoichiometry course, <*http://www.ncsu.edu/felder-public/cbe205site/studyguides/studyguide2.htm*>.
[5]R.M. Felder and R. Brent, "Learning by doing," *Chem. Engr. Education, 37*(4), 282–283 (2003), <*http://www.ncsu.edu/felder-public/Columns/Active.pdf*>.

mutually compatible lessons, assignments, and assessments. Instead of having to guess what you think is important, the students will clearly understand your expectations, and those with the ability to complete the tasks specified in the objectives will be much more likely to do so on the test. In other words, more of your students will have learned what you wanted them to learn. The objectives will also help you avoid trying to cram everything known about the subject into your lecture notes. If you can't think of anything students might do with content besides memorize and repeat it, consider either dropping that content or cutting down on it in lectures, giving yourself more time to spend on higher-level material.

4. *Get feedback during the course.*

It's always a good idea to monitor how things are going in a class so you can make mid-course corrections, particularly when the course is new. Every so often collect "minute papers," in which the students anonymously hand in brief statements of what they consider to be the main points and muddiest points of the class they just sat through. In addition, have them complete a survey four or five weeks into the semester in which they list the things you're doing that are helping their learning and the things that are hindering it. Look for patterns in the responses to these assessments and make adjustments you consider appropriate, or make a note to do so next time you teach the course.

5. *Do everything you can to minimize new preps early in your career, and especially try to avoid having to deal with several of them at a time.*

Some department heads inconsiderately burden their newest faculty members with one new prep after another. If you find yourself in this position, politely ask your head to consider letting you teach the same course several times before you move on to a new one so that you have adequate time to work on your research. Most department heads want their new faculty to start turning out proposals and papers in their first few years and will be sympathetic to such requests. It might not work, but as Rich's grandmother said when told that chicken soup doesn't cure cancer, it couldn't hurt.

Additional Resources on Course Design & Developing High-Level Skills

Course design

- Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching and assessing: A revision of Bloom's Taxonomy of Educational Objectives: Complete edition.* New York: Longman.
- Brent, R., & Felder, R. M. (1999). It's a start. *College Teaching, 47* (1), 14–17. Ideas for starting a course effectively. <*http://www.ncsu.edu/felder-public/Papers/Getting_started.html*>
- Felder, R.M., & Brent, R. (2003). "Designing and Teaching Courses to Satisfy the ABET Engineering Criteria," *J. Engr. Education, 92*(1), 7–25.
  <*http://www.ncsu.edu/felder-public/Papers/ABET_Paper_(JEE).pdf*>
- Felder, R. M. & Brent, R. (1997). Objectively speaking. *Chemical Engineering Education, 31* (3), 178–179. <*http://www.ncsu.edu/felder-public/Columns/Objectives.html*>
- Fink, L.D. (2003). *Creating significant learning experiences.* San Francisco: Jossey-Bass. An integrated approach to developing learning experiences for students. Check out Chapter 2 (pp. 27-59) for an alternative to Bloom's Taxonomy that includes foundational knowledge, application, integration, the human dimension, caring, and learning how to learn. Chapter 3 (pp. 60-101) has a detailed approach to course design.
- Forehand, M. (2005). Bloom's Taxonomy: Original and revised. In M. Orey (Ed.). *Emerging perspectives on learning, teaching, and technology*. <*http://www.coe.uga.edu/epltt/bloom.htm*>
- Gronlund, N.E. (2000). *How to write and use instructional objectives* (6th ed.). Upper Saddle River, NJ: Prentice-Hall.
- Mager, R.F. (1997). *Preparing instructional objectives* (3rd ed.). Atlanta: Center for Effective Performance.
- Stice, J. E. (1976). A first step toward improved teaching. *Engineering Education, 66*(5), 394-398. A classic paper that introduced learning objectives (then called instructional objectives) into the engineering education literature.

Developing higher level thinking skills:

- Brent, R., & Felder R. M. (1992). Writing assignments—Pathways to connections, clarity, creativity. *College Teaching, 40* (2), 43-47. Practical suggestions for getting students to take a deeper approach to their learning through "writing to learn" within courses in the disciplines. <*http://www.ncsu.edu/felder-public/Papers/Writing_Paper.pdf*>
- Felder, R. M. (1990). Meet your students: Michelle, Rob, and Art. *Chemical Engineering Education, 24* (3), 130-131. A short column about different approaches to learning and ways to motivate students. <*http://www.ncsu.edu/felder-public/Columns/Michelle.html*>
- Felder, R. M. (1987). On creating creative engineers. *Engineering Education, 77*(4), 222 (1987). Ideas for developing creativity and higher level thinking skills in students.
  <*http://www.ncsu.edu/felder-public/Papers/Creative_Engineers.pdf*>

B. How can I be an effective lecturer and get students actively involved in class?

Lecturing Tips

Preparing for the lecture

- *Decide on a reasonable amount of time to prepare for a lecture and stick to it.* Often faculty find they are spending all their time preparing for teaching, leaving no time for research and writing. Two hours of preparation for a one hour lecture is a good target—you won't always make it, but if you find yourself spending six or seven hours you're going overboard.
- *Organize your lecture around your learning objective(s).* When you identify what you want students to be able to do as the result of the lecture, you can select the important content and activities to lead to that result.
- *Preview lecture content and learning objectives.* Overview what is to come by telling students what they will learn (e.g. "By the end of the period today, you should be able to....") Some instructors write the objective for the day on the board and refer to it at the beginning and end of the lecture.
- *Write clear detailed notes for yourself.* Especially when first teaching a class, write out key ideas, example problem solutions, and specific applications so that you don't leave out important things or get confused while in front of the class. Include questions you want to ask, directions for activities and points where you expect to take a break.
- *Prepare lots of visuals: graphic organizers (like the one for this notebook), charts, graphs, flowcharts, cartoons.* Find visual images for any topic by searching on *Google Images* or in the databases on p. *vi* of this notebook.
- *Plan demonstrations whenever possible.* Real demonstrations in class are ideal, but don't overlook videotapes, CD-ROMs, and the Internet for valuable demonstrations.
- ***Use technology wisely.*** Interactive tutorials, multimedia presentations, hands-on simulations, concept tests with clickers, and anything else that gets the student involved in the learning experience can greatly enhance learning. On the other hand, *don't turn your lectures into PowerPoint shows* (see "Death by PowerPoint" on p. B22).
- *If it isn't written down, it will be ignored.* Plan what you will write on the board or on a transparency with an eye toward what you want students to have in their notes.
- ***Give out handouts with gaps**.*[*] Turn some or all of your lecture notes into handouts that the students bring to class, leaving gaps for students to fill in, and sprinkle the handouts with questions. Tell students that some of the missing material and questions will be included on tests, then do it. Let students read through straightforward material by themselves during the lecture, and when you come to a gap, either lecture on it, use it as the basis for an in-class activity, or leave it as an exercise for the students to do after class. After you've taught a class a few times, consider putting the handouts into a course pack that student purchase as a supplement to—or replacement for—the text. Excerpts from two course packs are shown on pp. B3 and B4.

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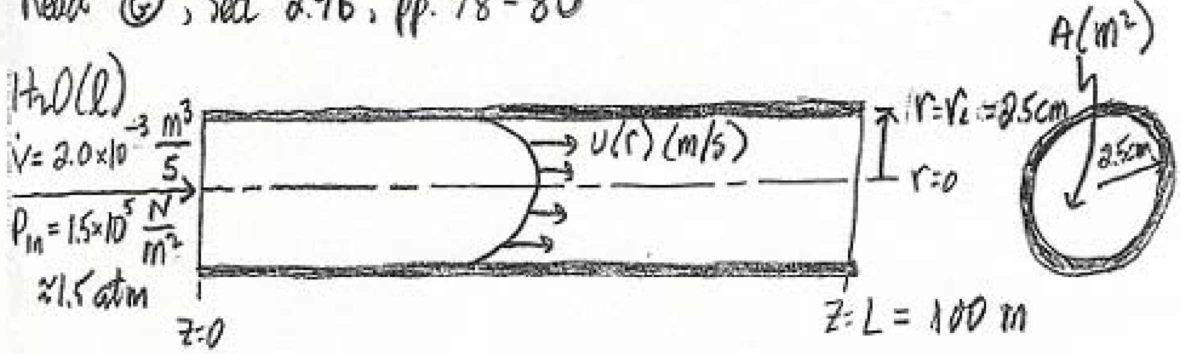
[*] T.L. Cornelius and J. Owen-DeSchryver ["Differential effects of full and partial notes on learning outcomes and attendance," *Teaching of Psychology, 35*(1), 6–12 (2008)] carried out research showing that relative to students who received complete lecture notes, students who only got partial notes got higher exam grades, higher course grades, and higher marks on conceptual questions that required mastery of material beyond definitions.

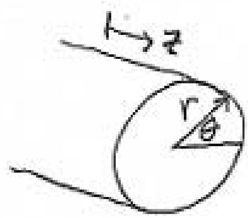
Course Pack Excerpt (RMF)

Steady-state Laminar flow of an incompressible Newtonian fluid in a horizontal circular pipe

Read ⓒ, Sect 2.9B, pp. 78-80



Water enters a 5-cm ID (inner diameter) × 10 m long pipe at a rate $2.0\times10^{-3}\ m^3/s$ and a pressure $P = 1.5\times10^5\ N/m^2$ (150 kPa, ≈1.5 atm). Our goal is to find out as much as we can about relations among system variables at steady-state



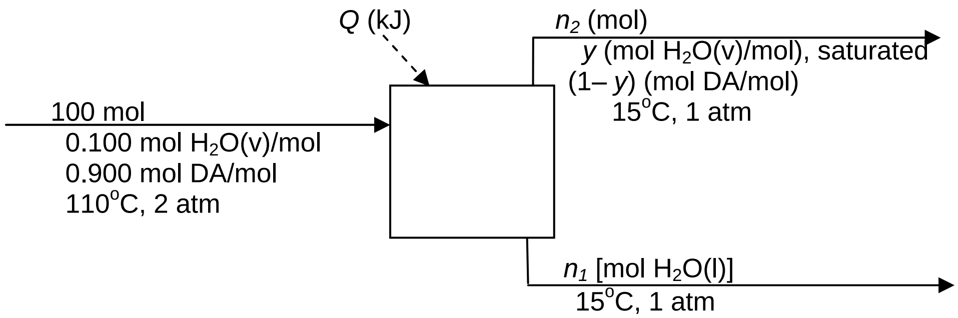
- $\dot{V}(z)$ (m^3/s) — volumetric flow rate
- $u(r,z)$ — local velocity profile
- $P(r,z,\theta)$ — local fluid pressure

- Calculate the mass flow rate, $\dot{m}$(kg/s), at the inlet.

- Does $\dot{m}$ vary with z? Explain.

- Does $\dot{V}$ vary with z? Explain.

Example: Continuous air conditioning process. Take basis of 100 mol feed. (Note: We'll label amounts instead of flow rates because of the basis, but we still need to use the open system balance equation.)



Calculate Q.

Question: What sign should the value of Q have?

Solution: Assume enthalpies are independent of pressure.

(a) DOF Analysis: unknowns:

equations:
1 energy balance

(b) Write all equations but energy balance. Circle unknowns for which you would solve.

(c) Choose references and prepare an inlet-outlet enthalpy table.

References: H_2O(l, 80°C, 1 atm), DA(g, 25°C, 1 atm) (*Why?*)

Species	n_{in}	$\hat{H}_{in}$	n_{out}	$\hat{H}_{out}$	
$H_2O(l)$	—	—	n_1	$\hat{H}_c$	n(mol)
$H_2O(v)$	10	$\hat{H}_a$	$n_2 y$	$\hat{H}_d$	$\hat{H}$(kJ/mol)
DA	90	$\hat{H}_b$	$n_2(1-y)$	$\hat{H}_e$	

(d) Write and simplify the energy balance equation, substituting values and labeled variables from the enthalpy table.

$$Q - W_s = \Delta H + \Delta E_k + \Delta E_p \Rightarrow$$

During the lecture

- *Come to the classroom a little before class begins to talk informally with students.* This technique sends a positive message to students that you are interested in them, allows you to answer questions for students who might not come to your office, and may reduce your nervousness before class.
- *Learn the students' names and use them.* (1) If you have trouble learning names or if you have very large classes, try preparing a seating chart. Use it when calling on students and quiz yourself while students are taking tests, working on an assignment or discussing in small groups. (2) Ask students to bring you a small photo or take instant photos. Label them and use to match names and faces. (3) Ask students to photocopy their ID cards or driver's licenses and use them to learn names. (4) Use 4" x 8" index cards folded lengthwise as tent-type name cards.
- *Make eye contact with students.* Don't read notes or talk to the board. Consciously think about scanning the room as you talk; it will help you see if students are confused, bored, or restless.
- *Make effective use of the board or overhead.* Be sure you are writing legibly and large enough for students at the back to see (To find out, ask them!). Don't write with the left hand and erase with the right. Use different colors for chalk or transparency pens to highlight key ideas. Erase extraneous material to reduce distraction—but not before checking to be sure students have the material in their notes. Label charts and graphs so students will have clear information in their notes.
- *Cue students on important points.* When you say something you think students should note, draw attention to it by using phrases like, "This is a key point" or "Be sure to get this in your notes."
- *Don't be afraid to pause periodically*. Pausing after presenting key content allows students to get material into their notes and to reflect on the information. Pausing after asking a higher level question will give everyone a chance to think about the answer before taking responses. Research indicates that this type of pause increases the number and quality of student responses.
- *Ask questions periodically, not just, "Is that clear?" or "Do you have any questions?"* (Check out "Any Questions?" in this section of the notebook for more ideas on formulating questions.)
  - — What should the solution look like?
  - — What do you think happens next?
  - — What have we assumed in writing this formula?
  - — Suppose I follow this procedure, and the product yield is 25% low. What could be responsible? How can I find out? How can I correct the problem? How could I have avoided it?
  - — What are possible safety problems here? Environmental problems? Ethical problems?
- *Avoid calling on individual students cold (with no time to think of a response) for answers—many find it intimidating. Do* call on individuals (1) to report on small group exercise results or (2) after the whole class has had time to formulate a response.
- *Have students individually write responses to questions in class.* Writing is a valuable tool for students to organize material, brainstorm ideas, or work out a problem. After a few moments to reflect on a question, many more students will be ready to respond.
- *Respond with respect to student comments, questions, and answers.* Even if a student response is wrong, a respectful response helps to foster a better atmosphere for discussion.
- *Don't bluff in response to student questions.* It's acceptable to tell you students you aren't sure of the answer to a question. Tell them you'll check it out and then let them know what you found. (Then do it!)
- *Summarize occasionally during the lecture and always at the end…or get students to do it.*
- *Remember the colleague who will follow you in the classroom.* End on time. Erase the board. Have students return chairs to their original positions if you've rearranged them.

Improving your lecture effectiveness

- *Have students complete a midterm course evaluation.* A few weeks into the course, ask students to respond anonymously to at least two prompts: "What features of this course and its instruction are helping you learn?" "What features of the course and instruction are hindering your learning?" (You might also include a request for comments on a specific feature of the course, such as in-class activities, and requests for the students to list things *they* might do to improve their performance.) Reading the lists will give you a better idea of how the class is going, and you may find some items you can adjust to improve things. In any case, the midterm evaluation will give you student feedback while you still have a chance to improve.
- ***Visit other classes***. It's amazing what you can learn by watching your colleagues teach. Find out who the best teachers are in your department or school and ask to sit in on a lecture or two. Then arrange to meet with them over lunch or a cup of coffee and get more ideas.
- *Find a colleague or two who also want to work on their teaching.* Agree to visit one another's classes and provide feedback. Get together periodically to talk about how your classes are going.
- *Read about teaching.* The paper and electronic reference lists in this notebook offer good places to start learning about teaching. Check out publications (*College Teaching, J. Coll. Sci. Teaching, J. Engr. Education, J. Chem. Education, The Physics Teacher,,...*), conferences and web sites for relevant professional organizations. Look back through this notebook for ideas or articles that interest you.
- *Videotape yourself teaching.* By viewing a recording of your teaching, you'll see yourself the way students see you. After you get over the shock (especially if you've never seen yourself on tape before), you'll start to see good things you're doing and points that need improvement. Some university teaching centers will set up a camera and will even sit down with you to analyze your performance. If you'd rather do it privately, it's a relatively easy matter to set up the camera in one corner of the room and let it run.
- *Work with university teaching center personnel (if available) to improve your teaching.* Many campuses now have centers devoted to helping faculty improve their teaching. Knowledgeable colleagues will talk with you about your goals, observe your class or a videotape, and give concrete suggestions that can make a big difference in your success in the classroom. They can also help you analyze student feedback in course evaluations that will lead to positive teaching improvements.
- *Use active learning (*p. B10 – B18).

