

## STEM Topic: Student diversity

Haak, D.C., Hillerislambers, J., Pitre, E., Freeman, S. 2011. Increased structure and active learning reduce the achievement gap in introductory biology. *Science*. Vol. 332, 1213-1230.

Science, technology, engineering, and mathematics instructors have been charged with improving the performance and retention of students from diverse backgrounds. To date, programs that close the achievement gap between students from disadvantaged versus nondisadvantaged educational backgrounds have required extensive extramural funding. We 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.

Eagan, M.K., Sharkness, J., Hurtado, S., Mosqueda, C.M., Chang, M.J. 2010. Engaging undergraduates in science research: Not just about faculty willingness. <http://heri.ucla.edu/PDFs/pubs/journals/EngagingUndergraduatesinScienceResearchNotJustAboutFacultyWillingness.pdf>

Despite the many benefits of involving undergraduates in research and the growing number of undergraduate research programs, few scholars have investigated the factors that affect faculty members' decisions to involve undergraduates in their research projects. We investigated the individual factors and institutional contexts that predict faculty members' likelihood of engaging undergraduates in their research project(s). Using data from the Higher Education Research Institute's 2007–2008 Faculty Survey, we employ hierarchical generalized linear modeling to analyze data from 4,832 science, technology, engineering, and mathematics (STEM) faculty across 194 institutions to examine how organizational citizenship behavior theory and social exchange theory relate to mentoring students in research. Key findings show that faculty who work in the life sciences and those who receive government funding for their research are more likely to involve undergraduates in their research project(s). In addition, faculty at liberal arts or historically Black colleges are significantly more likely to involve undergraduate students in research. Implications for advancing undergraduate research opportunities are discussed.

Esmonde, I. 2009. Ideas and identities: Supporting equity in cooperative mathematics learning. *Review of Educational Research*. Vol. 79, 1008-1043.

This review considers research related to mathematics education and cooperative learning, and it discusses how teachers might assist students in cooperative groups to provide equitable opportunities to learn. In this context, equity is defined as the fair distribution of opportunities to learn, and the argument is that identity-related processes are just as central to mathematical development as content learning. The link is thus considered between classroom social ecologies, the interactions and positional identities that these social ecologies make available, and student learning. The article closes by considering unresolved questions in the field and proposing directions for future research.

Kendall Brown, M., Hershock, C., Finelli, C.J., O'Neal, C. 2009. Teaching for Retention In Science, Engineering, and Math Disciplines: A Guide for Faculty. Center for Research on Learning and Teaching. No. 25. [http://www.crlt.umich.edu/publinks/CRLT\\_no25.pdf](http://www.crlt.umich.edu/publinks/CRLT_no25.pdf)

A number of recent national reports have called upon higher education to improve instruction in science, technology, engineering, and mathematics (STEM) as a means of safeguarding U.S. global leadership in these fields (National Academy of Engineering [NAE], 2005; National Academy of Sciences [NAS], 2007b; National Science Board [NSB], 2004). These reports emphasize the importance of preparing a diverse student body for the science and engineering challenges of the twenty-first century. However, statistics indicate that neither the number of students who graduate with STEM degrees, nor the diversity of the graduates is sufficient to meet the needs of a global workforce. Although the overall number of bachelor's degrees awarded annually in the U.S. has risen by nearly 50% over the last twenty years, (NSF, 2008), the proportion of university students achieving bachelor's degrees in STEM fields has declined by almost 40% (NAS, 2007a). Further, even though women now make up over half of the U.S. undergraduate population (U.S. Census Bureau, 2004), they earned just 21% of the bachelor's degrees awarded in engineering and 25% of bachelor's computer science degrees in 2004 (NSF, 2008).

King, D.B., Joshi, S. 2008. Gender differences in the use and effectiveness of personal response devices. *Journal of Science Educational Technology*. Vol. 17, 544-552.

The use of personal response devices (or "clickers") in the classroom has increased in recent years. While few quantitative studies on the effectiveness of clickers have been published, it is generally reported that clickers have been well-received by the students who use them. Two separate populations (Winter 2006 and Spring 2006) of engineering students were given clickers to use during a general chemistry class. Clicker use was compared to student grades for each course. During both terms, a higher percentage of female students than male students "actively participated" in the lectures, where active participation as defined as answering more than 75% of the clicker questions over the course of the term. Active male students earned final grades about 10 points higher than non-active male students. Active female students, however, scored only about 5 points higher than non-active female students. Student learning was assessed by comparing performance on exam questions and clicker questions with similar content. Students who answered clicker questions correctly were 11–13% more likely to answer the corresponding exam questions correctly than were students who did not answer the clicker question. In this paper, we demonstrate the effectiveness of clicker use in the classroom and examine gender differences associated with this use.

