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FOREIGN ADAPTATION OF U.S. ENGINEERING EDUCATION MODELS

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Abstract

The U.S. model of engineering education is rapidly being adopted in one form or another by countries around the world. Given the enduring strength of the U.S. economy and its strong base in technology, it is not surprising that countries wanting to emulate the U.S. economic success would see our model of engineering education as a desirable one. But seen from the inside, U.S. engineering education appears to have significant problems – such as declining enrollments, and the utilization of its graduates as a 'commodity' by employers. It also appears that new quasi-engineering academic programs have opened or are being developed to allow students to take more palatable paths to entry to lucrative technology careers. What are foreign countries getting when they adapt our engineering curricula, and is that approach appropriate to their needs?

Introduction

There was nothing unusual about the circumstances: two American university professors each received an invitation to share their knowledge of U.S. higher education with fellow academics and some government and industry types in a different developing country. The invitations originated with overseas friends, but the U.S. colleagues were brought in as official paid consultants. The assignment in Jordan was long-range and specific: "Help us design a new engineering college that will meet ABET standards." In the former Soviet Republic of Moldova, the assignment was short-term and generic: "You have two hours to teach us about the credit hour system in American higher education." And so we went and received appropriate compensation and gratitude for our contributions, but a nagging question remained: "What aspects of U.S. higher education should be exported overseas and what are the U.S. practices that, like some wines, do not travel well?"

The seminar in Chisinau, capital of Moldova, was sponsored by the Soros Foundation in support of the Moldovan government's recent decision to implement a credit hour system in their universities. As the presentation was being written, initial worries about communicating effectively with a wildly diverse audience gave way to a larger concern. The credit hour system in the U.S. is under active attack from within, as public pressure for accountability has forced U.S. colleges and universities to look at what their students have learned rather than how much time they have spent in class. The emphasis over the past fifteen years has been on outcomes rather than inputs. So wouldn't the Moldovan educators be better off leap-frogging the credit hour system and instead moving directly to creating an outcomes-based curriculum?

There was no forum for raising this issue. And in the end, practical politics took precedence over a more idealized approach. Moldovan students are being hindered in their attempts to study outside of their own country because their academic credentials cannot easily be evaluated for transfer. The credit hour system will provide a commonly spoken academic "language" and provide a quick fix to a country that desperately needs signs of connectivity to the Western world.

The second experience, assisting in the initial design and startup of a new engineering college in Jordan, contained similar experiences. The newly appointed Dean was quite experienced with both Middle East engineering education and that available in Western Europe and the United States. As an experienced ABET volunteer, the consultant was asked to help in developing a curriculum that would meet world standards – but also meet the immediate needs of the graduates and the local industries by which they would be employed. Meeting both of these goals within a four-year curriculum proved very difficult, and many tradeoffs had to be made. For example, the curriculum was designed by referring to specification driven criteria, not the more modern outcomes assessment approach. This was deemed necessary in order to give the large number of newly recruited faculty members firm guidance on course development. In addition, major blocks of time in the programs had to be devoted to building the backgrounds of students in areas not typical in Western engineering education – such as machine shop experience. The resulting curriculum thus takes considerable guidance from US standards, but is carefully tailored to meet local needs in a rapidly developing country.

The events are past: the questions remain, however. What do other countries want from us? To what extent is the heralded success of the U.S. system of engineering education site-specific? What is our responsibility, when we take on an overseas assignment, to raise questions about the suitability and limitations of our U.S. practices? Do codified accreditation standards reflect state-of-the-art thinking about the best of engineering education? Could non-traditional, experimental and highly idiosyncratic engineering programs perhaps be more suitable to the conditions in some developing countries? Whose role is it to raise these issues?

Export Of U.S. Model

Many countries are seeking to emulate the U.S. model of engineering education. Its attractiveness as a model appears to be based not only upon its inherent strengths and quality, but also from the assumption that it is a major contributor to the success of the technology driven economy in the United States.

Many countries have utilized the criteria of the Accreditation Board for Engineering and Technology (ABET), and consultative services of that body, as ways of adapting U.S. engineering education patterns to their local needs. ABET has worked closely with engineering societies and educators in foreign countries to assist in the development of effective accreditation systems based on the principles of self-assessment, peer review, and stakeholder involvement. ABET has met with representatives from numerous countries, sponsored a series of international workshops on accreditation system development, provided materials and speakers for symposia in foreign countries, and encouraged observers from abroad in all elements of the ABET accreditation process.

