Looking Back / Looking Forward

Insights from the Past; Hope for the Future

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The Future of the University

Thoughts from Karl Smith and John Prados (FIE 2002)

- "It's hard to predict, especially the future"
  - Niels Bohr
- "Prediction is difficult, especially about the future." -- Yogi Berra
- "We never educate directly, but indirectly by means of the environment. Whether we permit chance environments to do the work, or whether we design environments for the purpose makes a great difference."
  -- John Dewey, 1906

INVITED PAPER

Five Major Shifts in 100 Years of Engineering Education

The authors discuss what has reshaped, or is currently reshaping, engineering education over the past 100 years up until the current emphasis on design, learning, and social–behavioral sciences research and the role of technology.

By Jeffrey E. Froyd, Fellow IEEE, Phillip C. Wankat, and Karl A. Smith

1. a shift from hands-on and practical emphasis to engineering science and analytical emphasis;
2. a shift to outcomes-based education and accreditation;
3. a shift to emphasizing engineering design;
4. a shift to applying education, learning, and social-behavioral sciences research;
5. a shift to integrating information, computational, and communications technology in education.

http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&tp=&arnumber=6185632

Cooperative Learning Introduced to Engineering – 1981

- Smith, K.A., Johnson, D.W. and Johnson, R.T., 1981. The use of cooperative learning groups in engineering education. In L.P. Grayson and J.M. Biedenbach (Eds.), *Proceedings Eleventh Annual Frontiers in Education Conference*, Rapid City, SD, Washington: IEEE/ASEE, 26-32.

Structuring Learning Goals To Meet the Goals of Engineering Education

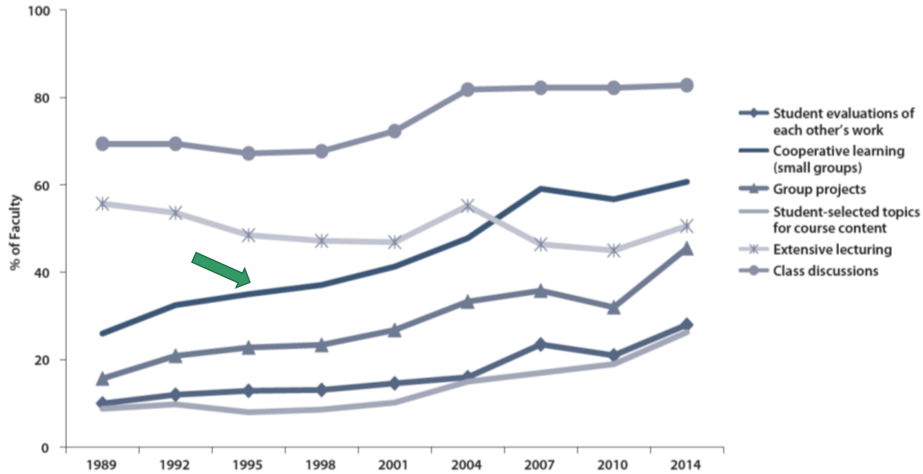
Karl A. Smith, David W. Johnson, and Roger T. Johnson
University of Minnesota

JEE December 1981

http://personal.cege.umn.edu/~smith/docs/Smith-Johnson-Johnson-Structuring_Learning-JEE-1981.pdf

Undergraduate Teaching Faculty: The 2013–2014 HERI Faculty Survey

Figure 2. Changes in Faculty Teaching Practices, 1989 to 2014
(% Marking "All" or "Most" Courses)



http://heri.ucla.edu/monographs/HERI-FAC2014-monograph.pdf 5

The American College Teacher:

National Norms for 2007-2008

Methods Used in "All" or "Most"	All – 2005	All – 2008	Assistant - 2008
Cooperative Learning	48	59	66
Group Projects	33	36	61
Grading on a curve	19	17	14
Term/research papers	35	44	47

http://www.heri.ucla.edu/index.php

Undergraduate Teaching Faculty, 2011*

Methods Used in "All" or "Most"	STEM women	STEM men	All other women	All other men
Cooperative learning	60%	41%	72%	53%
Group projects	36%	27%	38%	29%
Grading on a curve	17%	31%	10%	16%
Student inquiry	43%	33%	54%	47%
Extensive lecturing	50%	70%	29%	44%

