# 2006-1072: DESIGNING A B.S. DEGREE PROGRAM IN ENGINEERING FOR GLOBALLY SUSTAINABLE DEVELOPMENT

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# Designing a B.S. Degree Program in Engineering for Globally Sustainable Development

A new degree program for careers in international engineering is proposed. This degree program starts with a foundation of engineering science courses that are typical of most undergraduate engineering degree programs. Then, courses directly related to the practice of engineering in a global environment for sustainable development are added. To complement the engineering courses, a series of general education courses were chosen that address major global social issues. Herein, the new engineering program is described, along with the program plan. This new degree program has the advantage of developing an international-focused curriculum within engineering for students with a strong interest in eliminating world poverty in a sustainable manner.

## Introduction

A major role for faculty is curriculum updating and design. As the world of engineering changes, it is a faculty responsibility to keep the curriculum up to date and relevant for current and future students. Faculties normally respond by making incremental changes and adjustments to the curricula. Over time, incremental changes can lead to curricula that are no longer meeting the goals of the engineering workforce or the institution's graduates. At this point, other stakeholders may call for wholesale changes, or reforms, to the curriculum.

Siller and Johnson[1] describe how much of engineering education reform is really just about moving the boundaries that make up the sub-sections of the curriculum. For example, engineering programs forty years ago consisted primarily of large tracts of analysis courses with a much smaller tract of social (non-engineering) courses and synthesis courses were nearly non-existent. As described in that paper, ABET 2000 with its emphasis on synthesis and social courses has caused some changes within engineering curricula, but not enough to make engineering appealing to many underrepresented groups of students.

Kam[2] has noted that engineering does not appeal to women students even though engineering has been heavily marketed towards them. What is the problem? How might we fix it? Kam states that "whether we like it or not, the current engineering curriculum has demonstrated itself to be strongly oriented toward males." Kam continues "As unfashionable and unseemly as it may sound, the time may have come to try consciously to develop an engineering curriculum aimed deliberately at young women." Obviously, if the new curriculum is designed appropriately, it should appeal to men who have not been attracted to engineering because of how engineering has been perceived by them. In other words, engineering not only has not appealed to women but there are many men who have been turned off for the same reason that these young women have. Engineering programs that put technology in a societal context signal to women students that technology is useful and may be gainfully used in solving societal issues.[3] Engineering as a career in the U.S. and in other western countries may be at a crossroads. The commoditization of engineering, or at a minimum, the popular presses' persistent

writing that engineering and computer science are being commoditized, may further reduce the number of students entering engineering programs in the near future. Also, competition from India and China just in terms of the numbers of engineers graduating each year will more than likely inhibit entering engineering student numbers.

To counter these trends, engineering faculty must develop new curricula that fulfill career opportunities and appeal to entering college and university students. Many authors have described programs that emphasize entrepreneurial activities, or design, but these programs are flawed as well. The ability to create new industries is really based on business and legal infrastructures, not what is taught. Countries with available capital and with few limitations in starting businesses will do just as well as the U.S. in this regard. Similarly, as countries desire to rise up the product chain from manufacturing, they will naturally take on design as the next engineering function. And, this may be as it should be since the manufacturing base will serve the new or next product design function well.

**Engineering for Sustainable Development**

Recognizing that engineering education might move in new directions, the authors have undertaken an effort to design, from scratch, a four-year curriculum centered on engineering science with enough social courses added to provide a beginning background to a graduate to work for aid organizations (usually non-profit organizations) working in the developing world to do economic sustainable development from a multi-sectored[4] point of view, that is, to include health, water, sanitation, food and agriculture, education, economics, technology, and safety and security.

Over the next fifty years or less, economic development of the nearly two billion people on this planet living in or near poverty levels must become a major focus. There is no reason that engineers should not play a significant role in eliminating world poverty and doing it in a fully sustainable manner. After all, many of the problems with poverty environments are the lack of suitable infrastructure and lack of access to resources both economic and technologic. Because such an engineering program is very social in its construction and application, it is hoped that this engineering program will appeal to both men and women for whom engineering has not appealed in the past and who also have a strong social conscience.

The newly designed curriculum is illustrated in Table I. The first year is quite traditional. The usual mathematics and science core courses are included: two semesters of chemistry, two semesters of physics and two semesters of calculus. The year also includes college composition and public speaking. Most women students who enter engineering do not perceive these courses as too difficult, nor do they think they discriminate against women, however, the large number of intensive engineering analysis courses later in the curriculum do cause women students to leave engineering.

**Table I. An Engineering Science Concentration in Engineering for Sustainable Development**

**First Year**

| | | | |
|---|---|---|---|
| General Chemistry I | 4 | General Chemistry II | 3 |
| General Chemistry I Laboratory | 1 | General Chemistry II Laboratory | 1 |
| Calculus I for Physical Sciences | 4 | Calculus II for Physical Sciences | 4 |
| Physics I for Engineers | 5 | Physics II for Engineers | 5 |
| College Composition | 3 | Public Speaking | 3 |

**Second Year**

| | | | |
|---|---|---|---|
| Calculus III for Physical Scientists | 4 | Ordinary Differential Equations | 4 |
| Engineering Mechanics – Statics | 3 | Engineering Mechanics – Dynamics | 3 |
| Social Problems | 3 | Current World Problems | 3 |
| Principles of Plant Biology | 4 | Principles of Microeconomics | 3 |
| Americans in a Changing World | 3 | Public Health & Disease | |
| | | or | 2 |
| | | Bioethics & Society | |
| | | Thermodynamics | 3 |