In addition, ABET has sent teams of expert consultants to evaluate foreign engineering programs on their strengths and weaknesses and to make recommendations for improvement. These evaluations closely parallel the procedures and criteria used by ABET in the U.S., but the programs are not ‘accredited’ -- they are instead rated as to whether they are ‘substantially equivalent’ to accredited U.S. programs. This status implies reasonable confidence that the graduates possess the competencies needed to begin professional engineering practice at the entry level. Using its conventional engineering education criteria, ABET has evaluated and recognized over 70 programs at 14 institutions in 10 countries to date.

Engineering education in Europe is currently moving closer to the U.S. model, although not overtly indicating that as motivation for recent developments. The Bologna Declaration by the European Union, aimed at creating a European space for higher education, is steering higher education there into patterns typical in the U.S. The Declaration has as objectives a common framework of compatible degrees across Europe, undergraduate and postgraduate degree patterns in all countries, a compatible credit system, quality assurance at the European level, and the elimination of obstacles to mobility for students and faculty. The engineering educators there agree with the encouragement of mobility, but want to maintain the cultural diversity of national education systems. They agree with the desirability of having undergraduate and graduate degrees, but do not want an undergraduate degree to be a prerequisite for graduate study. Countries that have a ‘long program’ for educating engineers to an advanced level want to be able to continue that pattern. But the pressure is clearly toward the U.S. model of a four-year BS followed by an MS, and several European countries are moving to that pattern for their engineering education.

Engineering education in the United States has been undergoing considerable reform in recent years, fueled by demands for more accountability in undergraduate education overall from consumers and governments, and by a major program at the National Science Foundation (NSF) directly aimed at reform of engineering education. The NSF Engineering Coalitions Program solicited proposals from engineering schools in the spring of 1990, and began funding them for multi-year periods. During the course of this program, which is currently being phased down, some eight major coalitions were funded. Results of this major NSF effort to date have been encouraging. One primary benefit is that the major funding and highly visible priority of the Coalitions program have made engineering education research and development credible at universities where previously only scientific research had been emphasized as appropriate activity. The model programs developed by several of the Coalitions have also provided good models for others to adopt, in areas such as:

- Inversion of the curriculum, to bring engineering subjects into the lower division in order to keep student interest in engineering high, and to provide the rationale for the study of mathematics and science which heavily dominates the first two years of engineering study
- Just in time coordination of math and science coverage, within the context of engineering problem solving courses, as the major educational stream
- Engineering design throughout the curriculum as a major theme, beginning in the Freshman year
- Holistic, integrative experiences for undergraduate engineering students
- Links to pre-college education, and increased recruitment and retention of under-represented groups
- Integrated development of educational tools, including utilization of advanced technologies in the educational process

Due to the large number of engineering schools directly involved in the various Coalitions, and the size of many of those schools, large numbers of current U.S. engineering students are being directly impacted by these experimental programs. Some 40% of all current engineering students in the U.S. are enrolled at Coalition schools, and as the experimental approaches developed are tested and scaled up, this large number of students can be expected to be beneficially impacted. In addition, due to progress reports on Coalition results to engineering education more broadly, schools outside the Coalition program are also adapting some of these new approaches for their own use. Thus, engineering education in the United States has been undergoing a systematic and healthy reform, leading to more emphasis on undergraduate education in engineering faculties and to a resulting improvement in the educational process and its graduates. These developments have been widely reported in engineering education conferences and journals both in the U.S. and throughout the world, and thus are available as models for foreign engineering schools.

But All Is Not Well

While many aspects of engineering education in the U.S. are strong and vibrant, there are several trends which raise concerns. The number of high school graduates who enroll in engineering programs in the U.S. has been declining significantly in recent years, despite a sustained and increasing demand for technical graduates by employers of engineers. In the mid-1980's, engineering schools were graduating some 80,000 Bachelors degree students per year – a number that has dropped some 25% since then. It appears that many students are selecting other, often less demanding, paths to the technical employment marketplace – such as computer focused courses of study or quasi-engineering programs with less rigorous mathematics and science requirements.

There are some interesting trends among recently graduated engineers that may also be impacting on whether young people choose engineering education for career preparation. Many engineering graduates are now experiencing major job changes every few years throughout their careers, as employers ramp up and downsize depending on market shifts and mergers. These changes are often disruptive, and often lead to lateral job placements at best, thus giving the impression that the engineer pool is a 'commodity' – rather than engineering seen as a career with progressive placements. In addition, many engineering graduates – particularly those accepting first positions out of college – are being employed by financial consulting firms and similar non-engineering employers, who want to utilize their quantitative skills for a few years while they are on top of the latest high tech state-of-the-art. At some engineering colleges, as many as 40% of the recent graduates have taken such first jobs.

