

## Facilitating Change in Undergraduate STEM

An Eclectic Collection of Annotated Resources

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**Background:** Several barriers make the dissemination of resources on teaching and learning an especially challenging endeavor. First, there are no norms expecting college teachers to grow and develop as pedagogues the way they are expected to grow and develop as disciplinary scholars. As a consequence most college faculty read very little pedagogical literature. Instead they rely on experience—their own and that of colleagues. Most are not trained to teach and so their experiential understandings of teaching and learning can contain large, small and in between amounts of accurate knowledge and misinformation.

Given the absence of norms expecting growth, the lack of training and the reliance on experiential learning, what kind of resources might make teachers want to change, point out what needs to change and offer strategies with the potential to improve student learning? This collection of resources includes examples that illustrate one answer to the question.

It is an eclectic collection that contains research from the field of education and from faculty practitioners doing scholarship on teaching and learning within their disciplines, work that integrates and applies what is known about aspects of instruction, work based on the wisdom of practice, what faculty have learned from their own experience and the experience of others and scholarship about scholarly work on teaching and learning. Most of the examples here are from the STEM disciplines, although not all are. Even though many aspects of teaching and learning transcend disciplines, the scholarship most likely to be read by faculty practitioners is embedded within disciplines and most disciplinary scholarship assiduously eschews education research. The positioning of scholarly work on teaching and learning present another barrier to its use.

The examples in this collection address a number of different instructional topics and issues—those topics and issues I think most salient to facilitating change in undergraduate education. They include challenging the content orientation that equates instructional excellence with coverage, recognizing the place and power of active learning, and legitimizing the explicit development of learning skills. The research articles address these issues, all with robust, some with creative, empirical designs. The articles describing new techniques, recounting experiences, offering advice or integrating knowledge are exemplars of the kind of writing and formats useful to faculty. Given the barriers just mentioned and based on my many years of working with and in this literature, I offer these examples as the kinds of resources most likely to be read by faculty and most likely to contribute positively toward efforts to change undergraduate education.

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Auster, C. J., and MacRone, M. "The Classroom as a Negotiated Social Setting: An Empirical Study of the Effects of Faculty Members' Behavior on Students' Participation." *Teaching Sociology*, October 1994, 22, 289-300.

-- Based on a survey where students reflected on the course in which they participated most and least, researchers were able to correlate four faculty behaviors with increased participation; calling on students by name, providing positive reinforcement and encouragement, asking analytical as opposed to factual questions and soliciting student opinions even when they don't volunteer.

Bacon, D. R., and Stewart, K. A. "How Fast Do Students Forget What They Learned in Consumer Behavior? A Longitudinal Study." *Journal of Marketing Education*, 2006, 28, 181-192.

--Using interesting longitudinal design, these results show that after two years marketing majors in a consumer behavior course had lost virtually all the content from that course.

Black, K. A. "What to do When You Stop Lecturing: Become a Guide and a Resource." *Journal of Chemical Education*, 1993, 70 (2), 140-44.

--This article reports on experiences involved with the redesign of an organic chemistry course to a non lecture format with class time devoted to resolving questions and issues brought to class by students. The author honestly describes his fears and premonitions.

Braxton, J. M., Luckey, W., and Helland, P. *Institutionalizing a Broader View of Scholarship Through Boyer's Four Domains*. ASHE-ERIC Higher Education Report, 29 (2). San Francisco: Jossey-Bass, 2002.

--This survey research looks at the extent to which institutions are using Boyer's broader definitions of scholarship in their assessments of faculty work and finds that the preeminence of discovery-based scholarship still prevails.

Edwards, N. M. "Student Self-Grading in Social Statistics." *College Teaching*, 2007, 55 (2), 72-76.

--Edwards system lets students grade homework and exams, but it includes design features that keep students honest and prevents cheating.

Kember, D. and Gow, L. "Orientations to Teaching and Their Effect on the Quality of Student Learning." *Journal of Higher Education*, 1994, 65 (1), 58-74.

--This early work, in a now established line of educational research, documents that teaching methods affect approaches taken to learning; a strong content orientation that focuses on coverage makes it more likely that students will use surface approaches.

Kohn, A. *No Contest: The Case Against Competition*. Boston: Houghton Mifflin, 1986.

Kohn, A. *Punished by Rewards*. Boston: Houghton Mifflin, 1993.

--Both of Kohn's books make strong cases against current educational practices; in the first book he takes on competition and in the second it's extrinsic motivation. Both books are extremely well written and effectively encourage reflection and discussion.

Lewis, S. E., and Lewis, J. E. "Departing from Lectures: An Evaluation of a Peer-Led Guided Inquiry Alternative." *Journal of Chemical Education*, 2005, 82 (1), 135-139.

