# INTRODUCTION

## Strategies for Effective Teaching in Chemical Engineering

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My first formal introduction to effective teaching strategies in chemical engineering was a National Effective Teaching Institute that I attended in 1991. It was codirected by Richard Felder, James Stice, and Rebecca Brent, and has been held every year since 1991 just prior to the annual meeting of the American Society for Engineering Education (ASEE). Workshop participants are given the opportunity to gain firsthand knowledge of the elements of effective teaching, including lecturing, active and cooperative learning, course planning, and evaluation.

Of all the things I learned in the workshop, the most impactful was that the most widely used teaching method—lecturing, as traditionally practiced—is actually the least effective in promoting student learning and that students learn best by doing. My own experience confirms the numerous published demonstrations that the standard lecture format is less effective than a number of alternative teaching methods.[1,2]

Faculty interest in effective teaching has increased significantly over the past decade as a consequence of a variety of factors. Various constituencies, including employers, legislators, accrediting bodies, university administrators, and parents, have sought greater accountability for the educational training of skilled engineers equipped to solve 21st century engineering problems. The new Accreditation Board for Engineering and Technology (ABET) engineering criteria for accreditation that became standard in 2001 require engineering departments to demonstrate that their graduates have a command of engineering fundamentals as well as communication, critical thinking, and other lifelong learning skills.[3]

Faculty have responded to this increased focus on learning outcomes by re-evaluating how engineering is taught and by seeking ways to evaluate and improve teaching. It is increasingly recognized that traditional approaches to teaching often fall short of achieving the desired outcomes and that there are benefits in moving from a faculty-centered teaching model to a student-centered learning model.[4]

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Venues for faculty to learn about effective teaching continue to increase as more workshops dedicated to teaching are offered by universities, professional organizations, government agencies, and private foundations, as universities establish or expand teaching and learning centers, and as the literature on teaching and learning continues to grow. Every five years, the Chemical Engineering Division of ASEE offers a Summer School for chemical engineering faculty. The purpose of the Summer School is to disseminate innovative and effective teaching methods to a wide spectrum of chemical engineering undergraduate programs.

During the 2002 Summer School, I organized a poster session devoted to effective teaching strategies. It was designed to provide a forum for the exchange of creative ideas and approaches to chemical engineering education and for sharing practices related to effective teaching. The poster presentations that were judged the best by an expert faculty panel in each of four categories (lecture-, laboratory-, and computer-based strategies, and strategies related to general approaches, learning styles, or outreach) are presented in this issue of *Chemical Engineering Education.*

Some strategies for effective teaching that are represented in the following set of papers include active and cooperative learning, project-based learning, the use of high school outreach to enhance engineering student learning, and the use of a focus topic such as racing cars or biochemical/bioprocess engineering to illustrate core chemical engineer-

ing fundamentals in an elective course.

My hope is that the papers presented in this special issue will serve to further promote the sharing and exchange of ideas that began during the Summer School, and to disseminate a set of interesting and innovative approaches and best practices in chemical engineering education. Readers are also encouraged to investigate the burgeoning body of engineering education literature and resources. Several resources are recommended below as a starting point for this investigation.

***Articles***

Felder, R.M., and L.K. Silverman, "Learning and Teaching Styles in Engineering Education," *Eng. Ed.*, **78**(7), 674 (1988) <http://www.ncsu.edu/felder-public/Papers/LS-1988.pdf>

Felder, R.M., D.R. Woods, J.E. Stice, and A. Rugarcia, "The Future of Engineering Education. II Teaching Methods that Work," *Chem. Eng. Ed.*, **34**(1), 26 (2000) <http://www.ncsu.edu/felder-public/Papers/Quartet2.pdf>

Felder, R.M., and R. Brent, "Designing and Teaching Courses to Satisfy the ABET Engineering Criteria," *J. Eng. Ed.*, **92**(1), 7 (2003) <http://www.ncsu.edu/felder-public/Papers/ABET_Paper_(JEE).pdf>

***Books***

McKeachie, W.J., *McKeachie's Teaching Tips: Strategies, Research, and Theory for College and University Teachers,* 11th ed., Houghton Mifflin, Boston, MA (2002)

Wankat, P.C., and F. Oreovicz, *Teaching Engineering,* McGraw-Hill, New York, NY (1993) Out of print, but available free at <http://engineering.purdue.edu/ChE/News_and_Publications/teaching_engineering>

Wankat, P.C., *The Effective Efficient Professor,* Allyn & Bacon, Boston, MA (2002)

***Journals***

*Chemical Engineering Education*

*Journal of Engineering Education*

***Magazines and Proceedings***

ASEE *Prism*

Proceedings of ASEE Annual Conferences

***Web Sites***

Richard Felder's home page at <http://www.ncsu.edu/effective_teaching>

Effective teachers are creative and use a range of pedagogies and learning strategies designed to focus on student learning and to consider student learning styles. They also view students as active participants in the learning process, and view assessment as a means of driving the learning process. The papers included in this series represent some examples of effective teaching strategies that have been used successfully in chemical engineering.

## REFERENCES


1. Felder, R.M., G.N. Felder, and E.J. Dietz, "A Longitudinal Study of Engineering Student Performance and Retention. IV. Instructional Methods and Students Responses to Them," *J. Eng. Ed.*, **84**(4), 361 (1995)
2. Haile, J.M., "Toward Technical Understanding," Part 1. "Brain Structure and Function," *Chem. Eng. Ed.*, **31**(3), 152 (1997); Part 2, "Elementary Levels," *Chem. Eng. Ed.*, **31**(4), 214 (1997); Part 3, "Advanced Levels," *Chem. Eng. Ed.*, **32**(1), 30 (1998)
3. Felder, R.M., "ABET Criteria 2000: An Exercise in Engineering Problem Solving," *Chem. Eng. Ed.*, **32**(2), 126 (1998)
4. Barr, R.B., and J. Tagg, "From Teaching to Learning: A New Paradigm for Undergraduate Education," in *The Social Worlds of Higher Education: Handbook for Teaching in a New Century,* B.A. Pescosolido and R. Aminzade, eds, Pine Forge Press, Thousand Oaks, CA (1999) ❐


### PAPERS IN THIS SERIES

***Lecture***

- "Water Day: An Experiential Lecture for Fluid Mechanics," *Ford*
- "Synthesis, Resourcefulness, and Effective Communication in Group Learning: Introduction to Biochemical Engineering," *Peeples*

***General, Learning Styles, Outreach***

- "Engaging the Imagination of Students Using Experience Outside the Classroom: A Course in Bioprocess Engineering" *Ostafin, et al.*
- "Incorporating High School Outreach into Chemical Engineering Courses," *Ross and Bayles*

***Lab***

- "Lab-Based Unit Operations in Microelectronics Processing," *Chang, et al.*
- "Passing It On: A Laboratory Structure Encouraging Realistic Communication and Creative Experimental Planning," *Moor and Ferri*
- "Incorporation of Experimental Design in the Unit Operations Laboratory" *Doskocil*

***Computer-Based***

- "Increasing Time Spent on Course Objectives When Using Computer Programming to Teach Numerical Methods," *Silverstein*
- "High Performance Engines: Fast Cars Accelerate Learning," *Han, et al.*