The Freshman Year in Engineering

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Abstract

As engineers, we often are required to meet "specifications" or "standards," whether for testing or products. Shouldn't the same be expected of our freshman engineering curricula? Before we attempt to answer this question, we must first determine the following: (1) do secondary schools provide us with a "standard" freshman engineering student? (2) what role should Advanced Placement (AP) courses/exams play in the course selection of freshmen engineering students? (3) what do our institutions offer (either financially or administratively) in support of a First Year Experience? These questions and their relative importance will be addressed by comparing freshman engineering curricula across engineering disciplines and across institutional profiles with the expectation that a consensus response will lead to an improved Freshman Year in Engineering (FYE) for our students.

Introduction

Those of us who received Bachelor of Science degrees in engineering fields prior to the mid-1980s, experienced some version of the following during our first year: Calculus, Chemistry, Physics, Composition and History. Engineering courses typically began during the sophomore year. The engineering education community began investigating alternatives to this traditional approach by funding coalitions of schools who would agree to interact with one another and disseminate their results to engineering educators through presentations at conferences. The Foundation Coalition[1] was one such group of universities which encouraged “integrated” curricula. The recent work of Froyd and Ohland[2] provides an excellent assessment of the variety of programs which were developed using this approach. Some of the conclusions of their analysis of the current state of integrated engineering curricula are worth noting:

- The most significant long-term outcome of integrated programs may be faculty development.
- The implementation of integrated curricula has helped expand the use of cooperative learning and student teams, especially in design projects.
- Integrated programs have demonstrated various successful outcomes: improved retention ..., improved learning of disciplinary content, and (to a lesser extent) improved acquisition of nondisciplinary skills.[3]

The goal of this paper is to lay the foundation for a vigorous discussion of whether or not a somewhat generic Freshman Year in Engineering is feasible, given the diversity of institutions representing the community of engineering educators.

- Is improved retention (and at what level) a significant enough outcome to spend the man-hours and dollars restructuring our curricula?

- Can state universities with freshman engineering enrollments upwards of 1000 students expect results similar to those of private institutions whose freshman engineering class numbers in the low 100s?

It is my hope that these and other provoking questions can begin to be answered through a thoughtful review of the current state of engineering education.

Freshman Engineering Students: who are they?

The admissions offices at our colleges and universities compile statistics which give us only an inkling of understanding about our freshmen, mostly in the form of their academic records. For example, we know that the national average composite ACT score for all college-bound students in the fall of 2005 was 21.9 while it was 27.2 for Cedarville University (CU) engineering freshmen.[4] Similar numerical statistics could be presented for SAT scores, high school GPA, and class rank and then compared among any collection of students who matriculated during any given semester.

But are these statistics the best way measure who our incoming students really are? The Cooperative Institutional Research Program (CIRP) surveys freshmen at colleges and universities across the nation. Many of the questions probe family environment, lifestyle choices, and activities outside the classroom. CU freshmen have participated in the CIRP study since 1994. The most recent data was collected in the fall of 2006 and yield some intriguing differences between CU freshmen and those attending other four-year schools which declare a "religious affiliation."[5] Some of these are:

- CU freshmen are more likely to have mothers whose occupation is full-time homemaker or nurse.
- CU freshmen are more likely to have discussed religion with someone during their final year in high school
- CU freshmen are less likely to have participated in organized demonstrations during their final year in high school.
- CU freshmen are less likely to have drunk beer, wine, or liquor during their final year in high school.

In each case, the determination of "more likely" or "less likely" is based upon a 10% or greater difference in responses from CU students compared with others who took the CIRP survey.

Taking into account the diversity of life- and learning styles of our incoming students should certainly drive the Freshman Year in Engineering and must be addressed within the context of developing a standard curriculum.

Advanced Placement: what should be accepted?

Advanced Placement (AP) courses were conceived in the early 1950s with the notion that high school students with exceptional academic skills should be capable of performing at a level comparable to the first year in the academy. [6] Today, AP courses and their corresponding examinations are prized by college-bound students with the intention of forgoing many of their foundational collegiate courses such as history, biology, composition, and calculus. The current system permits each institution to determine whether a student has achieved the appropriate level of understanding in any given subject area based upon their AP exam grade (on a scale of 1 to 5). This opens the door for competition among college and university admissions departments for top students, perhaps at the expense of education.

Hugh Page, Dean of the First Year of Studies at Notre Dame University, sparked a lively discussion about AP credit offerings among the participants when he addressed this topic during a recent conference.[7] He suggested that AP courses seek a "higher baseline" of academic understanding. His impressions were that freshmen were matriculating at the university looking well-qualified "on paper," but perhaps too immature in their character development to launch into sophomore-level courses. One of the panelists at this same conference, Mark Sperling, Assistant Superintendent of the Merrillville (Indiana) Public Schools, suggested that many students in his school district have begun seeing colleges and universities not crediting students with equivalent courses even with AP grades of 3 and 4. One participant at the conference noted that his institution permitted AP credit only for courses not in the student's major; hence Calculus, Physics, and Chemistry AP credits would not be offered to most engineering majors.

Though Cedarville University enrolls only about 100 freshman engineering majors each fall, we are not immune from these conflicting issues. The concept of "teaching to the test" has become prevalent, even in quality secondary school systems across the United States. The national "No Child Left Behind Act" has changed the formula for classroom pedagogy into a measurements routine that may prevent teachers from offering subject matter beyond the scope of the "test." Thus, the CU Science and Mathematics Department no longer permits freshmen to bypass Calculus I, even with a score of 5 on the AB Calculus AP exam.[8] This had led to some hard feelings among freshman engineering students (and their parents) who were encouraged to spend the approximately $90 for the opportunity to sit for the AP exam.

