Literature Review - Evidence-based Teaching/Active learning and Underrepresented Groups


- A review of discipline-based education by the National Research Council (2012) revealed: traditional lectures are less effective than evidence-based instructional strategies at improving conceptual knowledge and attitudes about learning STEM. The report illustrated that evidence-based instructional strategies include a range of approaches, including making lectures more interactive, having students work in groups, providing formative feedback, and incorporating authentic problems and activities. In particular, the report emphasizes that instructors’ clarifying and facilitating student conceptual understanding is relevant across all STEM fields. While approaches to problem solving differ across fields, most research indicates that authentic problems and appropriately sequenced experiences are important for student learning of core concepts in STEM.
    
- The National Research Council’s report (2012) found that active instructional strategies supported all students’ STEM learning, and they especially supported learning among underrepresented students.


- Show that a highly structured course design, based on daily and weekly practice with problem-solving, data analysis, and other higher-order cognitive skills, improved the performance of all students in a college-level introductory biology class and reduced the achievement gap between disadvantaged and nondisadvantaged students—without increased expenditures. These results support the Carnegie Hall hypothesis: Intensive practice, via active-learning exercises, has a disproportionate benefit for capable but poorly prepared students.

- Tested the hypothesis that highly structured course designs, which implement reading quizzes and/or extensive in-class active-learning activities and weekly practice exams, can lower failure rates in an introductory biology course for majors, compared with low-structure course designs that are based on lecturing and a few high-risk assessments. We controlled for 1) instructor effects by analyzing data from quarters when the same instructor taught the course, 2) exam equivalence with new assessments called the Weighted Bloom's Index and Predicted Exam Score, and 3) student equivalence using a regression-based Predicted Grade. We also tested the hypothesis that points from reading quizzes, clicker questions, and other “practice” assessments in highly structured courses inflate grades and confound comparisons with low-structure course designs. We found no evidence that points from active-learning exercises inflate grades or reduce the impact of exams on final grades. When we controlled for variation in student ability, failure rates were lower in a moderately structured course design and were dramatically lower in a highly structured course design. This result supports the hypothesis that active-learning exercises can make students more skilled learners and help bridge the gap between poorly prepared students and their better-prepared peers.


- This book chapter presents the goals, structure, curriculum, and technology of the SCALE-UP Project. This project establishes a highly collaborative, hands-on, computer-rich, interactive learning environment for large, introductory college courses. Lecture and lab are integrated under multiple instructors in a way that provides an effective, economical alternative to traditional lecture-oriented instruction. Researchers and instructors have collaborated to develop the pedagogy, classroom environment, and teaching materials to support this type of learning. This chapter focuses on the calculus-based introductory physics course. In comparisons to traditional instruction, significant increases have been shown in conceptual understanding, improved attitudes, successful problem solving, and higher success rates, particularly for females and minorities.


- In this study, we disaggregate student data by racial/ethnic groups and first generation status to identify whether a particular intervention—increased course structure—works better for particular populations of students. We also explore possible factors that may mediate the observed changes in student achievement. We found that a “moderate-structure”
intervention increased course performance for all student populations, but worked disproportionately well for black students—halving the black–white achievement gap—and first-generation students—closing the achievement gap with continuing-generation students. We also found that students consistently reported completing the assigned readings more frequently, spending more time studying for class, and feeling an increased sense of community in the moderate-structure course. These changes imply that increased course structure improves student achievement at least partially through increasing student use of distributed learning and creating a more interdependent classroom community.


• This paper describes the implementation and evaluation of a program that uses active recruiting and peer-led team learning to try to increase the participation and success of women and minority students in undergraduate computer science. These strategies were applied at eight universities starting in the fall of 2004. There have been some impressive results:
  o We succeeded in attracting under-represented students who would not otherwise have taken a CS course.
  o Evaluation shows that participation in our program significantly improves retention rates and grades, especially for women.
  o Students in the program, as well as the students who served as peer leaders, are uniformly enthusiastic about their experience.


• Many students start college intending to pursue a career in the biosciences, but too many abandon this goal because they struggle in introductory biology. Interventions have been developed to close achievement gaps for underrepresented minority students and women, but no prior research has attempted to close the gap for first-generation students, a population that accounts for nearly a 5th of college students. We report a values affirmation intervention conducted with 798 U.S. students (154 first-generation) in an introductory biology course for majors. For first-generation students, values affirmation significantly improved final course grades and retention in the 2nd course in the biology sequence, as well as overall grade point average for the semester. This brief intervention narrowed the achievement gap between first-generation and continuing-generation students for course grades by 50% and increased retention in a critical gateway course by 20%. Our results suggest that
educators can expand the pipeline for first-generation students to continue studying in the biosciences with psychological interventions.


• In many science, technology, engineering, and mathematics disciplines, women are outperformed by men in test scores, jeopardizing their success in science-oriented courses and careers. The current study tested the effectiveness of a psychological intervention, called values affirmation, in reducing the gender achievement gap in a college-level introductory physics class. In this randomized double-blind study, 399 students either wrote about their most important values or not, twice at the beginning of the 15-week course. Values affirmation reduced the male-female performance and learning difference substantially and elevated women's modal grades from the C to B range. Benefits were strongest for women who tended to endorse the stereotype that men do better than women in physics. A brief psychological intervention may be a promising way to address the gender gap in science performance and learning.


• To test the hypothesis that lecturing maximizes learning and course performance, we metaanalyzed 225 studies that reported data on examination scores or failure rates when comparing student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses under traditional lecturing versus active learning. The effect sizes indicate that on average, student performance on examinations and concept inventories increased by 0.47 SDs under active learning (n = 158 studies), and that the odds ratio for failing was 1.95 under traditional lecturing (n = 67 studies). These results indicate that average examination scores improved by about 6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. Heterogeneity analyses indicated that both results hold across the STEM disciplines, that active learning increases scores on concept inventories more than on course examinations, and that active learning appears effective across all class sizes—although the greatest effects are in small (n ≤ 50) classes.