**Third Year**

| | | | |
|---|---|---|---|
| Fluid Mechanics | 4 | Statistics for Engineers & Scientists | 3 |
| Ecology | 3 | Issues in Environmental Economics | 3 |
| Community Dynamics & Development | 3 | Participatory Practices in Sustainable Development | 3 |
| Mechanics of Solids | 3 | Basic Hydrology | 3 |
| Intro to Economics of Natural Resources | 3 | Peoples & Cultures of Africa | |
| | | or | 3 |
| | | Modern Indian Culture & Society | |
| | | Intro to Electrical Engineering | 3 |

**Fourth Year**

| | | | |
|---|---|---|---|
| Engineering Design I for Sustainable Development | 3 | Engineering Design II for Sustainable Development | 3 |
| Cultures & the Global System | 3 | Women & Development | 3 |
| Appropriate Technologies for Sustainable Development | 3 | Sustainability of Renewable Resources | 3 |
| Civil Infrastructure | 4 | Perspectives in Global Health | 3 |
| Technical Elective | 3 | Monitoring & Assessment for Sustainable Development | 3 |
| | | Technical Elective | 3 |

The second year introduces the first true engineering courses – the two semester sequence in Engineering Mechanics: Statics and Dynamics and a course in Thermodynamics. In addition, the year contains an additional two semesters of mathematics, a third course in calculus and ordinary differential equations. The remainder of the year consists of a course in Plant Biology, Principles of Microeconomics and four social courses in Social

Problems, Americans in a Changing World, Current World Problems and a course in Public Health.

The third year includes four engineering courses: Fluid Mechanics, Mechanics of Solids, Basic Hydrology and an Introduction to Electrical Engineering and a course in Statistics for Engineers. At this point community dynamics is introduced through two courses – Community Dynamics and Development and Participatory Practices in Sustainable Development. Ecology, The Introduction to Economics of Natural Resources and Issues in Environmental Economics courses are also included. Each student is then allowed to specialize in either the culture of Africa or the Indian sub-continent. Here it would also be nice to offer a similar cultural elective class in Central and South America.

The fourth and final year includes three engineering courses: one on Civil Infrastructure, the second on Appropriate Technology for Sustainable Development and the third on Monitoring and Assessment for Sustainable Development. The highlight of this last year is the two semester capstone design course on Engineering Design for Sustainable Development. Two additional technical electives are chosen with the consent of the student's advisor. The two technical electives could both be taken during the first term of the fourth year or one in each term. This flexibility allows for the possibility that a two semester sequence could be taken, if desired. The remaining courses are Cultures and the Global System, Women and Development, Sustainability of Renewable Resources and Perspectives in Global Health. Table II[5] briefly describes the non-science, technology, engineering and mathematics courses.

The program was designed to be implemented as a Bachelor of Science degree program in the Engineering Science major at Colorado State University. Colorado State University has very strict guidelines concerning courses that make up the University Core Curriculum. Because of having to meet the Core Curriculum requirements, some courses appear in the curriculum that might not have if other rules, or the lack of rules, had permitted. The program consists of courses that are already taught at Colorado State University except that specialized senior design courses emphasizing sustainable development would have to be formalized. This program should be easily transported to other universities. There is nothing unique about Colorado State University. It is a very traditional land-grant institution. Obviously, some other courses could be easily substituted without changing the flavor of the program as long as the program is still tailored to sustainable development with a multi-sectored approach.

**Summary**

A new degree program has been designed to attract a new breed of engineering student into a program with a strong social orientation. The structure of the curriculum is approximately one-third science and mathematics, one-third engineering and technology, and one-third social courses. It is hoped that this program will appeal to students who are currently not attracted to engineering as a career by emphasizing major global social issues with respect to sustainable economic development for the purpose of eradicating global poverty. Graduates should find employment with major non-profit aid

organizations with the opportunity to make significant contributions in the developing world.

**Table II. Brief Course Description[5] of the non-STEM courses**

**Social Problems ─** Analysis of global and domestic social problems.

**Americans in a Changing World ─** Colonial and post-colonial discourse, politics of representation and epistemology of "location" it has produced: first and third world.

**Public Health and Disease ─** Function of the human body in health and disease; exercises for decision making related to health.

**Bioethics and Society ─** Major issues in bioethics.

**Current World Problems ─** Background and nature of international political events.

**Community Dynamics and Development ─** Nature of community: its institutions, problems and processes, including growth, disintegration, and development.

**Introduction to Economics of Natural Resources ─** Concepts, theories, institutions; analytical methods for economic evaluation of alternative resource use patterns and land use plans.

**Ecology ─** Interrelationships among organisms and their environments using conceptual models and quantitative approaches.

**Peoples and Cultures of Africa ─** Sub-Saharan life styles including marriage and family, traditional government, religion, ecology and economy, art, music and literature.

**Modern Indian Culture and Society ─** Anthropological contributions to the understanding of contemporary India.

**Cultures and the Global System ─** Analyze diversity, cultural responses, and adaptation of smaller-scale societies to emerging global trends.

**Women and Development ─** Research and policy issues related to women in developing countries.

**Perspectives in Global Health ─** Science, skills, and beliefs directed at the maintenance and improvement of health for all people.

**Sustainability of Renewable Resources ─** Aspects of sustainability of managed renewable resources.

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