Discipline-based education research seeks to marry deep knowledge of the discipline with similarly deep knowledge of learning and pedagogy (1, 2) and may encourage college and university faculty members to bring more rigor to classroom instruction. For example, the physics-based education research community has used tools such as the Force Concept Inventory (3) to determine that students taught with interactive teaching techniques developed from discipline-based education research [such as Peer Instruction (4, 5)] better understand the concepts of Newtonian physics than do students taught in a lecture-based format. Within the engineering community, the ultimate aims of such research include the creation of education programs that attract more, and more diverse, students to the study of engineering; retain more of the students who are enrolled; deepen students’ understanding of engineering concepts; broaden students’ appreciation of engineering’s role in meeting the needs of a global society; and better prepare students for further study or professional practice. In pursuing these aims, research in engineering education looks beyond questions solely devoted to teaching, learning, and assessment; it also examines issues associated with faculty rewards (6) and the organizational dynamics of engineering departments (7, 8).

Although not all engineering faculty will engage in such research, we contend that all should learn and benefit from its findings.

Our commitment to engineering-based education research does not devalue the work of researchers in colleges of education or that of cognitive or social scientists. Rather, we emphasize the maturation of the engineering education research community and the increased value attached to the emerging field by the academic engineering community.

Past, Present, and Future

In the 1990s, centers for research on engineering education opened on several campuses, with foci ranging from foundational university (2004), and Utah State (2005) and announced at Clemson (2007). The emergence of these departments marks the transition from isolated individual researchers to academic communities devoted to the scholarship of engineering education.

The Journal of Engineering Education was repositioned in January 2003 to focus on publishing scholarly research in engineering education. The change was celebrated with a special issue (12), and the journal continues to focus on advancing the rigor and recognition of engineering education research (13).

The 2005 and 2006 Engineering Education Research Colloquies (EERC) identified five research areas that will serve as the foundation for the new discipline of engineering education (14): (i) engineering epistemologies—research on what constitutes engineering thinking and knowledge in social contexts now and into the future; (ii) engineering learning mechanisms—research on engineering learners’ developing knowledge and competencies in context; (iii) engineering learning systems—research on instructional culture, institutional infrastructure, and epistemology of engineering educators; (iv) engineering diversity and inclusiveness—research on how diverse human talents contribute more robust solutions to global challenges and reinforce the relevance of the profession to all sectors of society; and (v) engineering assessment—research on, and the development of, assessment methods, instruments, and metrics to inform engineering education practice and learning.

Low rates of student retention within the discipline have heightened concerns in the engineering community about the structure, content, and delivery of engineering education. Although many engineering programs allow only a stringently prescreened population to enroll, on average, only 56% of undergraduate students admitted nationally...
into engineering disciplines are retained to graduation, with some schools reporting retention rates of only 30%. Academic difficulty is not why these students change course (15), leading the engineering education community to view these loss rates as indicators of defects within the system of engineering education that should be corrected. One application of engineering education research, developed with the goal of increasing retention rates, is the First-Year Engineering Projects (FYEP) course at the University of Colorado at Boulder.

The FYEP Course
The FYEP course was designed in the mid-1990s in response to research on other project-based engineering courses. Key principles included collaborative and team-based learning, experiential projects, open-ended design, and supportive instruction (16).

The FYEP course connects the conceptual and educational side of engineering with professional practice. This is primarily accomplished through a 13-week project that introduces first-year students to the design-build-test cycle of product prototype development (wherein a new object to meet a stated or perceived customer need is conceived, designed, realized as a physical object, and tested to verify that it meets requirements) in a team-based setting, supported by experimental testing (17). The innovations at the University of Colorado at Boulder are consistent with the results of previous science and engineering education research on experiential, interactive, and collaborative learning (18–24).

Only some of the 11 engineering programs at the University of Colorado at Boulder require the FYEP; for all others it is an accepted technical elective. This results in, on average, half of the incoming first-year student cohorts taking the class, which provides a useful comparative data set; it’s large, longitudinal, and multidisciplinary, and it contains a reasonable control group. No significant difference in retention was found between the required and volunteer FYEP takers, implying no volunteer effect.

To examine the impact of the course on student attrition, we gathered retention data across eight cohorts from the Fall 1994 through Fall 2002 semesters. This data set contained 5070 first-year engineering students, consisting of 2128 students (42%) who took the FYEP course and 2942 students (58%) who did not take the course. The sample included 1015 women and 4055 men, and included 3992 Caucasian, 402 Asian-American, 290 Latino, and 80 African-American, and 41 Native-American students. Student ethnicity data, provided by the university, reflected the self-reported ethnicity on a student’s admission application. An additional 265 students were classified as “unknown ethnicity” and were not included in the ethnicity analysis. The study sample incorporated only students who took the FYEP course as first-year engineering students; transfer students were excluded, as were students who were not engineering majors or who took the course after their first year. Engineering program retention was assessed at the third, fifth, and seventh semester for all students in the sample. Logistic regression and chi-square statistical tests were used to test for differences in retention between students who did and those who did not take the FYEP course and to test for differential impacts by both gender and ethnicity (25).

Retention Results
Across students, those who took the FYEP course were retained at a higher level through the seventh semester (P < 0.05) (see graph on page 1175) (25). Logistic regression analysis indicated no statistically significant indications that a first-year design project course has a differential impact by gender or ethnicity. Because the course was taught by multiple instructors during the 8-year period under study, no instructor effect was inferred.

A pattern of elevated retention for women at the seventh semester suggests that additional focus on course elements and pedagogy could be fruitful. The analysis by ethnicity was likely influenced by low sample sizes for Latino, African-American, and Native-American students. However, regardless of gender or ethnicity, retention in engineering is higher among students who take the FYEP course.

These results add to the growing body of evidence demonstrating that first-year projects-based curricula promote retention of engineering students (26).

Conclusion
Although a 64% retention rate is still too low for students that are heavily screened before admission to the major, it represents an improvement on the national engineering retention rate of 56%. Given that Seymour and Hewitt (15) have reported retention rates of 42% in the biological sciences, 29.9% in the physical sciences, and 29.2% in mathematics, why should we seek still higher engineering retention rates? Moller-Wong and Eide (27) organized attrition factors into student’s background, college administrative issues, academic and social integration, attitude and motivation, and fit within an institution; we suggest that all except a student’s background are subject to institutional intervention and improvement. Conceding that some students will decide that engineering is not right for them, we believe that the overwhelming majority of engineering students should graduate in engineering, and retention rates above 80% should be our aspiration. Engineering retention improvement over the past decade (15) suggests that great strides are possible; our challenge is to make the possible probable.

References and Notes

204 (2006).
204 (2006).