Chem. Engr. Education, 28(3), 174-175 (1994).

ANY QUESTIONS?

Richard M. Felder

Most questions asked in engineering classes follow one of two models:

1. *"If a first-order reaction* A→B *with specific reaction rate* 3.76 (min^{-1}) *takes place in an ideal continuous stirred-tank reactor, what volume is required to achieve a 75.0% reactant conversion at steady state if the throughput rate is 286 liters/s?*"
2. *"Do you have any questions?"*

While these may be important questions to ask, they don't exactly stimulate deep thought. "What's the volume?" has only one possible correct answer, obtained by mechanically substituting values into a formula. "Do you have any questions?" is even less productive: the leaden silence that usually follows makes it clear that the answer for most students is always "No," whether or not they understand the material.

Questions lie at the heart of the learning process. A good question raised during class or on a homework assignment can provoke curiosity, stimulate thought, illustrate the true meaning of lecture material, and trigger a discussion or some other form of student activity that leads to new or deeper understanding. Closed (single-answer) questions that require only rote recitation or substitution don't do much along these lines, and questions of the "Any questions?" variety do almost nothing.

Following are some different things we can ask our students to do which can get them thinking in ways that "Given this, calculate that" never can.

Define a concept in your own words

- *Using terms a bright high school senior (a chemical engineering sophomore, a physics major, your grandmother) could understand, briefly explain the concept of vapor pressure (viscosity, heat transfer coefficient, ideal solution).*[1]

Explain familiar phenomena in terms of course concepts

- *Why do I feel comfortable in* 65°F *still air, cool when a* 65°F *wind is blowing, freezing in* 65°F *water, and even colder when I step out of the water unless the relative humidity is close to 100%?*
- *A kettle containing boiling water is on a stove. If you put your finger right next to the kettle but not touching it, you'll be fine, but if you touch the kettle for more than a fraction of a second you'll burn yourself. Why?*

Predict system behavior before calculating it

- *Without using your calculator, estimate the time it will take for half of the methanol in the vessel to drain out (for all the water in the kettle to boil off, for half of the reactant to be converted).*
- *What would you expect plots of C_B vs. t to look like if you ran the reactor at two different temperatures? Don't do any calculations—just use logic. Explain the shapes of your plots.*
- *An open flask containing an equimolar mixture of two miscible species is slowly heated. The first species has a normal boiling point of* 75°C *and the second boils at* 125°C. *You periodically*

[1] Warning: Don't ask your students to give a comprehensible definition of something like τ_{xx} or entropy or temperature or mass unless you're sure *you* can do it.

measure the temperature, T, and the height of the liquid in the flask, h, until all of the liquid is gone. Sketch plots of T and h vs. time, labeling the temperatures at which abrupt changes in system behavior occur.[2]

Think about what you've calculated

- *Find three different ways to verify that the formula we just derived is correct.*
- *Suppose we build and operate the piping system (heat exchanger, absorption column, VLE still, tubular reactor) exactly as specified, and lo and behold, the throughput rate (heat duty, solvent recovery, vapor phase equilibrium composition, product yield) is not what we predicted. What are at least 10 possible reasons for the disparity?* [3]
- *Why would an intermediate reactor temperature be optimal for this pair of reactions? (Put another way, what are the drawbacks of very low and very high temperature operation?)*
- *The computer output says that we need a tank volume of 3657924 cubic meters. Any problems with this solution?*

Brainstorm

- *What separation processes might work for a mixture of benzene and acetone? Which one would you be tempted to try first? Why?*
- *What are possible safety (environmental, quality control) problems we might encounter with the process unit we just designed? You get double credit for an answer that nobody else thinks of. The longest list gets a three-point bonus on the next test.* Once a list of problems has been generated, you might follow up by asking the students to prioritize the problems in terms of their potential impact and to suggest ways to minimize or eliminate them.

Formulate questions

- *What are three good questions about what we covered today?*
- *Make up and solve a nontrivial problem about what we covered in class this week (about what we covered in class this month and what you covered in your organic chemistry class this month). Memory and plug-and-chug problems won't be worth much—for full credit, the problem should be both creative and challenging.*
- *A problem on the next test will begin with the sentence, "A first-order reaction $A \rightarrow B$ with specific reaction rate 3.76 (min^{-1}) takes place in an ideal continuous reactor." Generate a set of questions that might follow. Your questions should be both qualitative and quantitative, and should involve every topic the test covers. I guarantee that I will use some of the questions I get on the test.*

I could go on, but you get the idea.

Coming up with good questions is only half the battle; the other half is asking them in a way that has the greatest positive impact on the students. I have not had much luck with the usual approaches. If I ask the whole class a question and wait for someone to volunteer an answer, the students remain silent and

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[2]You will be amazed and depressed by how many of your students—whether they're sophomores or seniors—say the level remains constant until T=75°C and then the liquid boils.

[3] Be sure to provide feedback the first few times you ask this critically important question, so that the students learn to think about both assumptions they have made and possibilities for human error.

nervously avoid eye contact with me until one of them (usually the same one) pipes up with an answer. On the other hand, if I call on individual students with questions, I am likely to provoke more fear than thought. No matter how kindly my manner and how many eloquent speeches I make about the value of wrong answers, most students consider being questioned in class as a setup for them to look ignorant in public—and if the questions require real thought, their fear may be justified.

I find that a better way to get the students thinking actively in class is to ask a question, have the students work in groups of 2–4 to generate answers, and then call on several of the groups to share their results. I vary the procedure occasionally by having the students formulate answers individually, then work in pairs to reach consensus. For more complex problems, I might then have pairs get together to synthesize team-of-four solutions.

Another effective strategy is to put questions like those listed above into homework assignments and pre-test study guides, promising the students that some of the questions will be included on the next test, and then include them. If such questions only show up in class, many students tend to discount them; however, if the questions also routinely appear in homework and on tests, the students take them seriously. It's a good idea to provide feedback on their initial efforts and give examples of good responses, since this is likely to be a new game for most of them and so at first they won't know exactly what you're after. After a while they'll start to get it, and some of them may even turn out to be better at it than you are. This is not a bad problem to have.[4]

[4] For more information on helping students develop creative problem-solving abilities, see R.M. Felder, “On Creating Creative Engineers,” *Engineering Education*, *77*(4), 222 (1987) [<*www.ncsu.edu/felder-public/Papers/Creative_Engineers.pdf*>] and “The Generic Quiz,” *Chem. Eng. Education*, *19*(4), 176 (1985), and Chapter 5 of P.C. Wankat and F.S. Oreovicz, *Teaching Engineering*, New York, McGraw-Hill, 1993.

Active Learning

What is it? Getting all students to do something course-related in class other than just watching and listening to the instructor and taking notes.

Why do it?

- Get full student involvement in class
- Get many more responses to questions from more than the usual 2–3 responders
- Energize the class
- Excellent for multilingual classes (lets non-native speakers help each other, gives them a chance to catch up with the lecture)
- *Experimental study:* Class given 50-minute lecture, & immediately afterwards students tested on lecture content. Tests scored, percentage of correct answers to questions plotted vs. time in class when the information had been presented.

t = time in lecture when information was presented

Similar results are reported in three different studies (the 70% and 20% figures come from the first one):

1. Hartley, J., & Davies, I.K. (1978). "Note-taking: A critical review." *Programmed Learning & Educational Technology*, *15*, 207–224.
2. Penner, J. (1984). *Why many college teachers cannot lecture*. Springfield, IL: Charles C. Thomas. See in particular a reference to a study conducted by J. McLeish.
3. Stuart, J., & Rutherford, R. (1978). "Medical student concentration during lectures." *The Lancet*, *2*, 514–516.

For more extensive evidence that active learning promotes both short-term and long-term learning, see

- Prince, M. (2004). "Does active learning work? A review of the research." *J. Engr. Education*, *93*(3), 223-231, <*http://www.ncsu.edu/felder-public/Papers/Prince_AL.pdf*>.

Active Learning Structures

- **In-Class Teams.** Get class to form teams of 2-4 and choose team recorders. Give teams 30 seconds-5 minutes or more to

  — Recall prior material
  — Answer or generate a question
  — Start a problem solution
  — Work out the next step in a derivation
  — Think of an example or application
  — Explain a concept
  — Figure out why a given result may be wrong
  — Brainstorm a question (goal is quantity, not quality)
  — Summarize a lecture

  Collect some or all answers by randomly calling on several individuals first before taking responses from volunteers. *This activity works for all class levels and sizes.*

- **Think-Pair-Share.** Students think of answers individually, then form pairs to produce joint answers, and then share answers with class. (Optional) Pairs may discuss answers with other pairs before general sharing.

- **Cooperative Note-Taking Pairs.**[1] Students form pairs to work together during the class period. After a short lecture segment, one partner summarizes his or her notes to the other. The other partner adds information or corrects. The goal is for everyone to improve his or her notes.

- **Guided Reciprocal Peer Questioning.**[2] Students work in groups of three or four and are provided with a set of generic question stems:

How does … relate to what I've learned before?	What if…?
What conclusions can I draw about …?	Explain why …?
What are the strengths and weaknesses of …?	How are … and … similar?
What is the main idea of …?	Why is … important?
What is a new example of …?	How would I use … to …?
What is the best … and why?	How does … affect …?

  — Each student individually prepares two or three thought-provoking questions on the content presented in the lecture or reading. The generic question stems are designed to encourage higher level thinking skills.

  — Questions are discussed in small groups at the beginning of class, and the whole class then discusses questions that were especially interesting or controversial in the group discussions.

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[1] Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). *Active learning: Cooperation in the college classroom* (2nd ed.). Edina, MN: Interaction Book Co.
[2] King, A. (1993). From sage on the stage to guide on the side. *College Teaching, 41* (1), 30-35.

- **Writing assignments**[3,4] provide opportunities for students to reflect on their learning both in and out of class and are a powerful way of making sense of new material.
  - — Tell students why you are using the writing assignments and what benefits they can expect.
  - — In class
    - ➢ ask students to write what they know about a topic before you lecture on it to help them subsequently connect new ideas to what they already know.
    - ➢ stop after about 10-15 minutes of lecture and ask students to summarize the main ideas.
    - ➢ have students generate a list of practical applications of new material or questions they have about it.
  - — In the lab
    - ➢ have students summarize their results and reflect on what they might mean.
    - ➢ ask students to connect lab activities with material presented in lecture.
  - — Outside of class
    - ➢ get students to summarize readings and write questions about the material (See Guided Reciprocal Peer Questioning on previous page).
    - ➢ have students reflect on how their cooperative group activities are working.
  - — If you have many writing assignments in a course, consider having students keep them together in a learning log. Include the learning log as a requirement of the course and assign it a small percentage of credit in your evaluation scheme. Use a form at the front of the learning log and have students peer check for the presence of all required entries, signing to indicate completeness of the log. To keep the learning log to a reasonable size, consider asking students to use a “blue book” usually used for examinations.
- **Concept tests with clickers.**[5] Ask class challenging multiple-choice conceptual questions, with distractors that reflect common misconceptions. Have students vote individually, then pair and discuss, then vote again. Discuss why wrong answers were wrong.
- **Pair programming.**[6] Two students actively collaborate on a task that involves computer usage. The *pilot* does the keyboarding, and the *navigator* identifies problems and thinks strategically. The two switch roles frequently.
- **Minute paper**[7]**:** Stop the lecture with two minutes to go and ask students to anonymously write
  1. the main point(s)
  2. the muddiest (least clear) point(s).

  Collect the papers. Look through the responses to check for understanding. Begin the next lecture by addressing common questions from the minute papers. *Variation:* Provide students the option of including their names so that you can address individual questions via email.

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[3] Brent, R., & Felder, R. M. (1992). Writing assignments—Pathways to connections, clarity, creativity. *College Teaching, 40* (2), 43–47. < *http://www.ncsu.edu/felder-public/Papers/Writing_Paper.pdf* >
[4] Young, A. (1999). *Teaching writing across the curriculum* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.
[5] Educause Learning Initiative. “Seven things you should know about clickers.” <*http://www.educause.edu/ir/library/pdf/ELI7002.pdf*>. Accessed 3/12/08.
[6] Williams, L. *Pair Learning Web Site.* <*http://agile.csc.ncsu.edu/pairlearning/index.php*>.
[7] Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teaching* (2nd ed.). San Francisco: Jossey-Bass.

TAPPS[8] (Thinking Aloud Pair Problem-Solving) Student pairs solve a problem, work out a derivation, or work step-by-step through a solved problem or derivation or case study or article or passage of text. Time-consuming, but powerful.

- — Students form pairs (*dyads, learning cells*), one problem-solver (or explainer, if the solution is available), one listener (or questioner).
- — Instructor defines activity.
- — Problem solver talks though first part of solution (derivation, passage of text). Listener questions, gives hints when necessary, and keeps the problem solver talking.
- — After several minutes, instructor stops activity, collects solutions from several listeners to make sure everyone in class understands up to that point. Pairs reverse roles and continue.

Implementing Active Learning in Class

- *Explain what you're doing and why up front.*
- *For pair or group activities, have the students form into groups of 2-4 where they are sitting.*
- *Assign crucial roles.* Most often groups need a recorder to capture their ideas, but occasionally different roles might be appropriate (e.g. timekeeper, monitor).
- *Explain the task.* The explanation can usually be done orally. For more complicated exercises, make a transparency noting the steps to be taken or write them on the board.
- *Call randomly on individuals to report* (while working and after work is complete). This technique is an effective way to get individual accountability in the activity.
- *Keep activities short (30 seconds – 3 minutes).* This technique keeps students from wandering off-task and reduces the frustration level for groups that are struggling.
- *For longer exercises, circulate around the classroom listening in, giving hints, and checking for understanding.*
- *Remember the value of variety.* Don't get into a pattern with in-class exercises of always doing the same thing (lecture 10 minutes, 2-minute exercise,…). Mix it up by using different structures (individual reflection, groups, think-pair-share,…) to keep the class interesting.
- *Put some course material on handouts, leaving gaps and inserting questions.* Doing this will save enough class time for you to do all the active learning exercises you want to.

What might happen if you start using active learning?

- Initial awkwardness (the students and you) and noncompliance
- Rapidly increasing comfort level except for a few students who remain resistant
- Much higher levels of energy and participation
- More and better questions and answers from students
- Improved class attendance
- Greater learning

[8] Lochhead, J., & Whimbey, A. (1987). Teaching analytical reasoning through thinking aloud pair problem solving. In J. E. Stice (Ed.), *Developing critical thinking and problem-solving abilities: New directions for teaching and learning, No. 30.* San Francisco: Jossey-Bass.

ACTIVE LEARNING: AN INTRODUCTION*

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You're about 30 minutes into your Monday morning energy systems class, and things are not looking good. At least a third of the students are texting or sleeping. Many of them clearly don't understand much of what you're saying (their midterm exam grades prove it), but they never ask questions.

It's been like this since the beginning of the semester and you are getting desperate, so you decide to try something different. You complete your determination of the energy output of a power plant boiler furnace and suddenly say "Suppose they build this exact furnace and the power output is only 380 MW instead of the 550 MW we just calculated. Get into groups of two or three, pick one recorder, and list as many possible reasons as you can think of for the difference, including violations of at least three assumptions in the calculation. I'll give you one minute and then call on a few of you. Go!"

The students quickly get into groups—some waking their neighbors in the process—and go to work. You stop them after about a minute, call randomly on several individuals for responses, get more responses from volunteers, and proceed with your lecture. The whole process takes less than three minutes, during which most or all of your students are awake and actively engaged with the course material. When you later ask them to do something similar on a test, surprisingly many of them can do it.

That's *active learning*.[1-5] Most college instructors have heard of it and know that pedagogical experts say they should do it in their classes. If you bring it up with colleagues, though, they will immediately tell you why it's a bad idea (an educational fad, a waste of class time, spoon-feeding, lowering academic standards, a radical conspiracy to destroy the American System of Higher Education, etc.). In this paper, we offer our definition of active learning; say a few things about how to do it; and try to persuade you that it's none of those evil things listed in the last sentence but just a simple, effective, and easy teaching strategy with a solid foundation in research and common sense.

