Visitor Report for Departments of Civil Engineering at the University of Chile and Pontificia Universidad Católica de Chile

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Introduction

At the invitation of the University of Chile and the Pontificia Universidad Católica de Chile, I visited the departments of civil engineering from August 16 to August 21, 2007. The visit was conducted under the auspices of a Ministry of Education project to develop strategic directions for engineering curricula at the two leading universities in Chile (the Mecesup Project). The objectives of the visit were for me to learn about the civil engineering programs, discuss the proposed plans for reducing the time to obtain the first degree (engineering diploma), describe trends in the U.S. regarding engineering education, and provide information about recent changes in civil engineering at the University of California, Berkeley. This report summarizes my activities, provides observations about the civil engineering degree programs based on information learned during the brief visit, and concludes with recommendations.

University of Chile, August 16-17, 2007

In the morning of August 16, I met with structural engineering faculty and learned about their recent research projects. We discussed the six-year engineering degree program and the issues associated with reducing the length of the program. Historically, the six-year program provides a broad education in civil engineering and the opportunity for deep concentration in a discipline of the civil engineering field.

One of the important contextual issues is that an engineering graduate in Chile automatically has the license to practice as an engineer (e.g. design and approve structural plans for building construction, in the case of structural engineers). Therefore, the curriculum is expected to prepare graduates with the technical knowledge and design experience for this critically important function. In contrast in the U.S., an ABET accredited four-year B.S. degree is only one component of the engineering licensure system; but licensure also requires qualifying design experience after graduation and passage of one or more examinations. A convergence between the two systems is that the U.S. is moving to requiring additional education beyond the B.S. degree for professional engineering licensure. There is more discussion of the relationship between engineering education and professional practice later in this report.

In the afternoon, I met with more faculty and gave a research seminar on “Computational Simulation for Earthquake Engineering.” Approximately 30 people attended the seminar, including faculty and students from the University of Chile and Pontificia Universidad Católica de Chile and a few industry representatives.

The discussions continued in the morning of August 17, and the visit to the University of Chile concluded with a lunch meeting with members of the structural engineering faculty.

Pontificia Universidad Católica de Chile, August 20-21, 2007

I first met with the Mecesup Project Learning and Evaluation Committee and the project director. I learned about PUC engineering degree program and the alternatives that have been examined for reducing the length to five years. The assessment of the degree program and ABET accreditation were discussed.

The afternoon was devoted to a lengthy meeting with the PUC Civil Engineering committee working on the project. One of the important issues, which is similar in the U.S., is that civil engineering is a broad field, encompassing many disciplines, such as structural, geotechnical, environmental, transportation, water resources, and other areas. The educational difficulty is to identify what is core knowledge for all areas of civil engineering and what is specific to the disciplines. In the fast changing world of engineering and technology, with new fields of knowledge developing rapidly[1], it is also desirable that students be exposed to fundamental knowledge that will affect civil engineering in the future. Such rapid changes call for improved interdisciplinary education that will be effective for educating engineering leaders, but is challenging to do well.

During the morning of August 21, I had the opportunity to meet with the Dean Hernán de Solminihac, School of Civil Engineering. We had a deep and extensive discussion about the goals of the Mecesup Project, the current status, and the significance of the project for Pontificia Universidad Católica de Chile. I described the recent B.S. degree changes at UC Berkeley, the driving forces behind them, and an evaluation of the changes on our students and the profession.

Later in the morning, I gave a seminar, "Current Trends in the U.S. Facing the Civil and Environmental Engineering Field: An Update from UC Berkeley." The attendance was excellent with approximately 80 people from both universities. Because of the relevance of the seminar to the objectives of the visit, the major points are summarized in the following.

1. In a world where advanced knowledge is widespread and low-cost labor is readily available, the U.S. advantages in engineering and technology have begun to erode. A comprehensive and coordinated national effort is urgently needed to bolster U.S. competitiveness and pre-eminence in these areas.
2. It is clear that countries in the global economy need to consider diverse factors for successful competition: (a) cost of labor -- including professionals and "knowledge-creative" class; (b) access to capital markets, particularly venture capital; (c) quality and access to research and innovation talent; (d) access to qualified workforce; (e) quality of research universities; and (f) significant and high-impact research and development supported by the national government.