*Undergraduate Teaching Faculty. National Norms for the 2010-2011 HERI Faculty Survey,

www.heri.ucla.edu/index.php

Session T1A

Cooperative Learning: Lessons and Insights from Thirty Years of Championing a Research-Based Innovative Practice

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***Abstract* - Innovation according to Denning and Dunham (2010) is "the adoption of a new practice in a community." I argue that our innovations need to be based on good learning theory and good instructional practice. The Johnson and Johnson conceptual model of cooperative learning is an excellent example of a widely adopted evidence-based practice. I identified cooperative learning as important for engineering education in about 1974, tried it in my classes and did some systematic research on it with David and Roger Johnson, introduced it to the engineering education community in 1981 (FIE conference and JEE paper), and it took over 25 years for it to become widespread practice. My point in presenting this story is I don't think we can afford to wait 25 or more years for the current innovations to make it into practice. This paper summarizes the history of the emergence of cooperative learning in engineering education; documents the development of the theoretical, empirical, and practical support; maps the milestones and lessons learned; and provides insights and guidance for engineering education researchers and innovators especially concerning increasing the rate of adoption of evidence-based promising practices.**

Index Terms – cooperative learning, evidence-based promising practice, engineering education research and innovation

Clarification

Since there is the possibility of a confusion of terms, I'm starting with the definition of cooperative learning and highlighting how it is different from collaborative learning and cooperative education (or co-op). [Note: Thanks to the anonymous reviewer who recommended this addition]

Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each others' learning (Johnson and Johnson, 1974; Smith, Johnson and Johnson, 1981; Johnson, Johnson and Smith, 1991). Carefully structured cooperative learning involves people working in teams to accomplish a common goal, under conditions that involve both positive interdependence (all members must cooperate to complete the task) and individual and group accountability (each member individually as well as all members collectively accountable for the work of the group).

A common question is, "What is the difference between cooperative and collaborative learning?" Both pedagogies are aimed at "marshalling peer group influence to focus on intellectual and substantive concerns" (Matthews, et.al, 1995). The principal difference is that cooperative learning requires carefully structured individual accountability, whereas collaborative learning does not. Oxford (1997) summarizes the differences as follows, "Cooperative learning refers to a particular set of classroom techniques that foster learner interdependence as a route to cognitive and social development. Collaborative learning has a "social constructivist" philosophical base, which views learning as construction of knowledge within a social context and which therefore encourages acculturation of individuals into a learning community."

Another potential source of confusion is cooperative education (or co-op), which is "is a structured method of combining classroom-based education with practical work experience. A cooperative education experience, commonly known as a "co-op", provides academic credit for structured job experience" (Auld, 1972).

History

[Note: History and Concurrent Developments sections were adapted from Smith (2010)]
My first encounter with cooperative learning occurred in about 1974 in a Social Psychology of Education course taught by one of David Johnson's PhD students, Dennis Falk who is currently a Professor of Social Work at the University of Minnesota – Duluth. I began taking courses in the College of Education in the early 70s because I had an overwhelming sense that there was a better way to help engineering students learn than what I was doing, which was essentially what had been done to me, that is, lecture, homework assignments and individual exams. This overwhelming sense of a better way of doing things was prompted by questions the students asked, which revealed that they had no idea what I was talking about. A representative setting was a course in thermodynamics and kinetics – very abstract areas involving a lot of mathematics – where I was "teaching as taught." My sense that there was a better way was grounded in my training and experience as an engineer, where one of the fundamental ideas is "advancing the state-of-the-art". What I encountered in the

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http://personal.cege.umn.edu/~smith/docs/Smith-FIE-CL-1240-10-draft.pdf

ASEE Reports - A Path Forward

Seven Recommendations for Innovation with Impact

Who

1. Grow professional development in teaching and learning.
2. Expand collaborations.

What

3. Expand efforts to make engineering more engaging, relevant, and welcoming.

How

4. Increase, leverage, and diversify resources for engineering teaching, learning, and innovation.
5. Raise awareness of proven practices and of scholarship in engineering education.