What is active learning?

If you think of anything a teacher might ask students to do—answer questions in class, complete assignments and projects outside class, carry out lab experiments, or anything else other than sitting passively in a classroom—you will find people who would classify it as active learning. We find that a more restricted definition limited to in-class activities is more useful:

* *ASQ Higher Education Brief*, *2*(4), August 2009.

> Active learning is anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes.

You are doing active learning in your class when you ask a question, pose a problem, or issue some other type of challenge; tell your students to work individually or in small groups to come up with a response; give them some time to do it; stop them, and call on one or more individuals or groups to share their responses. You are *not* doing active learning when you lecture, ask questions that the same few students always answer, or conduct discussions that engage only a small fraction of the class.

We are not about to propose that you throw out lecturing and make every class you teach a total active learning extravaganza. You know more than most of your students do about your subject, and you need to spend part of your class time teaching them what you know—explaining, clarifying, demonstrating, modeling, etc. What we *are* suggesting is to avoid making lecturing the only thing you do. If a lecture or recitation session includes even a few minutes of relevant activity—a minute here, 30 seconds there—the students will be awake and with you for the remaining time in a way that never happens in a traditional lecture, and most will retain far more of what happens in those few minutes than of what you say and do in the rest of the session. If you do that in every course session, at the end of the semester you'll see evidence of high-level learning unlike anything you've seen before. (Research cited in Reference 5 of the bibliography supports that claim.)

What can you ask students to do?

It's limited only by your imagination. You can ask them to answer a question; explain a complex concept or a physical or social phenomenon in terms a high school student could understand; sketch a flow chart or diagram or plot or time line or concept map; solve a short problem or outline the solution of a longer problem; get started on or carry out the next step of a case study analysis or long problem solution or derivation; predict or interpret the outcome of a scenario or experiment; critique a report or proposal or design or article or op-ed column; troubleshoot a malfunctioning system; brainstorm a list; formulate a question about the material you just lectured on for the past 20 minutes…we could go on, but you get the idea.

When you're deciding what to ask students to do, avoid trivial questions that the whole class should be able to answer immediately. Instead, focus on the hard stuff—the things students always have trouble with on assignments and exams. If you simply lecture on those things and you're a good lecturer, the students may leave class thinking that they understood everything, but when they get to the assignments they soon learn otherwise. If you use active learning, those brief interludes of practice and feedback in class will make the assignments and exams go a whole lot smoother for most of them.

What formats can you use for activities?

Here is the basic active learning structure.

1. Tell the students to organize themselves into groups of 2–4 and randomly appoint a recorder in each group if writing will be required (e.g., the one born closest to the classroom, or the

one farthest to your right, or the one who woke up earliest that morning,…). Alternatively, tell the groups to appoint their own recorders, preferably someone who has not yet recorded that day.

2. Pose a challenging question or problem and allow enough time for most groups to either finish or make reasonable progress toward finishing. The time you give them should normally be between 15 seconds and three minutes. If they will need much more time than that, break the problem into several steps and treat each step as a separate activity.
3. Call on several individuals or groups to share their responses, and ask for volunteers if the complete response you are looking for is not forthcoming. Then discuss the responses or simply move on with your planned lecture.

The active learning literature offers many variations of this approach. Here are three particularly effective ones.

- *Think-pair-share.* Pose the problem and have students work on it individually for a short time; then have them form pairs and reconcile and improve their solutions; and finally call on several individuals or pairs to share their responses. This structure takes a bit more time than a simple group activity, but it includes individual thinking and so leads to greater learning.
- *Concept tests.* Ask a multiple-choice question about a course-related concept, with distractors (incorrect responses) that reflect common student misconceptions. Have the students respond using personal response systems ("clickers") and display a histogram of the responses. If clickers aren't available and the class isn't huge, have the students hold up cards with their chosen responses in large letters and scan the room to estimate the response distribution. Then have the students get into pairs and try to reconcile their responses and vote again. Finally, call on some of them to explain why they responded as they did and then discuss why the correct response is correct and the distractors are not.
- *Thinking-aloud pair problem solving* (TAPPS). This is a powerful technique for helping students work through and understand a problem solution, case analysis, or text interpretation or translation. Have the students get into pairs and designate one pair member as the *explainer* and the other one as the *questioner*. Give the explainers a minute or two to explain the problem statement line by line (or explain the first paragraph of the case history or interpret or translate the first paragraph of the text) to their partners, and tell the questioners to ask questions when explanations are unclear or incomplete and to give hints when necessary. Stop the students after the allotted time and call on several individuals to explain things to you. Once you get a satisfactory explanation, have the pairs reverse roles and continue with the next part of the problem solution or case analysis or text interpretation or translation. Proceed in this manner until the exercise is complete. In the end, your students will understand the exercise material to an extent that no other instructional technique we know of can match.

Frequently-asked questions

Q: *What mistakes do instructors make when they implement active learning?*

A: The two most common mistakes are (1) making exercises too long (more than three minutes), and (2) calling for volunteers to respond after every activity. If you give students, say, ten minutes to solve a problem, some groups will finish in two and waste eight minutes of valuable class time, and others will struggle for the full ten minutes, which is extremely frustrating and also a waste of class time. Keeping the activities short avoids both problems. If you always call for volunteers, the students quickly learn that they don't have to think about what you asked them to do—they can just relax and talk about the football game, and eventually someone else will supply the answer. On the other hand, if they know that any of them could be called on for a response after a minute or two, most or all of them will do their best to be ready. Avoid these two mistakes and active learning is almost guaranteed to work.

Q: *If I spend all this time on activities in class, how will I ever cover my syllabus?*

A: You can spend as much or as little time as you want to. Just a few minutes of activity in each class period will make a substantial difference in the learning that occurs in the class with at most a minor impact on the syllabus. To avoid losing any syllabus content at all, take most of the material you now spend a lot of time on—long prose passages, complex derivations and diagrams, etc.—and put it in handouts sprinkled with questions and gaps. Have the students read through the straightforward material in class (they can read much faster than you can write or drone through PowerPoint slides), and either lecture on the gaps or (better) use them as bases for activities. You'll cover more material than you ever did when you said every word and did every calculation yourself, and the quality of learning will be much greater. (For more details on this strategy, see Reference 3 in the bibliography.)

Q: *Won't it take me a lot of time to plan activities?*

A: Preparing good lesson plans for a new course is a huge task, whether or not the lessons include activities, but adding activities to lesson plans should not take much time. Just look over your lecture notes a few minutes before class, think of some things you might ask the students to do, and jot them down in the notes. You'll always come up with as many activities as you want, and after one or two iterations the ones that work well will become a permanent part of the lesson plans.

Q: *What if some of my students don't like being asked to work in class?*

A: Some probably won't, especially when you first start doing it. Many students want their instructors to tell them everything they need to know for the exam—not one word more or less—and if they are made to work in class they resent it. The key is to let them know up front that you are doing active learning not for your own selfish purposes but because you have research showing that students taught this way have an easier time with homework and do better on exams. Reference 4 in the bibliography ("Sermons for Grumpy Campers") gives details on how to make that case persuasively, and Reference 5 reviews the research. It won't take the students long to find out that you're telling them the truth, at which point the complaining will stop.

Q: *What should I do if some of my students refuse to get into groups when I ask them to?*

A: The first time you do an active exercise in a class unaccustomed to active learning, many students might just stare straight ahead, and you will have to personally encourage some of them to work with each other. By the second or third time you do it, there should be few if any holdouts. At that point, stop worrying about it. The research shows that students learn much more by doing things and getting feedback than by watching and listening to someone tell them what they're supposed to know (Reference 5). In your class activities, you're providing practice and feedback in the things you know the students will find difficult on the homework and tests. If some choose not to take advantage of those opportunities, it's their loss—don't lose five seconds of sleep worrying about it.

And that's all there is to it. Instructors who switch to active learning and follow those recommendations almost always say that their classes are much more lively and enjoyable and the quality of learning goes up dramatically. Try it in the next course you teach, and see if you don't have a similar story to tell by the end of the semester.

Acknowledgment

The authors are indebted to Kenny and Gary Felder for invaluable critiques of an early draft of this paper.

Bibliography

1. R.M. Felder & R. Brent. (2003). "Learning by Doing." *Chem. Engr. Education, 37*(4), 282–283. <*www.ncsu.edu/felder-public/Columns/Active.pdf*>. The philosophy and strategies of active learning.
2. R.M. Felder. (1994). "Any Questions?" *Chem. Engr. Education, 28*(3), 174–175. <*www.ncsu.edu/felder-public/Columns/Questions.pdf*>. Illustrative questions for engineering and science courses that can serve as the basis of active learning exercises.
3. R.M. Felder & R. Brent. (1999). "FAQs-2." *Chem. Engr. Education, 33*(4), 276–277. <*www.ncsu.edu/felder-public/Columns/FAQs-2.html*>. Responses to the questions "*Can I use active learning exercises in my classes and still cover the syllabus?*" and "*Do active learning methods work in large classes?*"
4. R.M. Felder. (2007). "Sermons for Grumpy Campers." *Chem. Engr. Education, 41*(3), 183–184. <*www.ncsu.edu/felder-public/Columns/Sermons.pdf*>. Short speeches to persuade students that active and cooperative learning are not violations of their civil rights but instructional methods likely to improve their learning and grades.
5. M.J. Prince. (2004). "Does Active Learning Work? A Review of the Research." *J. Engr. Education, 93*(3), 223-231. <*www.ncsu.edu/felder-public/Papers/Prince_AL.pdf*>. A summary of research evidence for the effectiveness of active learning.

SERMONS FOR GRUMPY CAMPERS*

Richard M. Felder
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In workshops, I push teaching methods like active and cooperative learning that make students more responsible for their own learning than they are when instructors simply lecture.[1-2] I believe in truth in advertising, though, and make it clear that the students will not all be thrilled with the added responsibility and some may be overtly hostile to it.[3] If you use those methods, you can expect some of your students to complain that you're violating their civil rights by not just telling them everything they need to know for the test and not a word more or less.

When you use a proven teaching method that makes students uncomfortable, it's important to let them know why you're doing it. If you can convince them that it's not for your own selfish or lazy purposes but to try to improve their learning and grades, they tend to ramp down their resistance long enough to see the benefits for themselves. I've developed several mini-sermons to help with this process. If any look useful, feel free to appropriate them.

* * *

Student: "*Those group activities in class are a waste of time. I'm paying tuition for you to teach me, not to trade ideas with students who don't know any more than I do!*"

Professor: "I agree that my job is to teach you, but to me *teaching* means making learning happen and not just putting out information. I've got lots of research that says people learn through practice and feedback, not by someone telling them what they're supposed to know. What you're doing in those short class activities are the same things you'll have to do in the homework and exams, except now when you get to the homework you will have already practiced them and gotten feedback. You'll find that the homework will go a lot smoother and you'll probably do better on the exams. (Let me know if you'd like to see that research.)"

* * *

S: "*I don't like working on homework in groups—why can't I work by myself.*"

P: "I get that you're unhappy and I'm sorry about it, but I've got to be honest with you: my job here is not to make you happy—it's to prepare you to be a chemical engineer. Here's what's not going to happen in your first day on the job. They're not going to say `Welcome to the company, Mr. Jones. Tell me how you like to work—by yourself or with other people?' No. The first thing they'll do is put you on a team, and your performance evaluation is likely to depend more on how well you can work with that team than on how well you solve differential equations and design piping systems. Since that's a big part of what you'll be doing there, my job is to teach you how to do it here, and that's what I'll be doing."

S: "*Okay, but I don't want to be in a group with those morons you assigned me to. Why can't I work with my friends?*"

* *Chemical Engineering Education, 41*(3), 181–182 (2007).

P: "Sorry—also not an option. Another thing that won't happen on that first day on the job is someone saying `*Here's a list of everyone in the plant. Tell me who you'd like to work with.*' What *will* happen is they'll tell you who you're working with and you won't have a vote on it. Look, I can show you a survey in which engineering alumni who had been through extensive group work in college were asked what in their education best prepared them for their careers.[4] The most common response was `*the groups*.' One of them said `*When I came to work here, the first thing they did was put me on a team, and you know those annoying teammates back in college who never pulled their weight—well, they're here too. The difference between me and people who came here from other colleges is that I have some idea what to do about those guys.'* In this class you're going learn what to do about those guys."

* * *

S: "*I hate these writing assignments and oral reports you keep making us do. One reason I went into engineering was to get away from that stuff*."

P: "I'm afraid there's no getting away from it—quite the contrary. Let me give you an example. A few years ago an engineer who was on campus interviewing students for jobs and summer internships came in to talk to an engineering class that was getting frequent communication assignments and complaining bitterly about it. He started by writing on the board a list of everything he did on his job, from designing and pricing process equipment to writing reports and memos and talking to people. Then he had the students get in groups and speculate on what percentage of his time he spent on each of those activities. They all thought 90% of his time went to the technical stuff but it was actually more like 10%. He said that in fact about 75% of his time was spent on writing and speaking—to coworkers, his boss, people reporting to him, people in other divisions, and customers and potential customers—and that his advancement on the job depended heavily on how effectively he communicated with those people. He also said—and this was what really got the students' attention—that the main thing he was looking for when he interviewed students for jobs was the ability to communicate effectively. Most industrial recruiters we bring in here will tell you the same thing. Since communication skill is something you'll need to get a job and succeed in it, you'd better acquire it while you're here, and you will in this class."

* * *

And that's that. My suggestion is to put your own spin on those sermonettes and trot them out when the right occasion presents itself. While I don't guarantee that they will immediately convert all students into believers—in fact, I guarantee they won't—my experience is that at least they'll keep student resistance down enough to enable the teaching methods we've been talking about to achieve their objectives.

Let me give you one more encouraging word about student resistance to learner-centered teaching methods. My colleague Lisa Bullard uses cooperative learning in both an introductory sophomore engineering course and the capstone senior design course. She once told me that she has always had problems with group work in the sophomore class but never with the seniors until one semester, when she got the Design Class from Hell. The students complained constantly about having to work in groups, many teams were dysfunctional, and things generally went the way they always had in the sophomore class only worse.

Lisa racked her brains trying to figure out what was different about the design class that semester and couldn't think of a thing—and then she got it. Up until that year the seniors had previously been in her sophomore class and so were accustomed to group work. She had not taught *this* group of seniors before, however, and so she was experiencing the headaches that normally come when students first encounter active and cooperative learning. So if you find yourself experiencing those headaches, remember two things. First, you're equipping students with skills that will serve them well throughout their careers, whatever those careers may be. Second, you're making life much easier for yourself or colleagues who teach those students in subsequent courses using the same methods. It's worth a few headaches.

References

1. M.J. Prince, "Does Active Learning Work? A Review of the Research." *J. Engr. Education, 93*(3), 223-231, (2004), <*http://www.ncsu.edu/felder-public/Papers/Prince_AL.pdf*>.
2. K.A. Smith, S.D. Sheppard, D.W. Johnson, & R.T. Johnson, "Pedagogies of Engagement: Classroom-Based Practices," *J. Engr. Education, 94*(1), 87–101 (2005).
3. R.M. Felder and R. Brent, "Navigating the Bumpy Road to Student–Centered Instruction," *College Teaching, 44* (2), 43–47 (1996), <*http://www.ncsu.edu/felder-public/Papers/Resist.html*>.
4. R.M. Felder, "The Alumni Speak," *Chem. Engr. Education, 34*(3), 238-239 (2000), <*http://www.ncsu.edu/felder-public/Columns/alumni.html*>.

DEATH BY POWERPOINT*

Richard M. Felder and Rebecca Brent

It's a rare professor who hasn't been tempted in recent years to put his or her lecture notes on transparencies or PowerPoint. It takes some effort to create the slides, but once they're done, teaching is easy. The course material is nicely organized, attractively formatted, and easy to present, and revising and updating the notes each year is trivial. You can put handouts of the slides on the Web so the students have convenient access to them, and if the students bring copies to class and so don't have to take notes, you can cover the material efficiently and effectively and maybe even get to some of that vitally important stuff that's always omitted because the semester runs out.