Engineering education is perhaps the most studied and discussed field of college and university education in the U.S. – subjected to repeated studies by educators and practitioners. While it is currently viewed as strong and healthy in terms of content and approach, the declining enrollments and developments in the employment market place appear to require continued attention by those concerned about the long-term well being of the profession and the technical economy of the country.

With these concerns, it behooves engineering educators and government agencies in foreign countries to look carefully at what they adapt from the U.S. engineering education model. For example, ABET has recently made a fundamental and broad change in its accreditation criteria, from a highly structured prescriptive set of criteria to an outcomes assessment format with only a few general specific criteria, called *Engineering Criteria 2000.* In seeking a model to make available to engineering educators in developing countries, the World Federation of Engineering Organizations Committee on Education and Training has recommended that such countries follow the previous ABET approach, rather than the new outcomes based approach.

Alternatives To Traditional Programs

Alternatives to traditional engineering programs have been proliferating over the past decade and a half. Some of these are offered on established college and university campuses, but others are located on corporate campuses, and still others exist in virtual space. All of these offer graduates additional entry points to employment in the booming technology sectors.

James Madison University's College of Integrated Science and Technology has a program which was purposely designed to be neither pure science, nor pure engineering nor pure business, but to strategically integrate these areas of studies. The program's mission statement (http://www.isat.jmu.edu/mission.htm) contains a claim about its superiority to traditional, narrower programs and can be read as a critique of where engineering education is perceived to have fallen short:

"The Program in Integrated Science and Technology (ISAT) educates students for positions that are often filled by graduates of the traditional sciences, engineering, and business programs. The ISAT graduate, however, is professionally prepared in a broader sense. ISAT students are educated to be technological problem solvers, communicators, and life-long learners. They are unique in having

- breadth of knowledge and skills across a variety of scientific and technological disciplines;
- formal training in collaborative and leadership methods, problem-solving techniques from many disciplines, and use of the computer as a problem-solving tool;
- the ability to integrate scientific and technological factors with political, social, economic, and ethical considerations in problem solving."

Of the thirty-nine faculty members teaching full-time in the program, fifteen have doctorates in engineering. Many of the others are in computer science, a few are classically trained physicists, and a large number specialized in applied sciences. The curricular design, however, obligates the faculty to work together, regardless of their disciplinary background.

Students are voting with their feet. The first class of majors in integrated science and technology was admitted to James Madison University in August of 1993. The first degrees were awarded to 37 students in 1997. Since then, enrollment has been growing at a fast pace, with 164 students graduating with undergraduate ISAT degrees in 2000. A continuing survey of campus recruiters and questionnaires sent to graduates indicates excellent success in placing them in jobs where their broad skills are highly valued and compensated.

If developing countries want to educate their own citizens to remain at home and engage in nation-building, they can legitimately ask about trade-offs, much as the founding faculty of the program in Integrated Science and Technology did as they designed their curriculum. What, for example, is the wisest trade-off between teaching high technical competencies required for employment as an engineer in the US and teaching about the strategic deployment of scarce resources and how to evaluate a proposed technical solution to a problem embedded deeply in a unique political, social, economic and cultural environment?

Other non-traditional approaches are also competing with traditional engineering education. Motorola University provides large numbers of technical and business oriented courses to current employees of the multinational high technology firm within which it is contained. Novell, Microsoft and other high technology companies offer commercial short course programs to prepare graduates for highly paid technical positions in the computer field – granting such titles as "certified software engineer". The University of Phoenix, a private institution with major electronic offerings and dispersed campuses serving adult learners, offers many programs aimed at preparing their graduates for entry into lucrative technical job markets. Should developing countries be emulating some of these approaches instead of or in addition to traditional engineering education programs?

Conclusions

What do these alternative approaches to engineering education offer as value-added to developing countries seeking to educate their citizens in ways that support economic development at home? Valuable aspects to be included in the education of new generations of engineers in developing countries would be: expertise in reaching out to non-traditional and under-represented populations; commitment to meeting the continuing education needs in the profession; training in business knowledge, skills and experience; explicit consideration of appropriate uses of technology in differing cultural and social environments; careful articulation with primary and secondary schools; and an emphasis on interdisciplinary work.

As more and more American engineering educators are called upon to lend their expertise to their overseas colleagues in establishing or refining engineering programs, the first question all parties need to ask is where the students are expected to practice. A U.S. look-alike program might well be counterproductive, turning out students fit for the U.S. labor market, but missing those skills which will be most useful to their own countries.

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