General Education for Baskin School of Engineering Students

Much of the discussion of general education for the Baskin School of Engineering programs revolves around what general education requirements within engineering make sense for students outside of engineering. The Baskin School faculty have also recognized the importance of considering general education for BSOE majors, and in this document, I discuss some of the relevant issues.

The Computer Engineering and Electrical Engineering programs are accredited by ABET (abet.org), and Bioengineering and Computer Science: Computer Game Design intend accreditation after the awarding their first degrees. The first three fall under the criteria of the Engineering Accreditation Commission (EAC), while CS:CGD will use the criteria of the Computing Accreditation Commission (CAC). These criteria have been set by ABET and the relevant professional societies, such as the Institute of Electrical and Electronic Engineers (IEEE) and the Association for Computing Machinery (ACM). The criteria are available at abet.org.

The bioinformatics B.S. was designed with thought toward accreditation as a new engineering discipline (*Bioinformatics: A new field in engineering education*, Hughey & Karplus, J Engineering Education, Jan 2003), but our ABET contacts doubted it would be possible to accredit in such a new area; it may now be possible to accredit under the recently revised CAC criteria, below.

The Computer Science B.A. is also worth mentioning. One of the goals of the B.A. program is to provide a degree path that accommodates a double major or major and minor combination, especially outside the Baskin School. In the spectrum of values between depth and breadth, is it possible to say that a Computer Science/Philosophy double major does not have an excellent general education? Thus, there are good arguments that students pursuing a double major or major/minor that cover distinctly different modes of thought (for example, are from "opposing" breadth groups) should have campus general education breadth requirements waived, maintaining only the fundamental requirements of writing and quantitative reasoning. Students who have the initiative should be systemically encouraged to seek the challenge of pursuing a double major, a minor, or extensive study within a language through a reduction in general education requirements.

The EAC and CAC criteria provide guiding principles for the general education incorporated in several of our majors, as the criteria include several items that partially or fully overlap the goals of general education.

Under the EAC, programs must demonstrate that their students attain 11 outcomes (*2008-2009 Criteria for Accrediting Engineering Programs*, ABET EAC, abet.org):
> (a) an ability to apply knowledge of mathematics, science, and engineering
> (b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such **as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability**
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Under the CAC criteria, accredited computing programs must demonstrate their students attain 9 specific outcomes (*2008-2009 Criteria for Accrediting Computing Programs - New Criteria,* ABET CAC, abet.org):
(a) An ability to apply knowledge of computing and mathematics appropriate to the discipline
(b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution
(c) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs
(d) An ability to function effectively on teams to accomplish a common goal
(e) An understanding of professional, ethical, legal, security and social issues and responsibilities
(f) An ability to communicate effectively with a range of audiences
(g) An ability to analyze the local and global impact of computing on individuals, organizations, and society
(h) Recognition of the need for and an ability to engage in continuing professional development
(i) An ability to use current techniques, skills, and tools necessary for computing practice.

Engineering and computing curricula also require specific amounts of mathematics and science, offered within and outside the division (48 credits of basic science and mathematics in the case of engineering, one year each in the case of computer science; these minimums are significantly exceeded).

Faculty design of our curricula, always with an awareness of the professional standards for computing and engineering undergraduate education, has led to an integration of many areas that might be termed general education (beyond mathematics and science) within our curriculum, in our own courses and also through the general education requirements of the campus. (To date, the Baskin School has not seriously considered the establishment of school-wide general education requirements, as is done at many engineering schools.)

The most obvious instance of this is the technical writing requirement (CMPE185) discussed in the disciplinary communication responses. The bioengineering, bioinformatics, computer engineering, and electrical engineering curricula have required CMPE185 since each date of inception, and this is a popular choice for the writing-intensive requirement of the computer science majors. This course is the primary, but not the sole, means of satisfying EAC objective (g), and will figure prominently in CAC objective (f).

ABET accreditation emphasizes continuous assessment and improvement – see soe.ucsc.edu/~larrabee/abet for more information on our processes. Seven years ago, a focus group on the EAC outcomes revealed that students found (f), concerning professional and ethical responsibility, to be a great outcome, but that we did not, in the students' opinion, achieve it. As a result, we immediately incorporated additional material on professional and ethical responsibility in CMPE185 and the senior design project, CE/EE/BME 123A & 123B, as well as a new ethics course requirement for CE and EE students, CMPE80E, Engineering Ethics, created for this requirement, or another approved ethics course (BME80G/PHIL80G, Bioethics, or PHIL22, PHIL24, or PHIL28). Bioinformatics and bioengineering require BME80G. CS:CGD requires any of the ethics courses as part of the profession standards of CAC objective (e). Thus, 75% of Baskin School declared majors already have a requirement in ethical reasoning. With the new CS:CGD and bioengineering majors, and recent growth in CE and in EE, nearly 90% of Fall 2008 entering Baskin School frosh are planning to pursue a major with an ethical reasoning requirement.

Should the campus adopt an ethical reasoning requirement as the BSOE has effectively done? Instead, perhaps as with disciplinary communication, the campus should adopt a requirement that all majors consider the place of ethical and professional reasoning within their curricula. Some majors may determine that it is not necessary, others may decide to include topics in specific courses, others may already include such topics, and some may have full course requirements. General education should not be independent of major, but should be thoughtfully integrated with majors by each program's faculty.

Among the Baskin School programs, the Computer Science: Computer Game Design program faculty have given the most thought to the other areas related to general education. The major constrains the current general education requirements to include several areas related to the design of computer games. Beyond the ethics requirement, students must complete one elective in 3 of 5 areas of art and social foundations: art, music, economics, theater, and film.

As the campus considers the general education framework in more detail, and as we prepare for a Fall 2009 ABET review, it would be highly appropriate for the rest of the Baskin School programs to especially consider the constraints of EAC-(c), and the attainment of EAC-(h), EAC-(j), and CAC-(g).

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