Clearly, a comprehensive First Year in Engineering program will have to include an openly distributed policy on just exactly how Advanced Placement credit will be handled, much to the chagrin of the institution's Admissions and Public Relations departments.

Financial Support: where is the money?

The final hurdle for successful curricular change boils down to dollars and cents. Whether we're looking at reducing faculty loads for the sake of integrating the curriculum or hiring additional administrative support for the purpose of analyzing survey data, the budget must be increased. The Foundation Coalition, the Gateway Coalition, and the SUCCEED Coalition were all generously supported by the National Science Foundation (NSF).[9] A private institution which does not accept government funding, such as CU, must be creative in order to develop and maintain modern curricula competitive with NSF-funded programs.

Having just completed our first ABET EC2000 self-study in the spring of 2005, it became clear that the old "bean-counting"system has truly been abolished and replaced with institutional self-assessment. Though the core values of what makes an engineering student into an engineer have not changed, the means to that end have truly become individually selectable by the institution. Whereas Purdue University continues to take a more traditional approach to its freshman engineering curriculum (separate courses in Math, Physics, Chemistry, and Computer Science),[10] Northwestern University combines content from Math, Physics, and Engineering Mechanics into a year-long Engineering Analysis sequence,[11] and Wright State University has chosen to eliminate the prerequisite requirement of its mathematics sequence by fast-tracking their students into engineering courses using a two-quarter sequence of "just in time" mathematics content.[12]

Cedarville's engineering programs require students to complete 140 semester hours of coursework. As a low "discount rate" institution, a large percentage of CU's academic budget stems from tuition dollars. Thus, keeping tuition revenues on campus is highly encouraged (as opposed to expanding opportunities for students to transfer credits from other institutions). With this in mind, the CU engineering faculty are finalizing a proposal for its engineering freshmen which would combine some of the features of the Northwestern and Wright State curricula. The key to the CU proposal would be the elimination of some of the duplication of course content by replacing Physics I (mechanics) with Engineering Mechanics I (Statics) in the spring semester of the freshman year. In order to provide the necessary mathematical prerequisites for this early start to the engineering course sequence as well as prepare students to complete their physics sequence, an Introduction to Engineering I course would be developed for the fall semester of the freshman year. The content of the course would be: Review of Algebra and Trigonometry, Linear Systems of Equations, Vectors, Differentiation of Functions, Integration of Functions, Linear Differential Equations with Constant Coefficients, Harmonic Oscillators, Waves, and Sound. Laboratory experiences would also be included.

Speaking of funding, who is going to teach this new course? The engineering faculty are certainly capable of handling the content, but this course increases their teaching load significantly. Dare we ask the physics faculty to teach this course, knowing that the enrollment for their own course (Physics I) will drop dramatically? Perhaps the mathematics faculty might see this as an affront to their goal of providing engineering students with a strong theoretical foundation and not support this proposal at all.

Concluding Remarks

Consensus-building and compromise are often thought ill of by engineering practitioners. And rightly so when it comes to stress analysis or decisions which would lead to the reduced safety of those who would perhaps lose life or limb were a product to fail in service. The reason for the adoption of standards by the engineering community is to assure (at least at high levels of probability) that a material or process or component will not fail under the contracted conditions for its use. The goal of instituting rigorous standards is to be able to stamp "user error" as the only reason for failure within the specified life-cycle of a mechanism.

These same lofty goals seem to dissolve when people with unique experiences, sensitivities, personalities, and visions become involved in the process of educating the next generation of engineers. Who is to say whether or not the pragmatic goal of improved retention among freshman engineering students should take precedence over their learning the fundamentals of mathematics and physics? Certainly the community among us which is heartily working to define every first degree in engineering as a five-year program would say BOTH are important enough to keep.

I hope this brief review of the current status of the Freshman Year in Engineering will lead to discussions among administrators, faculty, students, and prospective engineering students. The need to inspire our brightest high school students to enter fields of engineering as they matriculate at colleges and universities is great. But, once engineering departments take the hand-off from admissions offices, as many as half of these bright and talented young men and women disappear from the ranks of the engineer. Great must also be our effort to mentor these students through their difficult freshman year at the collegiate level with the expectation that the only reason for failure to remain an engineering major might be "student error."

References

1. http://www.foundationcoalition.org/home/keycomponents/firstyearcurriculum.html
2. J. E. Froyd and M.W. Ohland, "Integrated Engineering Curricula," *Journal of Engineering Education*, January 2005, pgs. 147-164.
3. Ibid., pgs. 155-156.
4. S. Johnson, editor, *2005 Factbook: Cedarville University*, pgs. 11-12.
5. S. Johnson, "Initial Fall 2006 Freshman Survey Results," Cedarville University Office of Institutional Research and Effectiveness, pg. 1-4.
6. http://en.wikipedia.org/wiki/Advanced_Placement_Program
7. *A Dialogue of Engineering Education: the Role of the First Year*, University of Notre Dame, July 30 – August 1, 2006.

8. There are two versions of the Advanced Placement exam for Calculus: the AB test and the BC test. The content covered on the AB test is a reduced set of the content covered on the BC test. CU permits one year of credit for calculus when students achieve a grade of 5 on the BC test.

9. Froyd and Ohland, op. cit., pg. 158.

10. https://engineering.purdue.edu/ENE/FirstYear/plan

11. http://www/mccormick.northwestern.edu/efirst/coursework.php

12. N. Klingbeil, et. al., "Work in Progress- The WSU Model for Engineering Mathematics Education," *35th ASEE/IEEE Frontiers in Education Conference*, Indianapolis, IN, October 19-22, 2005, paper F3C-5.

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