Or so the theory goes. The reality is somewhat different. At lunch the other day, George Roberts—a faculty colleague and an outstanding teacher—talked about his experience with this teaching model. We asked him to write it down so we could pass it on to you, which he kindly did.

* * *

"*About five years ago, I co-taught the senior reaction engineering course with another faculty member. That professor used transparencies extensively, about 15 per class. He also handed out hard copies of the transparencies before class so that the students could use them to take notes.*

"*Up to that point, my own approach to teaching had been very different. I used transparencies very rarely (only for very complicated pictures that might be difficult to capture with freehand drawing on a chalkboard). I also interacted extensively with the class, since I didn't feel the need to cover a certain number of transparencies. However, in an effort to be consistent, I decided to try out the approach of the other faculty member. Therefore, from Day 1, I used transparencies (usually about 8 -10 per class), and I handed out hard copies of the transparencies that I planned to use, before class.*

"*After a few weeks, I noticed something that I had not seen previously (or since)—attendance at my class sessions was down, to perhaps as low as 50% of the class. (I don't take attendance, but a significant portion of the class was not coming.) I also noticed that my interaction with the class was down. I still posed questions to the class and used them to start discussions, and I still introduced short problems to be solved in class. However, I was reluctant to let discussions run, since I wanted to cover the transparencies that I had planned to cover.*

"*After a few more weeks of this approach, two students approached me after class and said, in effect, `Dr. Roberts, this class is boring. All we do is go over the transparencies, which you have already handed out. It's really easy to just tune out.' After my ego recovered, I asked whether they thought they would get more out of the class and be more engaged if I scrapped the transparencies and used the chalkboard instead. Both said `yes.' For the rest of the semester, I went back to the chalkboard (no transparencies in or before class), attendance went back up to traditional levels, the class became more interactive, and my teaching evaluations at the end of the semester were consistent with the ones that I had received previously. Ever since that experience, I have never been tempted to structure my teaching around transparencies or PowerPoint.*"

* * *

The point of this column is not to trash transparencies and PowerPoint. We use PowerPoint all the time—in conference presentations and invited seminars, short courses, and teaching workshops. We rarely use pre-prepared visuals for teaching, however—well, hardly ever—and strongly advise against relying on them as your main method of instruction.

Most classes we've seen that were little more than 50- or 75-minute slide shows seemed ineffective. The instructors flashed rapid and (if it was PowerPoint) colorful sequences of equations and text and tables and charts, sometimes asked if the students had questions (they usually didn't), and sometimes asked questions themselves and got either no response or responses from the same two or three students. We saw few signs of any learning taking place, but did see things similar to what George saw. If

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* *Chem. Engr. Education, 39*(1), 28-29 (2005).

the students didn't have copies of the slides in front of them, some would frantically take notes in a futile effort to keep up with the slides, and the others would just sit passively and not even try. It was worse if they had copies or if they knew that the slides would be posted on the Web, in which case most of the students who even bothered to show up would glance sporadically at the screen, read other things, or doze. We've heard the term "Death by PowerPoint" used to describe classes like that. The numerous students who stay away from them reason (usually correctly) that they have better things to do than watch someone drone through material they could just as easily read for themselves at a more convenient time and at their own pace.

This is not to say that PowerPoint slides, transparencies, video clips, and computer animations and simulations can't add value to a course. They can and they do, but they should only be used for things that can't be done better in other ways. Here are some suggested dos and don'ts.

- *Do* show slides containing text outlines or (better) graphic organizers that preview material to be covered in class and/or summarize what was covered and put it in a broader context. It's also fine to show main points on a slide and amplify them at the board, in discussion, and with in-class activities, although it may be just as easy and effective to put the main points on the board too.
- *Do* show pictures and schematics of things too difficult or complex to conveniently draw on the board (e.g., large flow charts, pictures of process equipment, or three-dimensional surface plots). *Don't* show simple diagrams that you could just as easily draw on the board and explain as you draw them.
- *Do* show real or simulated experiments and video clips, but only if they help illustrate or clarify important course concepts and only if they are readily available. It takes a huge amount of expertise and time to produce high-quality videos and animations, but it's becoming increasingly easy to find good materials at Web sites such as SMETE, NEEDS, Merlot, Global Campus, and World Lecture Hall. (You can find them all with Google.)
- *Don't* show complete sentences and paragraphs, large tables, and equation after equation. There is no way most students can absorb such dense material from brief visual exposures on slides. Instead, present the text and tables in handouts and work out the derivations on the board or—more effectively—put partial derivations on the handouts as well, showing the routine parts and leaving gaps where the difficult or tricky parts go to be filled in by the students working in small groups.[1,2]

If there's an overriding message here, it is that doing too much of *anything* in a class is probably a mistake, whether it's non-stop lectures, non-stop slide shows, non-stop activities, or anything else that falls into a predictable pattern. If a teacher lectures for ten minutes, does a two-minute pair activity, lectures another ten minutes and does another two-minute pair activity, and so on for the entire semester, the class is likely to become almost as boring as a straight lecture class. The key is to mix things up: do some board work, conduct some activities of varying lengths and formats at varying intervals, and when appropriate, show transparencies or PowerPoint slides or video clips or whatever else you've got that addresses your learning objectives. If the students never know what's coming next, it will probably be an effective course.

References

1. R.M. Felder and R. Brent, "Learning by Doing," *Chem. Engr. Education, 37*(4), 282–283 (2003). On-line at <*http://www.ncsu.edu/felder-public/Columns/Active.pdf*>.
2. R.M. Felder and R. Brent, "FAQs. II. Active Learning vs. Covering the Syllabus, and Dealing with Large Classes," *Chem. Engr. Education, 33* (4), 276-277 (1999). On-line at <*http://www.ncsu.edu/felder-public/Columns/FAQs-2.html*>.

Additional Resources on Lecturing and Active Learning

Lecturing

- Race, P., & Brown, S. (2002). *Lecturing: A practical guide.* London: Kogan Page.
- Svinicki, M., & McKeachie, W.J. (2011). *McKeachie's teaching tips: Strategies, research, and theory for college and university teachers* (13th ed.), Ch. 5, 6, 18. Florence, KY: Cengage Learning.
- Wankat, P.C. (2002). *The effective, efficient professor*. Boston: Allyn & Bacon. Chapter 5: Lecture-style classes.

Active Learning

- Felder, R.M. (1991). "It goes without saying." *Chem. Engr. Education, 25*(3), 132-133. An illustrative lesson utilizing active learning. <*http://www.ncsu.edu/felder-public/Columns/WithoutSaying.pdf*>.
- Felder, R. M. (1997). Beating the numbers game: Effective teaching in large classes. *1997 ASEE Conference Proceedings*, Milwaukee, WI, June. Practical suggestions for managing large classes and getting students actively involved. <*http://www.ncsu.edu/felder-public/Papers/Largeclasses.htm*>.
- Felder, R.M., & Brent, R. (1999). "FAQs. II. Active learning vs. covering the syllabus, and dealing with large classes," *Chem. Engr. Education, 33* (4), 276-277. <*http://www.ncsu.edu/felder-public/Columns/FAQs-2.html*>.
- Felder, R.M., & Brent, R. (2001). "FAQs. III. Groupwork in distance learning," *Chem. Engr. Education, 35* (2), 102–103. <*http://www.ncsu.edu/felder-public/Columns/FAQs-3.html*>.
- Felder, R.M., & Brent, R. (2005). "Screens down, everyone: Effective uses of portable computers in lecture classes," *Chem. Engr. Education, 39*(3), 200–201. <*http://www.ncsu.edu/felder-public/Columns/Laptops.pdf*>.
- Johnson, D. W., Johnson, R.T., & Smith, K. A. (1998). *Active learning: Cooperation in the college classroom* (2nd ed.). Edina. MN: Interaction Book Co.
- Prince, M. (2004). "Does active learning work? A review of the research." *J. Engr. Education, 93*(3), 223-231, <*http://www.ncsu.edu/felder-public/Papers/Prince_AL.pdf*>.
- Radosevich, D.J., Salomon, R., Radosevich, D.M., & Kahn, P. (2008). "Using student response systems to increase motivation, learning, and knowledge retention," *Innovate: Journal of Online Education, 5*(1). <*http://www.innovateonline.info/index.php?view=article&id=449*>.
- Svinicki, M., & McKeachie, W.J. (2011). *McKeachie's teaching tips: Strategies, research, and theory for college and university teachers* (13th ed.), Ch. 14. Florence, KY: Cengage Learning.

C. What can go wrong in teaching? What can I do when it does?

Crisis Clinic

All in a day's work

It's a typical day in your class. As you lecture

- a student strolls in 10 minutes late, the earliest arrival for the student all semester
- several are absorbed in the newspaper
- two students are talking to each other and laughing
- one has head back, eyes closed, and mouth open
- a cell phone rings

What might you do about all this?

ALL IN A DAY'S WORK*

Richard M. Felder and Rebecca Brent

It's a typical day in your class. As you lecture,

- *several students stroll in during the first 10 minutes of the class and one arrives after 20 minutes. It is the earliest she has arrived all semester.*
- *a number of students are absorbed in the campus newspaper.*
- *two students are having an animated conversation, punctuated by laughter. All heads around them are turning to see what's going on.*
- *one student has his head back, eyes closed, and mouth open.*
- *a cell phone rings.*

You are not thrilled by all this, but you're not sure what to do about it.

* * *

We sometimes present this scenario in our teaching workshops and ask the participants to brainstorm possible responses to any of these behaviors—not just good responses, but good, questionable, and terrible responses. Here are typical suggestions.

1. Ignore it.
2. Lock the door.
3. "YOU TWO SHUT UP!"
4. Fall silent and wait.
5. Throw chalk.
6. Set off a firecracker.
7. Flap your arms and cluck like a chicken.
8. Ask a question.
9. Leave.
10. Set fire to the newspaper.
11. Talk to the offender outside class.
12. Review the rules.
13. Start an activity.
14. Throw the bums out.
15. "That looks like an interesting conversation over there—why don't you share it with the rest of us?"

Next, we suggest that the *best* response depends on whether the offending behavior is disruptive or non-disruptive—that is, whether or not it distracts the class's attention from your teaching—and whether it is a first offense or a recurring one. Non-disruptive behaviors include sleeping (without snoring), reading, or slipping into the back of the room late. You may not like it—seeing students asleep drives some instructors crazy—but it is not distracting to the other students. (Watching someone sleeping just doesn't have that much entertainment value.)

* *Chem. Engr. Education, 34*(1), 66–67 (2000).

Disruptive behaviors include talking or otherwise making noise, or coming in late and promenading ostentatiously up the aisle.

After making these distinctions between different offending behaviors, we tell the participants to get into groups of three or four and try to reach consensus on the best response for each category. We collect their nominations and then propose ours. Sometimes several groups nominate our responses; often none do.

You might enjoy making your own nominations before we tell you ours. In your opinion, what is the best way to deal with

(a) a student sleeping in class whom you have never seen sleeping before?
(b) a student who sleeps in almost every class session?
(c) two students talking and laughing who have not done so before?
(d) two students talking and laughing who do so frequently?

First indicate what you would do in class when you observe the offensive behavior, and then add what (if anything) you would do outside class. *Hint*: One of our nominations is not included in the 15 listed ones.

* * *

Best response to non-disruptive behavior

If you do *anything* in class to address a non-disruptive behavior, you turn it into a disruptive one. Our suggestion for what to do in class about a sleeping (or reading or unobtrusively late) student is, therefore...*nothing*. If the student is a first-time offender, forget about it. If you notice the same student sleeping every period, you may continue to ignore it, or if it seriously annoys you, you might express your annoyance outside class and ask why he is doing it. If he is bored, knowing that his sleeping bothers you may get him to work harder at staying awake. On the other hand, if he is holding down a 40-50 hour/week job while going to school or is working the night shift, warn him that he could be missing important information and then stop worrying about it.

Sometimes someone suggests initiating a learning activity to get students' attention. We are staunch believers in active learning, but we want to use activities when they fit, not just because we happen to see someone sleeping.

Best response to disruptive behavior

Ignoring disruptive behavior is not a viable option. If you allow disruptions to proceed, they will become increasingly widespread and frequent until the class is out of control.

Our nomination of the best response requires some preliminary explanation.[*] Speech communication experts tell us that there are three categories of responses to objectionable behavior: *aggressive, passive (indirect)*, and *assertive.* Yelling at students, throwing things at them, and throwing them out of class are aggressive responses. Doing anything non-aggressive

[*] We are indebted to Rebecca Leonard of the N.C. State University Department of Communication for the analysis that follows.

other than clearly stating what you want is a passive response. Calmly and clearly stating the problem and asking for what you want is an assertive response.

Do aggressive responses work? In the short run, they generally do. As an instructor, you hold a great deal of power over the students: if you scream at them to shut up, chances are they will. But while you may win the battle, you are likely to lose the war. When you resort to aggression, you effectively admit that the only way you can control your class is to lose control of yourself. You will lose the respect of the students, and the rest of the semester could be grim for both you and them.

What about throwing the chalk or an eraser? Everyone has stories—some fond, some bitter—about teachers they had or knew about who used to do that sort of thing. That was then; this is now. Can you say "law suit"?

Then there are passive responses. Ignoring those two chattering students—the ultimate passive response—is clearly a poor idea. Falling silent and waiting for them and other noisemakers to quiet down themselves might work eventually, but it wastes valuable class time (especially in a large class, where you might wait for a *long* time) and penalizes the non-disruptive students as much as the few miscreants. Locking the door penalizes chronic latecomers, but it also penalizes the one-time offender who may have a perfectly legitimate and unavoidable reason for being late.

Some professors argue for the ever-popular "Why don't you share that joke with the rest of us?" That is, first of all, a passive response. You are not asking for what you really want: the last thing in the world you want is to know what those two birds are twittering about. You know, and they know, and the rest of the class knows, that your goal is simply to embarrass them into quieting down. Will it work? Again, probably in the short term, but once you resort to sarcasm or anything else that has embarrassment as its objective you again lose respect that may be hard or impossible to regain.

Which brings us to our nomination: the direct, assertive response. Look in the direction of the offending students and calmly say "Excuse me—that noise is disrupting the class. Could you please keep it down?" They usually will. The talkers may be mildly embarrassed but your primary objective was clearly not to embarrass them—it was simply to quiet them down. You maintain control without having to use aggression or sarcasm, and the students' respect for your authority stays the same or increases.

Finally, what if you have to quiet down the same students in several classes, or the same student keeps coming in late? We propose doing the same thing we suggested for repeated non-disruptive behaviors. Talk to the offenders outside class, telling them that their behavior is offensive and must stop, and then ask them why they're doing it. Regardless of what they say, you will probably achieve your objective. In our combined years of teaching, we have never had to do this with a student more than once. Barring pathological cases, neither should you.

Interestingly, the assertive response—simply asking the offenders to stop doing what they're doing—is usually not on the list of possibilities brought up during the initial brainstorm. It's almost as if instructors don't know it's legal to do it. It is legal. And it works.

ACADEMIC INTEGRITY: MINIMIZING CHEATING ON EXAMS*

Question: *Is there likely to be cheating on exams in the course I'm about to teach or TA?*
Answer: *Yes.*
Question: *How will they do it?*
Answer:

1. *The Sneak Preview.* (They get advance copies.)
2. *The Eyes Have It.* (They scan neighbor's papers.)
3. *The Note of Precaution*. (They bring crib sheets or information on their calculator or hand-held.)
4. *The Call of (a Warped) Nature*. (They leave the test room and get help.)
5. *Quick Change Artistry*. (They pick up your worked-out solution and correct the paper before handing it in.)
6. *Now You See It, Now You Don't.* (They don't hand in the test and later claim you lost it.)
7. *Three-Page Monte*. (They substitute correct solutions for incorrect ones after the graded tests are handed back.)
8. *Who was that masked man?* (Hire a substitute.)
9. *History Repeating Itself.* (They memorize solutions to the same questions on past tests.) This one is not cheating -- it's the instructor's fault for repeating questions.