Quitadamo, I.J., Kurtz, M.J. 2007. Learning to improve: Using writing to increase critical thinking performance in general education biology. *Life Sciences Education*. Vol. 6, 140-154.

Increasingly, national stakeholders express concern that U.S. college graduates cannot adequately solve problems and think critically. As a set of cognitive abilities, critical thinking skills provide students with tangible academic, personal, and professional benefits that may ultimately address these concerns. As an instructional method, writing has long been perceived as a way to improve critical thinking. In the current study, the researchers compared critical thinking performance of students who experienced a laboratory writing treatment with those who experienced traditional quiz-based laboratory in a general education biology course. The

effects of writing were determined within the context of multiple covariables. Results indicated that the writing group significantly improved critical thinking skills whereas the nonwriting group did not. Specifically, analysis and inference skills increased significantly in the writing group but not the nonwriting group. Writing students also showed greater gains in evaluation skills; however, these were not significant. In addition to writing, prior critical thinking skill and instructor significantly affected critical thinking performance, whereas other covariables such as gender, ethnicity, and age were not significant. With improved critical thinking skill, general education biology students will be better prepared to solve problems as engaged and productive citizens.

Rath, K.A., Peterfreund, A.R., Xenos, S.P., Bayliss, F., Carnal, N. 2007. Supplemental instruction in introductory biology I: Enhancing the performance and retention of underrepresented minority students. *Life Sciences Education*. Vol. 6, 203-216.

Supplemental instruction classes have been shown in many studies to enhance performance in the supported courses and even to improve graduation rates. Generally, there has been little evidence of a differential impact on students from different ethnic/racial backgrounds. At San Francisco State University, however, supplemental instruction in the Introductory Biology I class is associated with even more dramatic gains among students from underrepresented minority populations than the gains found among their peers. These gains do not seem to be the product of better students availing themselves of supplemental instruction or other outside factors. The Introductory Biology I class consists of a team-taught lecture component, taught in a large lecture classroom, and a laboratory component where students participate in smaller lab sections. Students are expected to master an understanding of basic concepts, content, and vocabulary in biology as well as gain laboratory investigation skills and experience applying scientific methodology. In this context, supplemental instruction classes are cooperative learning environments where students participate in learning activities that complement the course material, focusing on student misconceptions and difficulties, construction of a scaffolded knowledge base, applications involving problem solving, and articulation of constructs with peers.

Blickenstaff, J.C. 2005. Women and science careers: leaky pipeline or gender filter? *Gender and Education*. Vol. 17, 369-386.

Women are under-represented in science, technology, engineering and mathematics (STEM) majors and careers in most industrialized countries around the world. This paper explores the broad array of explanations for the absence of women in STEM put forth in the literature of the last 30 years. It is argued that some proposed explanations are without merit and are in fact dangerous, while others do play a part in a complex interaction of factors. It is suggested that the very nature of science may contribute to the removal of women from the 'pipeline'. Recommendations for reform in science education to address this problem are also provided.

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., Gentile, J., Lauffer, S., Stewart, J., Tilghman, S.M., Wood, W.B. 2004. Scientific teaching. *Science*. Vol. 304, 521-523.

Since publication of the AAAS 1989 report "Science for all Americans" (1), commissions, panels, and working groups have agreed that reform in science education should be founded on "scientific teaching," in which teaching is approached with the same rigor as science at its best (2). Scientific teaching involves active learning strategies to engage students in the process of science and teaching methods that have been systematically tested and shown to reach diverse students (3).

Roth, W.M., Lee, S. 2002. Scientific literacy as a collective praxis. *Public Understanding Science*. Vol. 11, 33-56.

In this article, we conceive of scientific literacy as a property of collective activity rather than individual minds. We think of knowing and learning science as situated in and distributed across social and material aspects of a setting. To support the proposed conception, we provide several detailed cases from our three-year multi-site ethnographic study of science in one community, featuring different types of citizens who walk a creek, interact during an environment-oriented open-house event, discuss water problems, collect data, and have different conceptions of human-environment relations. The case studies show that collectively, much more advanced forms of scientific literacy are produced than any individual including scientists could produce. Creating opportunities for scientific literacy to emerge from collective activity, irrespective of whether one or more participants know some basic scientific facts, presents challenges to science educators very different from teaching basic facts and skills to individuals.