--In this study one lecture per week was replaced by a guided discussion; students in the guided discussion sections scored as well on a comprehensive final as those students who listened to a full complement of lectures.

McCreary, C. L., Golde, M. F., and Koeske, R. "Peer Instruction in General Chemistry Laboratory: Assessment of Student Learning." *Journal of Chemical Education*, 2006, 83 (5), 804-810.

--In this study students (who had taken the lab previously and been trained) led lab sections. In several ways students taking those lab session performed at a higher level than students in conventionally run labs; in no area measured by the researchers did they perform less well.

Nunn, C. E. "Discussion in the College Classroom: Triangulating Observational and Survey Results." *Journal of Higher Education*, 1996, 67 (3), 243-66.

--Nunn studied participation in college classrooms. In the classes observed, less than six percent of the time (or one minute for every 40) were students participating.

Paulson, D. R. "Active Learning and Cooperative Learning in the Organic Chemistry Lecture Class." *Journal of Chemical Education*, 1999, 76 (8), 1136-1140.

--Paulson describes an interesting collection of strategies that he used in a large course. Their impacts on learning were assessed with some simple, straightforward, albeit effective mechanisms.

Pintrich, P. R. "A Motivational Perspective on the Role of Student Motivation in Learning and Teaching Contexts." *Journal of Educational Psychology*, 2003, 95 (4), 667-686.

--This well-organized, comprehensive review of research on motivation is noteworthy because it spells out implications for practice based on what is known about motivation.

Prince, M. "Does Active Learning Work? A Review of the Research." *Journal of Engineering Education*, July 2004, 223-231.

--This marvelously functional review of research piece offers clear definitions, succinct, nontechnical summaries of research findings and implications for practice. It's the article to share with faculty still unconvinced that active learning makes a difference.

Prince, M., and Felder, R. "Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases." *Journal of Engineering Education*, 2006, 95 (2), 123-38.

--The inductive methods reviewed here include inquiry learning, problem-based learning, project-based learning, case-based teaching, discovery learning and just-in-time teaching; another well organized and useful review of research with implications for practice clearly spelled out.

Singham, M. "Moving Away from the Authoritarian Classroom." *Change*, May/June 2005, pp. 51-57.

--Singham finds the authoritarian language and structure of course syllabi symptomatic of the breakdown of trust in the teacher-student relationship. He describes how he redesigned the syllabus for his large physics course and explains what happened when he did.

- Spence, L. D. "The Case Against Teaching." *Change*, 2001, 33 (6), 11-19.  
--A kick-in-the-butt piece that has motivated many faculty to move in the direction of greater emphasis on learning.
- Springer, L., Stanne, M. E., and Donovan, S. S. "Effects of Small-Group Learning on Undergraduates in Science, Mathematics, Engineering, and Technology: A Meta-Analysis." *Review of Educational Research*, 1999, 69 (1), 21-51.  
--This meta-analysis of studies looks the effects of small group learning experiences in undergraduate science, math, engineering and technology courses. It finds that small group experiences promote greater academic achievement, more favorable attitudes toward learning and increased persistence in these courses.
- Svinicki, M. D. "Helping Students Understand Grades." *College Teaching*, 1998, 46 (3), 101-105.  
--Svinicki uses educational research to identify viable grading systems and proposes ways to discuss grading issues with students; a great example of scholarship that integrates and applies educational research.
- van Gelder, T. "Teaching Critical Thinking: Some Lessons from Cognitive Science." *College Teaching*, 2005, 53 (1), 41-46.  
--van Gelder extrapolates research a series of lessons from cognitive science that should guide efforts to teach critical thinking skills; a great examples of scholarship that integrates and applies educational research
- Weimer, M. *Enhancing Scholarly Work on Teaching and Learning*. San Francisco: Jossey Bass, 2006  
--This book looks at practitioner pedagogical scholarship that is published mostly within disciplines; describes its characteristics, identifies examples, proposes standards and suggests what scholarship like this contributes to instructional practice.
- Weimer, M. "Positioning Scholarly Work on Teaching and Learning." *International Journal of Scholarship on Teaching and Learning*. 2008, 2 (1).  
<http://www.georgiasouthern.edu/ijstol/>  
--This article raises issues related to the location of scholarly work on teaching and learning. It challenges the current move to embed practitioner scholarship exclusively within the disciplines.
- Woods, D. R. "How Might I Teach 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, 1987.  
--This research shows that solving problems does not necessarily develop an explicit understanding of problem solving skills.
- Woods, D. R. "Participation is More than Attendance." *Journal of Engineering Education*, 1996, 85 (3), 177-181.  
--Woods developed a strategy that involves students in the creation of an instrument that is then used to assess involvement in discussion.