Question: *How can I minimize cheating on exams?*
Answer:

1. Don't leave copies of the exam lying around, *including in computer files.*
2. Know how many copies were run off & count them before handing them out.
3. Make sure the exam is carefully proctored.
    - Someone (ideally, more than one person for large sections) should be present in the exam watching the class at all times.
    - Circulate throughout the classroom during the exam.
    - Be on the lookout for students consulting resources that are not allowed (extra sheets of paper, writing on skin or clothing)
    - Be particularly mindful of what occurs at the end of class as papers are being handed in.
4. Don't hand out or post worked-out solutions until you are sure all the papers have been collected.
5. Log in the papers as soon as you collect them.
6. Use exam booklets or colored paper to make post-grading substitution harder. This also makes it harder for students to have "illegal" materials during closed note exams if the test booklet/paper is something other than white paper.
7. Make photocopies of some or all graded exams, particularly those of anyone you have suspicions about, before handing them back.
8. Give alternative versions of tests to make copying harder.
9. Require complete solutions. Don't give credit for the right answer magically appearing.
10. Give tests that are easy to read and possible to solve. Students are much more likely to cheat on tests they regard as unfair.
11. Include an honor pledge for students to sign on exams.
12. Don't repeat exams!

* Adapted from NCSU New Faculty Orientation materials developed by Richard Felder and Rebecca Brent.

ACADEMIC INTEGRITY: MINIMIZING CHEATING ON HOMEWORK*

<u>Question</u>: *Is there likely to be cheating on homework in the course I'm about to teach or TA?*
<u>Answer</u>: *Yes.*
<u>Question</u>: *How will they do it?*
<u>Answer</u>:

1. *Two Heads Are Better Than One (*They "work together" to discuss the problem and develop with a draft of the solution, then each go off and copy the final solution individually.)
2. *Hand-Me-Downs (*They get the homework from someone who took it last year and copy homework problems that are repeated.)
3. *Go To Google (*They Google to find solutions which were posted on-line from another school or on a "knowledge sharing" website.)
4. *eBay Excursions (*They buy the solution manual on eBay or get a bootleg copy from China.)
5. *Oops (*They "accidentally" pick up the solution from the TA's desk.)
6. *Excuse Me (*They lean over the TA's shoulder during office hours when the TA is helping someone else.)
7. *Lounge Lizards (*They hang out in the lounge and wait until a student has stepped out, then go over and take their homework out of their book and make a copy.)
8. *Trash Trollers (*They fish around the trashcan in the computer room for someone's old printout.)
9. *Excelling at Evildoing. (*They get a copy of someone's Excel file, change the font and color of the lines on the graph, and save as their own. Alternatively, they copy the content of the file and paste it into a new file, saving it under their own name.)
10. *Three-Page Monte*. (They substitute correct solutions for incorrect ones after the graded homeworks are handed back.)

<u>Question</u>: *How can I minimize cheating on homework and catch students if they do cheat?*
<u>Answer</u>:

1. See items 1, 4, 5, 7, and 9 above for exams—these ideas also apply to homework.
2. Be clear up front about what is acceptable and not acceptable with regard to individual and group homework assignments. Putting language in the syllabus, as well as providing "scenarios" of acceptable and unacceptable behavior, lets students know what you expect.
3. Set a deadline for late homework submissions. Hand the graded papers back after that deadline. Do not accept late homework after graded papers have been returned.
4. Try to avoid having copies of the solution in your hand, in your book, or on your desk during office hours – review the problems so you can help people without the solution in hand.
5. Grading: Be sure to write something on every page of the graded paper (even a red check mark) to avoid pages being inserted with the claim that you "missed" them. Draw a red line down the page to fill any blank space.
6. If the solution key has a typo or mistake, note any papers that duplicate that mistake.

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* Adapted from NCSU New Faculty Orientation materials developed by Richard Felder and Rebecca Brent.

7. If the solution key has a written (text statement) answer, be attentive to papers that repeat the written statement exactly or with one or two words changed. Look for correct solutions that have identical sequence, order of variables and equations, layout, etc.
8. If you get the sensation that you've graded that paper before, you probably have. Scan the papers you've already graded for the duplicate.
9. If you are using homework problems from the text, keep track of which homework problems are assigned and try not to repeat them too frequently.
10. For lab reports or technical writing assignments: look for "change of voice" from one paragraph to the next, which might indicate "lifting" an uncited paragraph from another source. If something sounds "too good" to be written by an undergraduate at that level, it probably is. Google a phrase or unusual word as a quick check.

<u>Question</u>: *What about electronic files and programming assignments?*
<u>Answer</u>:

1. The Department of Computer Science has sophisticated software, MOSS (***http://theory.stanford.edu/~aiken/moss/***) that can run all the submitted code and provide the probability that someone's code is a duplicate of another student. This is why the Department of Computer Science has one of the highest rates of cheating reported – they have a valid way to detect it.
2. Excel files
    a. Under File/Properties, check the Author and Time of Creation to see if there are duplicates. Note, students trying to cover their tracks can edit the Author field, but they cannot edit the time of creation of the file.
    b. If you can overlay two files and the placement of information, significant figures, titles for columns and rows, etc. are identical, it's worth looking into for possible cheating.

TA's: For all cases of suspected cheating, identify the suspicious papers, document your concerns, and turn whatever you have over to the instructor.

Suggestions for Addressing Academic Integrity Issues*

1. **Integrate the concept** of academic integrity into the content of the course, as opposed to talking about it once and forgetting about it. Think about how you could relate the issue to course content or professional practice.

2. **Decide that you are going to be proactive** and do something about it. Recognize that this will take time and effort on your part. However, time and effort spent up front will hopefully prevent incidents later that require more time and effort to address.

3. **Establish clear expectations** about behavior

   a. Use specific language in the syllabus (see attachment with examples).
   b. In-class discussion – discuss scenarios of what is acceptable and not acceptable as related to the specific class. (Note: it is not possible to describe every unacceptable scenario. You can only try to distinguish the "spirit of the law" and give students guidance on your expectations, not define every unacceptable act. They can always think of another you have not mentioned). We have developed these specific examples into a skit (and subsequently a video).
   c. Discuss consequences and risks of these behaviors.
   d. Discuss the NCSU Code of Student Conduct and/or the Code of Ethics of your professional society.

4. **Document control**

   a. Avoid repeating homework and exam problems. Students keep and pass around hard copies and electronic versions of assignments. Keep a spreadsheet of problems from the text that you assign, and try to not repeat problems too often.
   b. Avoid posting solutions to homework or tests in electronic form. (Some students will print out solutions to the course they are taking next semester, and anything on the web becomes available to the world). If you must post solutions, use a locked bulletin board.
   c. Have students hand in a CD with their lab, design report, project, etc. so that you can compare with subsequent reports if necessary. This is particularly important with lab experiments that are performed every semester.

5. **Tests**

   a. Have students complete tests in blue books or colored paper that you distribute.
   b. No cell phones or electronic devices.
   c. Be sure to have sufficient proctor coverage. Actively walk around the room and make eye contact with individual students. Following the exam, log in which students took the exam.

6. **Train TA's and faculty graders to recognize cheating**

   a. Handwritten homework assignments – have one person grade all of one problem. Draw a red line down the rest of a blank page. Have students write only on one side of their paper.
   b. Excel assignments – check authorship of files, time and date created.
   c. Lab write-ups – compare against lab manual and other reports.

7. **Hold students accountable if there are incidents of misconduct**

   a. Initiate student conduct proceedings.
   b. Give feedback to the class about violations right away instead of waiting to see if other students will make the same mistake.

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* Lisa G. Bullard, Dept. of Chemical & Biomolecular Engineering, N.C. State University

Examples of syllabus language that addresses academic integrity

Example 1:

Academic integrity. Students should refer to the University policy on academic integrity found at <*http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php*>

It is the instructor's understanding and expectation that the student's signature on any test or assignment means that the student contributed to the assignment in question (if a group assignment) and that they neither gave nor received unauthorized aid (if an individual assignment). **Authorized aid on an individual assignment includes discussing the interpretation of the problem statement, sharing ideas or approaches for solving the problem, and explaining concepts involved in the problem. Any other aid would be unauthorized and a violation of the academic integrity policy.** All cases of academic misconduct will be submitted to the Office of Student Conduct. If you are found guilty of academic misconduct in the course, you will receive a zero for that component of the grade (e.g. if you are found guilty of cheating on a homework assignment, you will receive a zero for 20% of your grade). In addition, you will be on academic integrity probation for the remainder of your years at NCSU and may be required to report your violation on future professional school applications. It's not worth it!

Example 2:

All work that you turn in for grading must be your own (this means that it is an independent and individual creation by you). Any attempt to gain an unfair advantage in grading, whether for oneself or for another, is a breach of academic integrity and will be reported to the Office of Student Conduct. **Penalties for cheating can be as severe as suspension from the university. Students who are found cheating on a project or test will receive a grade of –100% (negative 100 percent) for that work. Turning in code that is written by other students is considered cheating. Giving code for other students to turn in is considered cheating.** Cheating is simply not worth it. **Cheating is much worse than not turning in an assignment at all.** Cheating penalties are severe. They are permanent. The CSC department used special software to detect cheating violations for programming projects. In Spring 2004, approximately 60 students were charged with academic integrity violations. All of those students are on permanent academic probation. We will be using that same software this semester.

Examples of cheating. Some examples of behaviors that constitute cheating are as follows:

- It is cheating to give any student access to any of your work which you completed for class assignments. Your campus account is for your use alone.
- It is cheating to use another person's work, either an assignment or a test, and claim that it is your own. In all cases, you are expected to complete an assignment on your own.
- It is cheating to attempt to interfere with other students' use of computing facilities or to circumvent system security.
- It is cheating to mail copies of your work to another student, to use ftp to get another student's work, or to put your work out for others to obtain via the World Wide Web or other bulletin board type services.
- It is cheating to give another student access to your directories and/or the password to your account.
- It is cheating for you and another student to work on the same file to turn in for an assignment. You may not work in conjunction with other students on the EOS system or on home computing system files to be ported to EOS.

Useful Resource: Center for Academic Integrity, <*http://www.academicintegrity.org/index.asp*>. A Duke University facility that provides numerous resources for addressing misconduct problems at institutional levels and in individual classrooms.

Crisis Clinic

Why me, Lord?

An agitated student comes into your office, begins to discuss the quiz he just did so poorly on, and then in a broken voice tells you that he had a B average coming into this semester and he's now failing all his courses and doesn't know what he's going to do. He makes an effort to pull himself together, apologizes for taking up your time, and gets up to leave.

What might you do?

WHY ME, LORD?*

Richard M. Felder
North Carolina State University

Charlie, a student in your first-semester sophomore course, stands in front of your desk in obvious distress. He starts talking about the test he just failed, and then he tells you that he had a B average in his freshman year but things are falling apart this semester and he's failing most of his courses. As he talks, he gets more agitated and seems to be fighting back tears. Then it's as if he suddenly thinks "Hey, this is my professor—I can't lose it right in front of him." He makes a heroic effort to pull himself together, apologizes to you for taking your time, and turns and heads for the door. What should you do?

This is one of several scenarios in the "Crisis Clinic" segment of the teaching workshops Rebecca Brent and I give. After presenting it, I assure the participants that it is not hypothetical—if they haven't seen Charlie in their office yet it's just a matter of time. I first ask them to discuss in small groups their responses to "What should you do," and then I tell them the step-by-step procedure I follow in situations like that. Before I tell you, why don't you take a moment and think about what you would do (or what you did if you've already met Charlie).

* * *

Here's my algorithm.

1. *I stop the student from leaving.*

If he leaves your office, you've lost your best opportunity to do anything useful to help. Say something like "*Hang on a minute, Charlie—I've got some time now and I'd really like to find out more about what's going on. Have a seat*." He will almost certainly take you up on it. He's clearly desperate, and if you indicate that you're willing to listen to him he'll probably grab the offer with gratitude.

2. *I reach into the left middle drawer of my desk, take out a box of tissues, and put it down in front of the student without saying a word.* (That part is optional—don't do it if you're not comfortable with it.) *Then I take a seat near him and wait until he regains control.*

I'm giving two messages when I do this. First, Charlie doesn't have to hold himself back any longer—if he wants to let go, it's permissible. Second, he's not the first student who's ever been in this situation in my office—I'm ready for this! Sometimes students use the tissues, sometimes they don't. Either way is fine—I just want them to know that they can.

3. *I say "OK, Charlie—tell me a little about what's been going on in your life."*

There are many things I might hear. Charlie might simply be over his head academically, or he may have gotten behind early in the semester and can't manage to catch up, or he may be overloaded with work and/or extracurricular activities and is too exhausted to study or to be at his best on exams, or his learning style may be incompatible with the way his courses are being taught, or he could be homesick or anxious about a health problem or a death in the family or the breakup of a relationship, or he may be worried about losing the scholarship that's keeping him

* *Chem. Engr. Education, 41*(4), 239-240 (2007).

in college, or he may have gone into engineering for reasons other than interest or aptitude (such as the promise of a high starting salary or because his father told him to become an engineer) and he actually hates it, or he could be abusing drugs or alcohol. Another possibility is that he is clinically depressed and has stopped taking his medications or has never been diagnosed and treated. Whatever he says, I listen and continue to gently probe until I believe I have the whole story, or as much of it as Charlie is willing to share.

What I do next of course depends on what the story is. If it looks like a straightforward academic problem, I may try to persuade Charlie to get some tutoring in the courses he's having trouble with (in my upper right-hand drawer I have a list of campus resources with contact information for all the tutoring and academic counseling programs available to engineering students) or I may decide to do some tutoring myself if I have the time and inclination. As a rule, though, when a student falls apart to the extent described in the scenario, something else is almost inevitably going on.

In the workshop, I ask the participants to suppose that this is the case—Charlie is clearly in a serious state of depression or anxiety related to a current crisis in his life or to a chronic condition. Then I ask, what *don't* you do at this point? How would you answer that question?

The answer is, you don't behave like an engineer and start to problem-solve—which is to say, you don't play therapist. You don't say "*Charlie, I think I know what's going on here. This looks like a severe case of paranoic schizophrenia—I just read about that in* Psychology Today. *Let me tell you what I think you should do.*" Forget that! Your diagnosis could be wrong—it's almost guaranteed to be wrong—and if Charlie takes your advice and it seriously backfires, you don't want to live with the consequences. So, what do you do?

4. *Get Charlie into the hands of a qualified counselor.*

Most universities and colleges have counseling centers, some with counselors on call 24/7, and most smaller institutions have at least one individual available to provide counseling. Your job is to persuade Charlie to take advantage of this service. You have to be careful about how you do it, though: saying "Boy, are you messed up—you'd better get to a shrink as quickly as you can!" will probably not get you where you want to go.

I generally approach it like this. I first repeat Charlie's story to him to make sure I got it right, getting him to correct me if necessary. Then I say "*OK, Charlie—I understand the problem, and it's a real one. But what you need to know is that you're not the first student on this campus in this situation—it's far more common than you would imagine—and we have excellent counselors here who know good strategies for dealing with problems like this. I'd like you to talk to one of them and find out what your options are*." Then I go to my upper right-hand drawer, pull out the number of the Counseling Center, and try to persuade Charlie to call right then and make an appointment—or if the way he's been talking or acting suggests that he may be suicidal or a threat to someone else or simply in acute distress, I will walk with him to the Counseling Center, continuing to talk calmly and reassuringly to him and not leaving him until he is with a trained counselor. At that point I'm almost finished.

Of course you can't force students into counseling—all you can do is persuade, and some may refuse (although most of the students I have tried to persuade have agreed to go). If that happens, all I can do is proceed to Step 5—unless again I believe that Charlie is a threat to himself or to others, in which case I will call the Counseling Center or Campus Security and let them know what's going on so they can do their own checking and intervene if necessary. (I have never had to do that, but it can happen.) In any case, the last step is:

5. *Follow up.*

I make a point of periodically checking in with Charlie for at least several months after that initial meeting. "*Hey, Charlie—how are you doing? What's happening with that problem we talked about? Did you meet with the counselor—how did it go*?" Many depressed students who drop out or worse feel isolated, sensing that no one knows or cares what's going on with them. The knowledge that at least one of their teachers is concerned enough to inquire about them could go a long way toward helping them recover and start functioning effectively in their courses again. At that point, I'm finished—regardless of what happens to Charlie, I can rest comfortably knowing that I have done all I can for him.*

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* Like all professors I'm occasionally forced to act as a counselor and like most of them I was never trained for this role, so I asked several excellent psychotherapists—Elena Felder, Grace Finkle, Denise Moys, and Sheila Taube—to look over this column before I sent it in. I acknowledge with gratitude their helpful comments and suggestions.