Seven Recommendations for Innovation with Impact *(continued)*

Creating a Better Culture

To measure progress in implementing policies, practices, and infrastructure in support of scholarly and systematic innovation in engineering education:

6. Conduct periodic self-assessments in our individual institutions.
7. Conduct periodic community-wide self-assessments.

https://www.asee.org/member-resources/reports/Innovation-with-Impact

LAST WORD — OPINION BY SUSAN SINGER & KARL SMITH

Follow the Evidence

Discipline-based education research dispels myths about learning and yields results – if only educators would use it.

Last year, the National Research Council released the report *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. That consensus study, on which we served as committee members, brought together experts in physics, chemistry, biology, the geosciences, astronomy, and engineering, as well as higher education researchers, learning scientists, and cognitive scientists to focus on how students learn in particular scientific and engineering disciplines. Our key conclusion: Findings from the growing field of discipline-based education research (DBER) have yet to spur widespread changes in the teaching of science and engineering.

For example, research-based instructional approaches to teaching that actively engage students in their own learning, such as group projects, have been shown to be more effective than traditional lectures. Yet science and engineering faculty still cling to familiar practice. While there's no magic solution for adopting evidence-based teaching practices, finding out what is known about undergraduate learning in engineering and science—and identifying impediments to implementation in the classroom—can point the way.

First, many students have incorrect understanding about fundamental concepts—particularly phenomena that are not directly observable, such as those involving very large or small scales of time and space. Understanding how educators can help students change these misconceptions is in the early stages, but DBER has uncovered some effective instructional techniques. One promising approach is to use "bridging analogies" that link students' correct knowledge with the situation about which they harbor false beliefs. For instance, a student may not believe that a table can exert a force on a book resting on its surface but accepts the notion if a spring is placed under the same book. Linking these two ideas, with perhaps an intermediate of a book resting on a foam block, can move the student toward a correct understanding of forces.

STUDENTS ARE CHALLENGED BY KEY ASPECTS OF ENGINEERING AND SCIENCE THAT CAN SEEM EASY OR OBVIOUS TO EXPERTS.

Students also are challenged by important aspects of engineering and science that can seem easy or obvious to experts. When tackling a problem, for instance, students tend to focus on the superficial rather than on its deep structure. Instructors may have an "expert blind spot" and not recognize how different the student's approach is from their own, which can impede effective instruction. Several strategies appear to improve problem-solving skills, such as providing support and prompts—known as "scaffolding"—as students work their way through problems. Another common issue for students in all disciplines is difficulty in extracting information from graphs, models, and simulations. Using multiple representations in instruction is one way to move students toward expertise.

The report recommends future DBER research that explores similarities and differences in learning among various student populations, and longitudinal studies that shed additional light on how students acquire and retain an understanding (or misunderstanding) of concepts. However, we also need strategies that translate the findings of DBER and related research into practice. That includes finding ways around barriers, such as the faculty reward system, the relative value placed on teaching versus research, lack of support for faculty learning to use research-based practices, problems with student evaluations, and workload concerns.

The report urges universities, disciplinary organizations, and professional societies to support faculty efforts to use evidence-based teaching strategies in their classrooms. It also recommends collaboration to prepare future faculty members who understand research findings on learning and teaching and who value effective teaching as part of their career aspirations. By implementing these recommendations, engineering and science educators will make a major first step toward using DBER to improve their practice—and learning outcomes.

Susan Singer, the Laurence McKinley Gould Professor of the Natural Sciences at Carleton College, chaired the National Research Council committee that prepared the consensus study. Karl Smith, the Cooperative Learning Professor of Purdue University's School of Engineering Education and emeritus professor of civil engineering at the University of Minnesota, represented engineering on the committee. To view the report, visit http://www.nap.edu/

http://personal.cege.umn.edu/~smith/docs/Last%20Word%20SUMMER%20final-1.pdf