Chem. Engr. Education, 22(4), 168–169 (Fall 1988).

IMPOSTORS EVERYWHERE

Richard M. Felder
North Carolina State University

He knocks on my office door, scans the room to make sure no one else is with me, and nervously approaches my desk. I ignore the symptoms of crisis and greet him jauntily.

"*Hi, Don—what's up?*"

"*It's the test tomorrow, Dr. Felder. Um...could you tell me how many problems are on it?*"

"*I don't see how it could help you to know, but three.*"

"*Oh. Uh...will it be open book?*"

"*Yes—like every other test you've taken from me during the last three years.*"

"*Oh...well, are we responsible for the plug flow reactor energy balance?*"

"*No, it happened before you were born. Look, Don, we can go on with this game later but first how about sitting down and telling me what's going on. You look petrified.*"

"*To tell you the truth, sir, I just don't get what we've been doing since the last test and I'm afraid I'm going to fail this one.*"

"*I see. Don, what's your GPA?*"

"*About 3.6, I guess, but this term will probably knock it down to...*"

"*What's your average on the first two kinetics tests?*"

"*92.*"

"*And you really believe you're going to fail the test tomorrow?*"

"*Uh....*"

Unfortunately, on some level he really does believe it. Logically he knows he is one of the top students in the department and if he gets a 60 on the test the class average will be in the 30's, but he is not operating on logic right now. What *is* he doing?

The pop psychology literature calls it the *impostor phenomenon*.[*] The subliminal tape that plays endlessly in Don's head goes like this:

I don't belong here...I'm clever and hard-working enough to have faked them out all these years and they all think I'm great but I know better...and one of these days they're going to catch on...they'll ask the right question and find out that I really don't understand...and then...and then....

The tape recycles at this point, because the consequences of *them* (teachers, classmates, friends, parents,...) figuring out that you are a fraud are too awful to contemplate.

I have no data on how common this phenomenon is among engineering students but when I speak about it in classes and seminars and get to "...and they all think I'm great but I know better," the audience resonates like a plucked guitar string—students laugh nervously, nod their heads, turn to check out their neighbors' reactions. My guess is that most of them believe deep down that those around them may belong there but they themselves do not.

They are generally wrong. Most of them do belong—they will pass the courses and go on to become competent and sometimes outstanding engineers—but the agony they experience before tests and whenever they are publicly questioned takes a severe toll along the way. Sometimes the toll is too high:

[*] Pauline R. Clance, *Impostor Phenomenon: Overcoming the Fear that Haunts Your Success*, Peachtree Pubs., 1985.

even though they have the ability and interest to succeed in engineering they cannot stand the pressure and change majors or drop out of school.

It seems obvious that someone who has accomplished something must have had the ability to do so (more concisely, you cannot do what you cannot do). If students have passed courses in chemistry, physics, calculus, and stoichiometry without cheating, they clearly had the talent to pass them. So where did they get the idea that their high achievements so far (and getting through the freshman engineering curriculum is indeed a high achievement) are somehow fraudulent? Asking this gets us into psychological waters that I have neither the space nor the credentials to navigate; suffice it to say that if you are human you are subject to self-doubts, and chemical engineering students are human.

What can we do for these self-labeled impostors?

- *Mention the impostor phenomenon in classes and individual conferences and encourage the students to talk to one another about it.*

There is security in numbers: students will be relieved to learn that those around them—including that hotshot in the first row with the straight-A average—have the same self-doubts.

- *Remind students that their abilities—real or otherwise—have sustained them for years and are not likely to desert them in the next 24 hours.*

They won't believe it just because you said so, of course—those self-doubts took years to build up and will not go away that easily—but the message may get through if it is given repeatedly. The reassurance must be gentle and positive, however: it can be helpful to remind students that they have gone through the same ritual of fear before and will probably do as well now as they did then, but suggesting that it is idiotic for a straight-A student to worry about a test will probably do more harm than good.

- *Point out to students that while grades may be important, the grade they get on a particular test or even in a particular course is not that crucial to their future welfare and happiness.*

They will be even less inclined to believe this one but you can make a case for it. One bad quiz grade rarely changes the course grade and even if the worst happens a shift of one letter grade changes the final overall GPA by about 0.02. No doors are closed to a student with a 2.84 GPA that would be open if the GPA were 2.86. (You may not think too much of this argument but I have seen it carry weight with a number of panicky students.)

- *Make students aware that they can switch majors without losing face.*

It is no secret that many students enter our field for questionable reasons—high starting salaries, their fathers wanted them to be engineers, their friends all went into engineering, and so on. If they can be persuaded that they do not *have* to be chemical engineers (again, periodic repetition of the message is usually necessary), the consequent lowering of pressure can go a long way toward raising their internal comfort level, whether they stay in chemical engineering or go somewhere else.

Caution, however. Students in the grip of panic about their own competence or self-worth should be deterred from making serious decisions—whether about switching curricula or anything else—until they have had a chance to collect themselves with the assistance of a trained counselor.

One final word. When I refer at seminars to feeling like an impostor among one's peers, besides the resonant responses I get from students I usually pick up some pretty strong vibrations from the row where the faculty is sitting. That's another column.

Chem. Engr. Education, 35(4), 266-267 (2001)

FAQs. IV. DEALING WITH STUDENT BACKGROUND DEFICIENCIES AND LOW STUDENT MOTIVATION

Richard M. Felder and Rebecca Brent
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Students can be frustrating, as evidenced by the fact that the next two in our list of frequently asked questions at workshops are among the most common we get.

- I tried putting my students to work in groups but some of them hated it and one complained to my department head. *What am I supposed to do about student hostility to teaching methods that make them take responsibility for their own learning?*
- Many of my students are (a) unmotivated, (b) self-centered, (c) apathetic, (d) lazy, (e) materialistic, (f) unprepared, (g) unable to do high school math, (h) unable to write, (i) unable to read, (j) spoiled rotten. (Pick any subset.) *How can I teach people who don't have the right background or the willingness to work or even the desire to learn?*

We have written elsewhere about student resistance to non-traditional instruction—why it occurs, what forms it takes, and how to defuse it.[2] The remainder of this column deals with the second question.

The problems of poor student motivation and preparation are challenging. Certainly there are some students in our courses who appear to be uninterested in the subject, unwilling to work at it, and clueless about things they were supposed to have learned in prerequisite courses or high school. There may be even more students like that now than there were 20 years ago (as many older professors claim), although this trend is more likely due to a shift in entering college student demographics than to a general weakening in the moral fiber of today's youth. But while grumbling about the students (and the high schools or Ted Kennedy or Jesse Helms or whoever else we hold responsible for widespread moral fiber decay) may have some therapeutic benefit, it doesn't solve anything. For better or worse, these students are the ones we have to work with—we can't write off an entire generation and hope for better things from the next one.

A more productive approach is to take our students where they are and find ways to overcome whatever shortcomings in preparation or motivation they may have. It's not impossible—professors at every university and college do it all the time. If you think about your faculty colleagues, you can surely come up with one or two who set high standards that most of their students regularly meet and exceed, who consistently get top ratings from students and peers, and about whom the alumni talk reverently years and decades after graduation. These professors are obviously doing *something* to reach the same students whose lack of motivation and deficient backgrounds their colleagues keep complaining about. What is it?

Motivating students to learn

Student motivation in a class generally falls into three broad categories. Some students have a high level of interest in the course topic and will study it intensively regardless of what the instructor does or fails to do. No special motivation is necessary for these students—the two of them will do fine on their own. Others have a complete lack of aptitude for the subject and/or a deep-seated antipathy toward it, but the course is required for their degree and so there they sit, defying the instructor to teach them anything. Trying to motivate *these* charmers may be more trouble than it's worth, but (at least in engineering courses) there are fortunately not many of them either. Still others—usually a large majority—are in the third category: they don't have a burning interest in the subject but they also don't hate it and they have the ability to succeed in it. How the instructor teaches can profoundly affect how these students approach the course.

In another column[3] we discussed what educational psychologists have termed a “deep approach” to learning. Students who take this approach do whatever it takes to gain a conceptual understanding of the subject being taught. They routinely try to relate course material to other things they know, look for applications, and question conclusions—precisely the kinds of things that the students whose lack of motivation we complain about never do.

Certain course attributes have been found to correlate with students taking a deep approach,[3] suggesting that the key to motivating students in that large third category might be to build as many of those attributes into our courses as we can. The attributes are **(a)** *clear relevance of the course material to familiar phenomena, material in other courses the students have taken or are currently taking, and problems they will be called upon to solve in their intended careers*; **(b)** *explicit statements of the knowledge and skills the students are expected to acquire*, which may take the form of instructional objectives[4] or detailed study guides for exams; **(c)** *assignments that provide practice in the skills specified in the objectives and are not too long*, so that the students have time for the studying and reflection entailed in a deep approach; **(d)** *some choice over learning tasks* (e.g., a choice between problem sets and a project); and **(e)** *well-designed tests that are clearly grounded in the objectives* (no surprises or tricks) *and can be finished in the allotted time*. (For more details, see Reference 3.) Building those things into your course may take some work but will probably motivate enough of your students to allay any concerns you may have about their generation.

Teaching Underprepared Students

What about the students who come into your class having successfully completed prerequisite courses but apparently having absorbed little or nothing from them? Again, blaming the instructors who taught the prerequisites (who “passed students they clearly should have failed”) or the Math Department (which “doesn’t know how to teach calculus to engineers”) or the K–12 system (which “doesn’t know how to teach anything”) is easy but doesn’t help with the immediate problem. The fact is, these students are in your class now and somehow you’ve got to teach them, and you don’t want to spend the first three weeks of the course re-teaching what they were supposed to know on Day 1. What can you do?

Here’s a technique that works well. On the first day of class, announce that the first exam in the course will be given in the following week and will cover only the prerequisite material. Hand out a study guide containing instructional objectives[4] for that exam, including only the knowledge and skills required for your course and not everything in the prerequisite course text. Further announce that you will not lecture on that material but will be happy to answer questions about it in class or during your office hours. (You may also choose to hold an optional review session.) Then start the course. Most of the students will manage to pull the required knowledge back into their consciousness by the day of the exam, and the few who fail will be on notice that they could be in deep trouble and might think about dropping the course and doing whatever it takes to master the prerequisites by next semester.

You might also try to persuade your colleagues who teach the prerequisite courses to adopt some of those methods that induce students to take a deep approach to learning. If they do that, the problem in your course could take care of itself.

References

1. R.M. Felder and R. Brent, “Navigating The Bumpy Road to Student–Centered Instruction,” *College Teaching, 44* (2), 43–47 (1996). Available on-line at < *http://www.ncsu.edu/felder-public/Papers/Resist.html*>.
2. R.M. Felder, “Meet Your Students. 3. Michelle, Rob, and Art,” *Chem. Engr. Education,24*(3), 130–131 (1990). Available on-line at the URL in Reference 1.
3. R. Brent and R.M. Felder, “Objectively Speaking,” *Chem. Engr. Education, 31*(3), 178–179 (1997). Available on-line at the URL in Reference 1.

Additional Resources on Advising and Classroom Management

Advising and Student Support

- Felder, R.M., & Stice, J.E. "Tips on test-taking." Good practices in preparing for tests and taking them. <*http://www.ncsu.edu/felder-public/Papers/testtaking.htm*>.
- Felder, R.M. (1999). "Memo to Students Who Are Disappointed with Their Last Test Grade." *Chem. Engr. Education, 33*(2), 136-137. Suggestions for improving test grades. <*http://www.ncsu.edu/felder-public/Columns/memo.html*>.
- Felder, R.M. (2003). "How to Survive Engineering School." *Chem. Engr. Education, 37*(1), 30–31. Success strategies for engineering students (and all other students). Access at <*http://www.ncsu.edu/felder-public/Columns/Surviving-School.html*>.
- Wankat, P.C. (2002). *The effective, efficient professor.* Boston: Allyn & Bacon. Chapter 7: Rapport with students and advising.

Academic Misconduct (Cheating)

- *Center for Academic Integrity*, <*http://www.academicintegrity.org/index.asp*>. A Duke University facility that provides numerous resources for addressing misconduct problems at institutional levels and in individual classrooms.
- Svinicki, M., & McKeachie, W.J. (2011). *McKeachie's teaching tips: Strategies, research, and theory for college and university teachers* (13^{th} ed.), pp. 95–99. Florence, KY: Cengage Learning.

Classroom Management

- Svinicki, M., & McKeachie, W.J. (2011). *McKeachie's teaching tips: Strategies, research, and theory for college and university teachers* (13^{th} ed.). Chapter 13: Dealing with student problems and problem students (there's almost always at least one). Florence, KY: Cengage Learning.

D. How Can I Maximize My Research Productivity

Early Research Options.* Three basic ways to structure early research programs:

1. **Staying the course:** Continuing to work in the area of the Ph.D. dissertation and/or postdoctoral research.
   a. *Best Case Scenario:* You develop real expertise in your research area and find funding easily because of your strong track record and reputation in the professional community. If you're in a really hot or highly productive area, you build a strong program centered around related work making it easier to have your research team help each other and piggyback on each other's work.
   a. *Worst Case Scenario:* If you stay in exactly the same track as your earlier work, you may be accused of simply re-doing your dissertation, and you will probably find yourself competing with your former advisor and other well-established faculty for research funding. The research landscape may change leaving you stuck with only one area of expertise.

2. **I've got what you need:** Taking specific tools used in your earlier work (like Java programming or statistical expertise) and applying them in a variety of collaborative projects.
   a. *Best Case Scenario:* You can explore a variety of fields and projects with collaborators. You develop expertise using your tools and understand them in a deep way because of experience with different applications. You take the lead in larger scale projects by assembling a diverse team.
   b. *Worst Case Scenario:* You could always be a junior collaborator and fail to develop your own program. Since collaboration is challenging, you could have trouble finding good people to work with. It could be more difficult to get your students working together productively since their projects may be very different from each other.

3. **Changing horses:** Moving into a new research area.
   a. *Best Case Scenario:* You get some initial funding in the areas related to your previous work to capitalize on your experience. You find a mentor with experience and a track record in the research area you want to go into giving you the chance to build up your expertise and credentials. Eventually you are independently able to secure funding and pursue research in the new area.
   b. *Worst Case Scenario:* You try to break into the new area on your own or with a weak collaborator. You find yourself unable to secure funding because of your lack of a track record, and you can't establish your program quickly enough for career success.

Some viable options.

- Initially stay the course, but gradually move into other areas after 2-3 years
- Change horses, but begin in collaboration with an established expert. Progressively differentiate your work & take leadership in projects.
- Bring your tools to other projects, but make sure you take the PI role in some of them.

* Rebecca Brent, Education Designs, Inc.

Promoting Your Research and Recruiting Students

Project Title: Permeabilities and diffusivities of gaseous permeants in polymeric membranes
Principal Investigator: Arvin Schmaltzig

The permeation of a gas through a tubular polymeric interface is described by the following equation:

$$\frac{\partial C}{\partial t} = \frac{D}{r}\frac{\partial}{\partial r}\left(r\frac{\partial C}{\partial r}\right)$$
$$t = 0, C = 0$$
$$r = r_1, C = Sp_1$$
$$r = r_2, C = 0$$

We have assumed that the inner surface of the membrane is abruptly exposed to a gas in which the permeant partial pressure is p_1, and the outer surface is exposed to a gas in which the permeant concentration is maintained low enough to be considered effectively zero. The permeant dissolves at the inner surface of the membrane (Henry's law solubility = S) and the dissolved permeant whose concentration is $C(t,r)$ diffuses through the membrane (Fickian diffusion coefficient = D), desorbs, and enters the gas at the outside surface. We neglect mass transfer resistance at both membrane surfaces. The permeation rate through the membrane is

$$Q(t) = -D(2\pi r_2 L)\left(\frac{\partial C}{\partial r}\right)_{r=r_2}$$

where L is the tube length. It is well known that the permeability of the permeant, $P = DS$, can be determined from the steady state value of the permeation rate, $Q(t \to \infty)$. In a recent paper, we demonstrated that the diffusivity can be determined as a simple function of the zeroth moment of the normalized inverse permeation rate,

$$D = f\left[\int_0^\infty \left(1 - \frac{Q(t)}{Q(t \to \infty)}\right) dt\right]$$

In the research to be performed, a continuous permeation tube will be exposed to several different permeants at several temperatures, and the transient permeant flux will be monitored and analyzed to validate the ideal solution-diffusion model and to determine permeant diffusivities and solubilities at the temperatures studied. Flow rate variations will be used to test the assumption of the neglect of mass transfer at high flow rates, and if the permeation rate varies with flow rate at low flow rates, further analysis will be performed to estimate the effective boundary layer mass transfer coefficients. The implications of the results for determining concentrations of trace pollutants in stack gases will be explored.

Project Title: Design of a polymeric gas sampling interface for monitoring waste gas emissions in highly polluted environments
Principal Investigator: Arvin Schmaltzig

Measuring emissions of toxic pollutants (say, H_2S) in stack discharges from industrial processes is an important and difficult task. The filthy and corrosive atmospheres in many stacks can easily destroy conventional sampling instruments in a short period of time. The development of an accurate stack gas analysis method that functions reliably for long periods of time under such conditions would be a major advance for environmental protection.

We recently proposed using a corrosion-resistant polymeric material like teflon as an interface for stack gas sampling. A U-tube containing a section of the polymer is inserted in the stack and a clean carrier gas flows through the inside. The hydrogen sulfide in the stack dissolves at the outside tube surface, diffuses through the tube wall, and emerges into the carrier gas, which flows to an analyzer capable of measuring hydrogen sulfide concentrations down to parts-per-billion levels. If the device works as intended, particulate matter in the stack would simply bounce off the tube (which functions as a non-stick surface in a skillet) and acid gases in the stack would similarly have little corrosive effect on the polymer.

Designing an instrument for a specific application of this technique means that the relationship between the permeant (pollutant) concentration in the stack and the flux of the permeant through the tube wall must be known as a function of stack gas temperature and pressure. Recent theoretical work conducted by our research group has established this relationship, and has shown that the solubility and diffusivity of gases in a polymer can be determined from measurements of transient permeation rates through a membrane exposed to a step concentration change at one of its surfaces. The research to be carried out will involve the following steps:

- Design and construct a continuous-flow permeation cell and use it to demonstrate the feasibility of the proposed stack sampling technique.
- Carry out permeation rate measurements for a permeant of environmental importance (probably sulfur dioxide) to validate the ideal solution-diffusion model on which the previous analysis was based and to determine the permeant diffusivities and solubilities as a function of temperature and carrier gas flow rate. (These data do not now exist in the literature and would be valuable additions to it.) Extend the prior analysis to determine effects of mass transfer resistance in the carrier gas on the permeation rate.
- Build a stack sampling interface and test it in a real stack environment. (Arrangements for this portion of the research have already been made with a nearby sulfuric acid manufacturing facility.)

The student working on this project will gain experience in measuring and modeling membrane transport phenomena (which have environmental applications but are also important for such things as gas separations, food packaging, and controlled drug delivery) and in monitoring emissions of trace pollutants in industrial gas discharges. Funding from the Environmental Protection Agency will begin in January.

Organizing an Effective Research Project Description

Whether you're trying to persuade a search committee to offer you a faculty position, a funding agency program director to award you a research grant, or new graduate students to sign on with you as a research advisor instead of one of your more famous and experienced colleagues, you need to sell your research. The first of the two project descriptions just given does a terrible selling job; the second one is much better. Here is a suggested framework for a project description:

- What is the general topic? Why is it important to science or sociology or general education or society?
- What problem is this research going to help solve? Why is *it* important?
- What approach will be taken? Experiments conducted? Models developed?
- How will the results contribute to the solution of the research problem?
- What knowledge and skills will the graduate student develop?
- If the research is part of a continuing project, where does the project stand?
- Is funding available now? If not, how likely is it to become available?

Avoid elaborate descriptions of quantitative and/or qualitative and/or statistical procedures and long detailed summaries of background literature, but be prepared to discuss those things if someone asks you about them.

Meeting with Prospective Graduate Students

- Be friendly & courteous. Find out about their backgrounds and interests.
- Re-emphasize the importance of your research to your field or society and the skills that the student will develop in the course of doing the research
- Minimize technical and mathematical details (be ready to discuss them if asked)
- Show enthusiasm! If you're not enthusiastic about the research, why should they be?
- Communicate your expectations and desires for every graduate student in your research team. (See Laurie Williams' Ph.D. Completion Milestones on the next page for an example of how to do it.)

Involving Undergraduates in Your Research

The best undergraduates at most universities are as smart or smarter than most graduate students. Consider putting their talent to work for you by involving them in your research.

- Identify *good* undergraduates and actively recruit them (especially if you're just starting your research program and are struggling to attract graduate students). Beware of weak ones—they can be a major time drain.
- If your department has an REU (Research Experience for Undergraduates) grant, sign up to participate in it.
- Define a task they can learn to do quickly. Help them build their learning through their work.
- If you have graduate students or postdocs, assign them to mentor the undergraduate researchers.
- If you are teaching a course related to your research area, consider giving assignments and projects that help the students develop important skills and at the same time contribute to your research.

Building an Effective Research Environment

Research environments vary considerably from one discipline to another, but certain common elements are needed to make them as effective as they can be. They can (a) be organized and orderly, or chaotic and unsafe; (b) be collegial and cooperative, or competitive and combative; (c) produce M.S. and Ph.D. graduates in reasonable times, or students who switch to other advisors or leave school without their degrees

Creating an effective, professional, and welcoming research environment

- *Discuss your desired reporting and writing strategies.* Written updates? Lab notebooks? (Give them one on the graduate students' first day.) Oral reports? How often? One-on-one or to the research team? Structure of the dissertation? Expected frequency of presentations and papers?
- *Meet regularly with each of your RAs.*
  - get progress reports
  - discuss future research & writing plans
  - advise, consult, encourage, applaud, share,…
  - fit frequency of meetings to student's needs
- *Hold regular research team meetings.* Designate a facilitator to set the agenda and guide each meeting, and rotate this role.
  - research updates
  - literature reviews
  - conference reports
  - sharing successes & problems
  - planning for the future (involve everyone!)
- *Be sensitive to students' course pressures, especially in their first 1–2 years.*
  - Plan research responsibilities around exams.
  - Help relate research to coursework.
  - Keep track of students' performance in classes.
  - **Don't discourage them from taking courses.** Graduate school provides a unique opportunity for students to learn from experts in all fields. Don't deprive them of this opportunity because you want them to spend every waking hour working on their dissertation research. That might be in your best interests, but it's not in theirs.
- *Maintain good lab maintenance and safety practices.*
- *Encourage a professional environment, & avoid cliques*. Build an appreciation for differences (minorities, international students).
- *Make sure everyone treats staff (secretaries, technicians) respectfully.* Discourtesy to anyone is always wrong, and discourtesy to department staff can lead to serious breakdowns in the efficiency and effectiveness of a research program (particularly the research of those being discourteous).

The three roles of an advisor. Blend them, switch between them when appropriate.

1. **Boss.** Set expectations and rules, allocate resources, monitor and maintain order and safety, approve papers, theses, and dissertations. This role is important early in the graduate program and should diminish with time.

2. **Mentor**. Provide training and guidance in

   - grant writing
   - paper writing
   - reviewing papers and grants
   - effective presentation techniques
   - teaching strategies
   - tips for job interviews
   - research ethics

   This role is critical throughout the graduate program and may go on for years after graduation.

3. **Colleague.**

   - Give students responsibility & trust.
   - Share recognition with them.
   - Introduce them as colleagues.

   This role should be the dominant one toward the end of the doctoral program and thereafter.

Avoiding problems in research programs, and dealing with them when they arise

- Make sure research questions & plan of work are clear to RA's.
- Involve RA's in the whole research process, including budget management.
- Consult as much as possible, don't supervise unless absolutely necessary.
- Take the graduate students' ideas seriously.
- Meet monthly with them in groups for brief progress reports.
- *Stay on top of the budget*.
- Be open to changes in the research plan when they become necessary.
- Get RA's to do first drafts of all papers, presentation abstracts.
- When appropriate, make them first authors.
- Have them present, and don't be too quick to rescue.
- *Facilities/equipment problems* (always!). Explore using equipment in other laboratories.
- *A student leaves the program*. Most contracting agencies will understand if you inform them as soon as possible.
- *Plagiarism and forged (desired) results.* Constantly challenge students to justify their results (set the example—challenge your own results). There are no correct results, only validated results.
- *The students won't work together*. Follow suggestions on p. H7.
- *Students have personal problems*. Be understanding and supportive, but don't play therapist. Be prepared to refer them to appropriate campus resources, such as the Counseling Center.
- *Their work does not meet your expectations*. Criticize what they do but never who they are (they can change what they do).
- *The research isn't working or the environment has changed.* Know when to switch topics.
- **Do all those things that were suggested to build a welcoming research environment!**

Crisis Clinic

It's just not happening

I've got to write papers at a breakneck pace and finish my book and get some proposals sent to have a chance at reappointment and tenure, but not much is going out the door. I'm really trying to write—what am I doing wrong?

HOW TO WRITE ANYTHING[*]

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> *I write when I'm inspired, and I see to it that I'm inspired at nine o'clock every morning.*
> (Peter De Vries)

Here's the situation. You're working on a big writing project—a proposal, paper, book, dissertation, whatever—and in the last five weeks all you've managed to get done is one measly paragraph. You're long past the date when the project was supposed to be finished, and you just looked at your to-do list and reminded yourself that this is only one of several writing projects on your plate and you haven't even started most of the others.

If you're frequently in that situation (and we've never met a faculty member who isn't) we've got a remedy for you. First, though, let's do some truth in advertising. Lots of books and articles have been written about how to write clear and persuasive papers, proposals, dissertations, lab reports, technical memos, love letters, and practically everything else you might ever need to write. We're not going to talk about that stuff: you're on your own when it comes to anything having to do with writing quality. All we're going to try to do here is help you get a complete draft in a reasonable period of time, because that usually turns out to be the make-or-break step in big writing projects. Unless you're a pathological perfectionist (which can be a crippling obstacle to ever finishing anything), once you've got a draft, there's an excellent chance that a finished document suitable for public consumption won't be far behind.

We have two suggestions for getting a major document written in this lifetime: (1) commit to working on it regularly, and (2) keep the creating and editing functions separate.[**]

Dedicate short and frequent periods of time to your major writing projects

See if this little monologue sounds familiar. "*I don't have time to work on the proposal now—I've got to get Wednesday's lecture ready and there's a ton of email to answer and I've got to pick the kids up after school tomorrow...BUT, as soon as fall break (or Christmas or summer or my sabbatical) comes I'll get to it*."

It's natural to give top priority to the tasks that can be done quickly or are due soon, whether they're important (preparing Wednesday's lecture) or not (answering most emails), and so the longer-range projects keep getting put off as the weeks and months and years go by. If a major project has a firm due date, you panic when it approaches and quickly knock something out well below the best you can do. If it's a proposal or paper, subsequent rejection should not

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[*] Chemical Engineering Education, 42(3), 139-140 (2008).

[**] We didn't invent either technique—you can find variations of both in many references on writing. A particularly good one is Robert Boice, *Professors as Writers.* Stillwater, OK: New Forums Press, 1990.

come as a surprise. If there is no firm due date, the project simply never gets done: the book you've been working on for the last ten years never gets into print, or your graduate students leave school with their research completed but without their Ph.D.s because they never finished their dissertations.

The strategy of waiting for large blocks of time to work on major writing projects has two significant flaws. When you finally get to a block, it's been so long since the last one that it can take hours or days to build momentum again and you're likely to run out of time before much gets written. Also, as soon as the block arrives other things rush in to fill it, such as your family, whom you've been neglecting for months and who now legitimately think it's their turn.

A much more effective strategy is to *make a commitment to regularly devote short periods of time to major writing projects.* Thirty minutes a day is plenty, or maybe an hour three times a week. One approach is to designate a fixed time period on specified days, preferably at a time of day when you're at your peak, during which you close your door, ignore your phone, and do nothing but work on the project. Alternatively, you might take a few 10–15 minute breaks during the day—times when you would ordinarily check your email or surf the Web or play Sudoku—and use them to work on the project instead. Either way, when you start to write you'll quickly remember where you left off last time and jump in with little wasted motion. When you've put in your budgeted time for the day, you can (and generally should) stop and go back to the rest of your life.

These short writing interludes won't make much difference in how many fires you put out each day, but you'll be astounded when you look back after a week or two and see how much you've gotten done on the project—and when a larger block of time opens up, you'll be able to use it effectively with very little warm-up. You can then be confident of finishing the project in a reasonable time...provided that you also take our next suggestion.

Do your creating and editing sequentially, not simultaneously

Here's another common scenario that might ring a bell. *You sit down to write something and come up with the first sentence. You look at it, change some words, add a phrase, rewrite it three or four times, put in a comma here, take one out there…and beat on the sentence for five minutes and finally get it where you want it. Then you draft the second sentence, and the first one is instantly obsolete and you have to rewrite it again...and you work on those two sentences until you're satisfied with them and go on to Sentence 3 and repeat the process...and an hour or two later you* may *have a paragraph to show for your efforts.*

If that sounds like your process, it's little wonder that you can't seem to get those large writing projects finished. When you spend hours on every paragraph, the 25-page proposal or 350-page dissertation can take forever, and you're likely to become frustrated and quit before you're even close to a first draft.

At this point you're ready for our second tip, which is to *keep the creating and editing processes separate.* The routine we just described does the opposite: even before you complete a sentence you start criticizing and trying to fix it. Instead of doing that, write whatever comes into your head, without looking back. If you have trouble getting a session started, write *anything*—random words, if necessary—and after a minute or two things will start flowing. If you like working from outlines, start with an outline; if the project is not huge like a book or dissertation and you don't like outlines, just plunge in. If you're not sure how to begin a project, start with a middle section you can write easily and go back and fill in the introduction later.

Throughout this process, you will of course hear the usual voice in your head telling you that what you're writing is pure garbage—sloppy, confusing, trivial, etc. Ignore it! Write the first paragraph, then the next, and keep going until you get as much written as your budgeted time allows. Then, when you come back to the project the next day (remember, you committed to it), you can either continue writing or go back and edit what you've already got—and then (and *only* then) is the time to worry about grammar and syntax and style and all that.

Here's what will almost certainly happen if you follow that procedure. The first few sentences you write in a session may indeed be garbage, but the rest will invariably be much better than you thought while you were writing it. You'll crank out a lot of material in a short time, and you'll find that it's much easier and faster to edit it all at once rather than in tiny increments. The bottom line is that you'll find yourself with a completed manuscript in a small fraction of the time it would take with one-sentence-at-a-time editing.

We're not suggesting that working a little on big projects every day is easy. It isn't for most people, and days will inevitably come when the pressure to work only on urgent tasks is overwhelming. When it happens, just do what you have to do without beating yourself up about it and resume your commitment the next day. It may be tough but it's doable, and it works.

E. Integration and Balance: The Keys to Faculty Success

Crisis Clinic

Was this in the contract?

Things are not exactly going according to plan:

- I’m spending hours and hours planning my lectures and assignments and tests. There’s very little time to work on the proposals and papers.
- I have to spend most of my time during the day in my office trying to get the research and teaching stuff done. People here are very nice, but I’m not getting much help from anyone—it feels like they just threw me in the deep end and it’s up to me to sink or swim.
- I also have to spend most of my time in the evening working on research and teaching. I don’t have much time for family and friends and exercise and recreation, even though I know how important they all are.
- I wonder if I’ve chosen the wrong profession.

Success Strategies for New Faculty

Message:

- People are not born knowing how to be professors. Trial-and-error may not be the most efficient way to learn.
- Most new professors take five years to reach full effectiveness. Some ("quick starters") do it in 1–2. We know a lot about what makes the difference.
- Low productivity in research is costly. So is ineffective teaching. Quick starters are valuable.
- Research productivity and teaching effectiveness both involve teachable skills. *Faculty development can produce quick starters*.

Untenured faculty stress points[a]

- Not enough time
- Inadequate feedback and recognition
- Unrealistic expectations
- Lack of collegiality
- Balancing work and life outside work

plus, for non-majority faculty (including women in traditionally male fields)[b]

- Chilly climate
- Excessive committee assignments
- Excessive student demands

Faculty in their first four years: Common mistakes and strategies for avoiding them[c]

- 95% of new faculty members make certain mistakes that cost them time, productivity, and sanity!
- We can identify the things the other 5%—the "quick starters"—do to avoid making these mistakes.
- *Mistake #1: Giving proposal and paper writing their highest verbal priority while spending relatively little time on them and producing relatively little.*
  - Concentrating on most pressing tasks (putting out fires).
  - Waiting for "blocks of time" to do "real writing."
  - <u>Results</u>: Lack of productivity, anxiety about it. Long warm-up time when blocks come.
- *Success Strategy #1: Schedule regular time for scholarly writing and keep track of it in time log.*
  - Schedule 30-45 minutes daily or 2–3 longer blocks weekly, at times of peak working efficiency.
  - Periodically keep log of time spent on all activities.
  - <u>Results</u>: Regular writing sessions help maintain momentum & minimize warm-up time; make steady progress, experience less anxiety. Time log helps keep priorities straight.

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[a] M.D. Sorcinelli, "New and Junior Faculty Stress: Research & Responses," *New Directions for Teaching and Learning*, No. 50, San Francisco: Jossey-Bass, 1992, pp. 27–37.

[b] J. Moody, *Demystifying the Profession: Helping Junior Faculty Succeed*, West Haven, CT: New Haven Press, 1997.

[c] The information about quick starters, the first three mistakes to be listed, and the strategies to avoid them are based on material in R. Boice, *Advice for New Faculty Members: Nihil Nimus*, Boston: Allyn & Bacon, 2000.

- *Mistake #2: Overpreparing for classes.*
  - Spend up to 27 preparation hours per week for a 3-credit course**;** equate good teaching with correct and complete content; try to be ready for any question.
  - Results: Rush to cover material, little chance for student questions and activities; little time for anything else (research, personal life).
- *Success Strategy #2***.** *Limit preparation time for class (especially after the first offering).*
  - Target: 2 hours preparation per hour of lecture. Keep track of time in time log.
  - Results: Less material in lecture notes, more time for questions and activities; less preparation time leaves more time for other professional and personal activities**.**
- *Mistake #3: Working non-stop and alone*
  - Wait for colleagues to make the first move.
  - Results: Few opportunities to learn the culture of the department, college, and university; failure to get support and help when both are available; sense of isolation.
- *Success Strategy #3***.** *Network at least two hours a week*
  - Visit colleagues, go to lunch, have a cup of coffee with colleagues in and out of the department; discuss research, teaching, campus culture**.** If you are offered a mentor, accept! If you aren't, try to find one (or two—one for research and one for teaching) yourself.
  - Results: Quickly learn culture, discover campus resources; cultivate allies and advocates.
- *Mistake #4: Working without clear goals and plans*
  - Accepting too many commitments that won't help achieve long-term goals; failing to take steps that will help.
  - Results: Becoming spread too thin; falling behind in tenure quest; uncertainty, anxiety, stress.
- *Success Strategy #4***.** *Develop clear goals and a plan to reach them*
  - Identify long-term objectives & what needs to happen in next three years to achieve them
  - Get feedback on plans from department head, mentor, other colleagues, and make adjustments
  - Periodically review progress (at least annually)
  - Results: Make commitments wisely, maximize chance for reaching goals

Faculty Guide to Time Management
or
How to simultaneously write proposals, do research, write papers, teach classes, advise students, grade papers, serve on committees, eat, sleep, and occasionally visit your family.[14]

Richard M. Felder and Rebecca Brent
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- Set 2–3 year goals along with reasonable steps necessary to reach them. For example
  1. Stay in good health
     — Exercise 3 times a week
     — Get sufficient sleep
     — ...
  2. Get promoted to associate professor
     — Write __ papers in refereed journals
     — Write __ proposals.
     — ...
  3. Learn to wind-surf
  4. Remain married
- Prioritize goals. Find an order that satisfies you now—you can always change it. *Suggestion*: Make staying in good health top priority—it will make the others possible.
- Develop a Gantt chart to track your progress in meeting your professional productivity goals.
- Create and frequently update a to-do list. Use a 4-quadrant system[15]:

  I. Urgent and important. (Deadline-driven activities that further your goals.)

  II. Important but not urgent. (Long-term professional, family, and personal activities that further your goals.)

  III. Urgent but not important. (Much e-mail, many phone calls and memos, things that are important to someone else but don't further your goals.)

  IV. Neither urgent nor important. (TV, computer games, junk mail.)

  Commit to several hours a week on Quadrant II items, and cut down on time spent in Quadrants III and IV.
- Work on Quadrant I and II items when you're at peak efficiency.
- If you're trying to write a book, put it on the Quadrant II list, otherwise it will never get written.
- Keep a log for time spent writing (30-45 minutes daily or longer blocks 2-3 times a week) and preparing for lectures (2 hours or less for each lecture hour) until the work pattern becomes a habit.[16]

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[14] P.C. Wankat & F. S. Oreovicz, *Teaching Engineering*, New York: McGraw-Hill, 1993. Chapter 2 contains excellent ideas on efficiency, some of which are included in this list.
[15] S.P. Covey, A.R. Merrill, and R.R. Merrill, *First Things Firs*t, New York: Simon & Schuster, 1994.
[16] R. Boice, *Advice for New Faculty Members*, Boston: Allyn and Bacon, 2000. This book is filled with terrific suggestions especially designed to help new faculty develop balanced work habits.

Office hours and mail

- Set office hours and let students know you will be faithful in keeping them. When students come to see you outside of office hours and you're busy, ask them if they can come back during office hours or make an appointment.
- Be mindful of time spent reading and responding to email. Limit response to email to one or two time periods each day. If you encourage email from students, have a special address set up for each class. Read and respond to student email no more than once or twice a day and let students know when you are likely to respond.
- Learn how to get people out of your office when you don't have the time to spend. ("Good talking to you, but I've got something I need to attend to now.")
- Meet in the other person's office, not yours. (Easier to get away.)
- Handle each mail item once, if possible. Open, respond, file, or discard.

Working smarter

- Schedule blocks of uninterrupted time to complete larger tasks. If necessary, work at home, in the library, or at an out-of-the-way desk in the department.
- Learn to type if you don't know how already and do your own manuscript composing on a word processor.
- Avoid perfectionism—don't keep revising until the deadline, and don't revise unimportant letters and memos at all. Be aware of the point of diminishing returns.
- Be careful of computer graphics—they're a time sink.
- Piggyback work—use the same notes or manuscripts for multiple applications.
- Keep research projects in the pipeline. Well before a project ends, start writing the next proposal.
- Reward yourself—take breaks.

Learn how and when to say no!

- Always give yourself a chance to think about a commitment overnight before agreeing to it. The time will give you a chance to see if it fits in with your goals and priorities.
- Keep an updated list of all your service responsibilities. Refer to it when the next request comes in.
- Check out service requests with your mentor or department head. Consider showing the latter your list if he or she is the one making the request.
- Practice declining requests:
  1. "That sounds interesting, but can I call you back tomorrow? I need a little time to think about it before I can decide."
  2. "I'm sorry, but I've just got too many other commitments right now."
  3. "I'd love to help, but I really don't have time for a formal commitment. Maybe we could just talk once or twice."
  4. "I'm afraid I'm not the best person to help you with this. Have you thought about asking ______?" (Penny Gold)

THINGS I WISH THEY HAD TOLD ME*

Richard M. Felder

Most of us on college faculties learn our craft by trial-and-error. We start teaching and doing research, make lots of mistakes, learn from some of them, teach some more and do more research, make more mistakes and learn from them, and gradually more or less figure out what we're doing.

However, while there's something to be said for purely experiential learning, it's not very efficient. Sometimes small changes in the ways we do things can yield large benefits. We may eventually come up with the changes ourselves, but it could help both us and our students immeasurably if someone were to suggest them early in our careers. For whatever they may be worth to you, here are some suggestions I wish someone had given me.

- *Find one or more research mentors and one or more teaching mentors, and work closely with them for at least two years.* Most faculties have professors who excel at research or teaching or both and are willing to share their expertise with junior colleagues, but the prevailing culture does not usually encourage such exchanges. Find out who these individuals are, and take advantage of what they have to offer, if possible through collaborative research and mutual classroom observation or team-teaching.

- *Find research collaborators who are strong in the areas in which you are weakest.* If your strength is theory, undertake some joint research with a good experimentalist, and conversely. If you're a chemical engineer, find compatible colleagues in chemistry or biochemistry or mathematics or statistics or materials science. You'll turn out better research in the short run, and you'll become a better researcher in the long run by seeing how others work and learning some of what they know.

- *Whenever you write a paper or proposal, beg or bribe colleagues to read it and give you the toughest critique they're willing to give.* Then revise, and if the revisions were major, run the manuscript by them again to make sure you got it right. THEN send it off. Wonderful things may start happening to your acceptance rates.

- *When a paper or proposal of yours is rejected, don't take it as a reflection on your competence or your worth as a human being. Above all, don't give up.* Take a few minutes to sulk or swear at those obtuse idiots who clearly missed the point of what you wrote, then revise the manuscript, doing your best to understand and accommodate their criticisms and suggestions.

  If the rejection left the door open a crack, send the revision back with a cover letter summarizing how you adopted the reviewers' suggestions and stating, *respectfully*, why you couldn't go along with the ones you didn't adopt. The journal or funding agency will usually send the revision back to the same reviewers, who will often recommend acceptance if they believe you took their comments seriously and if your response doesn't offend them. If the rejection slammed the door, send the revision to another journal (perhaps a less prestigious one) or funding agency.

- *Learn to identify the students in your classes, and greet them by name when you see them in the hall.* Doing just this will cover a multitude of sins you may commit in class. Even if you have a class of over 100 students, you can do it—use seating charts, labeled photographs,

* *Chem. Engr. Education, 28*(2), 108-109 (1994).

whatever it takes. You'll be well compensated for the time and effort you expend by the respect and effort you'll get back from them.

- *When you're teaching a class, try to give the students something active to do at least every 20 minutes.* For example, have them work in small groups to answer a question or solve a problem or think of their own questions about the material you just covered.* In long class periods (75 minutes and up), let them get up and stretch for a minute.
  Even if you're a real spellbinder, after approximately 10 minutes of straight lecturing you begin to lose a fraction of your students—they get drowsy or bored or restless, and start reading or talking or daydreaming. The longer you lecture, the more of them you lose. Forcing them to be active, even if it's only for 30 seconds, breaks the pattern and gets them back with you for another 10-20 minutes.

- *After you finish making up an exam, even if you KNOW it's straightforward and error-free, work it through completely from scratch and note how long it takes you to do it, and get your TA's to do the same if you have TA's.* Then go back and (1) get rid of the inevitable bugs and busywork, (2) make sure most of the test covers basic skills and no more than 10-15% serves to separate the A's from the B's, and (3) cut down the test so that the students have at least three times longer to work it out than it took you to do it.

- *Grade tough on homework, easier on time-bound tests.* Frequently it happens in reverse: almost anything goes on the homework, which causes the students to get sloppy, and then they get clobbered on tests for making the same careless errors they got away with on the homework. This is pedagogically unsound, not to mention unfair.

- *When someone asks you to do something you're not sure you want to do—serve on a committee or chair one, attend a meeting you're not obligated to attend, join an organization, run for an office, organize a conference, etc.—don't respond immediately, but tell the requester that you need time to think about it and you'll get back to him or her. Then, if you decide that you really don't want to do it, consider politely but firmly declining.* You need to take on some of these tasks occasionally—service is part of your professorial obligation—but no law says you have do everything anyone asks you to do.*

- *Create some private space for yourself and retreat to it on a regular basis.* Pick a three-hour slot once or twice a week when you don't have class or office hours and go elsewhere—stay home, for example, or take your laptop to the library, or sneak into the empty office of your colleague who's on sabbatical.

  It's tough to do serious writing or thinking if you're interrupted every five minutes, which is what happens in your office. Some people with iron wills can put a "Do not disturb!" sign outside their office door, let their secretaries or voice mail take their calls, and Just Do It. If you're not one of them, your only alternative is to get out of the office. Do it regularly and watch your productivity rise.

- *Do your own composing on a word processor instead of relying on a secretary to do all the typing and correcting.* If you're a lousy typist, have the secretary type your first draft but at least do all the revising and correcting yourself.

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* Many other ideas for active learning exercises are given in References 1 and 2.
* However, if your department head or dean is the one doing the asking, it's advisable to have a good reason for saying no.

Getting the secretary to do everything means waiting for your job to reach the top of the pile on his desk, waiting again when your job is put on hold in favor of shorter and more urgent tasks, waiting yet again for the corrections on the last version to be made, and so on as the weeks roll merrily by. If a job is really important to you, do it yourself! It will then get done on your time schedule, not someone else's.

- *Get copies of McKeachie* [1] *and Wankat and Oreovicz*.[2] Keep one within easy reach in your office at school and the other in your home office or bathroom. You can open either book to any page and get useful pointers or answers to troubling questions, and you'll also get research backing for the suggestions presented.
- *When problems arise that have serious implications—academic misconduct, for example, or a student or colleague with an apparent psychological problem, or anything that could lead to litigation or violence—don't try to solve them on your own. The consequences of making mistakes could be disastrous.*

  There are professionals at every university—academic advisors, trained counselors, and attorneys—with the knowledge and experience needed to deal with almost every conceivable situation. Find out who they are, and bring them in to either help you deal with the problem or handle it themselves.

References

1. W.J. McKeachie, *Teaching Tips: A Guidebook for the Beginning College Teacher*, 8th Edn., Lexington, MA, D.C. Heath & Co., 1986.
2. P.C. Wankat and F.S. Oreovicz, *Teaching Engineering*, New York, McGraw-Hill, 1993.

Chem. Engr. Education, 26(4), 175 (1992).

SORRY, PAL—IT DOESN'T WORK THAT WAY
Richard M. Felder

Dear Professor Felder: Kindly review the enclosed 47-page manuscript, "A New and Much Longer Derivation of the Quantum Correction to Klezmer's Tensor Correlation for Nonnewtonian Flow of Molten Cheese in an Octagonal Orifice. Part 7: Effects of Sunspots." Sincerely, W. Schlepper, Editor, *Journal of Pretentious Fluid Mechanics*.

P.S. We are attempting to clear our inventory of back papers and so I would appreciate your returning the review by next Tuesday.

...and I know I got a 36 on the final exam, Dr. Felder, and it was my high grade so far, but I really think I should get an A in the course because I really worked hard on it and I really understand the material and...

Dear Professor Felder: I am a chemical engineering student at East Indiana Tech. We are using your book, *Elementary Principles of Chemical Processes*, this semester. I think I would learn much better if I could check my solutions against yours. Please send me a solution manual. Sincerely, Alvin Wimbish.

P.S. Please send it by Federal Express.

Um, Dr. Felder—the TA missed this here test page completely on that quiz we took last January and it's got everything right on it—I think I should get full credit.

Hey, am I speaking to the Chemical Engineering Department at State?...Who's this?...How you doin', Professor?...You don't know me, but my wife got some black crud on our white linoleum floor and the 409 won't get rid of it, and I said, I'll bet you one of them chemical engineering fellers over at State will know just the thing to clean it up...so what should I get, Doc?

Rich, do me a favor. I just got this manuscript to review from JPFM and I'm tied up with a proposal deadline...it's right up your alley—Snaveley's latest work on nonnewtonian cheese flow...pick up this one for me, ok—I'll owe you. Thanks. Walt.

P.S. By the way, could you get it out by Tuesday?

Hello, is this Dr. Felder?...This is one of your 205 students...I know it's past midnight, but I can't figure out the recycle problem that's due tomorrow and I thought you might...

Dear Professor Felder: We have received the reviews of the paper you submitted in April. All the reviewers agree that the work is publishable but only after major revisions are made. Reviewer 1 wants you to expand the experimental section considerably, providing details of all sample preparation steps and adding a glossary of the terms in Figure 6. Reviewer 2 wants the experimental section to be shortened and Figure 6 replaced with a simple flow chart. Reviewer 3 proposes deleting the experimental section, since everyone knows how to do this sort of measurement, and substituting a *Far Side* cartoon for Figure 6. I agree with the reviewers' suggestions and request that you comply with all of them. Sincerely, E. Wombat, Editor.

P.S. We're trying to clear our back paper inventory and so I'd like to get the revision back by next Tuesday.

Hello, is this Dick Felder?...Dick, you don't know me but I've got a fantastic opportunity for you to earn big bucks. Let me just have a few minutes of your time to explain....