[1] To name a few new and emerging fields that are affecting civil and environmental engineering: information technology and communications systems; materials, particularly nano-scale fabrication and modification; sustainability, including energy and the environment; high-performance computation, including grid computing and massive parallel processing; embedded computing and cyber-physical systems; engineering as a service science.

3. The recommendations of a recent report by the National Academies[2] ("Gathering Storm") are that the U.S. needs to: (a) improve teaching of science, math, engineering, and technology in K-12; (b) strengthen the U.S. commitment to long-term basic research to "maintain the flow of ideas that fuel the economy, provide security, and improve the quality of life;" (c) make the U.S. the most attractive country to study and perform research; and (d) support innovation through intellectual property regulations (e.g. patent law) and tax policy.
4. The American Society of Civil Engineers (ASCE) completed a vision document that can be summarized as civil engineers will be the master planners, designers, and stewards of the built and natural environment[3]. This vision is motivated by trends in which the bulk of the world population participating in the global economy is shifting to Asian countries, declining interest among U.S. students in pursuing engineering, and market pressures that are resulting in the commoditization and outsourcing of engineering services. The top engineering schools will not succeed in the long run if they teach only knowledge and skills that become commodities. In a rapidly changing engineering world, this is major challenge for civil engineering programs.
5. At UC Berkeley, the Department of Civil and Environmental Engineering has responded to these trends through an ongoing strategic planning process and continual evaluation and change of the B.S. curriculum over the past ten years. The goals of the department are three-fold: (a) deliver high-quality curricula to educate students to become tomorrow's leaders; (b) pursue research that addresses critical societal needs, including interdisciplinary collaborations; and (c) meet the needs for CEE professional leadership.
6. A major programmatic innovation in CEE at UC Berkeley has been to develop a new Civil Systems graduate program that is *intra*-disciplinary within CEE and *inter*-disciplinary with other engineering fields such as electrical engineering, computer science, and mechanical engineering. This program has enabled new research and access to non-traditional CEE students in areas such as sensing, communications, and distributed network control for applications such as infrastructure monitoring and assessment, water quality, and real-time transportation operations and management.
7. The B.S. degree in civil engineering is a broad program that offers students considerable flexibility. After basic science, math, engineering science and humanities courses, students are required to take at least one course in four of seven areas of civil engineering and one civil engineering design course. Students take five or six technical electives, which may consist of almost any advanced undergraduate course in the College of Engineering. Most students decide to concentrate in one or two disciplines within civil engineering, but some take a broader program because of their interest, career goal, or plans for graduate study. Our surveys should approximately one-quarter of B.S. degree graduates immediately go to graduate school; after three years, 72% of the students pursue a graduate degree in engineering or other fields.
8. New educational assessment methods have been established to determine how well the outcomes of the courses and objectives of the degree program are being accomplished.

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[2] *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, National Academies Press, 2007. http://www.nap.edu/catalog.php?record_id=11463

[3] "The Vision for Civil Engineering in 2025," American Society of Civil Engineers, final draft report, January 12, 2007. http://www.asce.org/files/pdf/professional/summitreport12jan07.pdf

This is required for ABET accreditation, but it has also helped improve the quality of the program.

The afternoon concluded with a meeting with the entire faculty of Structural Engineering to discuss the points I covered in the presentation.

Observations

After examining the issues with faculty at both universities, I believe that the two leading civil engineering schools should move towards a five-year degree for four reasons. First, Chile functions, very successfully, in a global economy and the internationalization of engineering education and engineering services are inexorable trends. In the U.S. the standard degree is a four-year B.S. degree, but in many domestic civil engineering markets a B.S. plus an M.S. degree are expected entry-level credentials. In Europe, the Bologna process calls for a three-plus-two year degree, and most universities have changed their programs. Mobility of students and engineering technology and services between Chile and other countries (which may be two way) will be enhanced with a five-year engineering degree. Second, and this may seem paradoxical, civil engineering knowledge and the field is changing so rapidly because of technology innovation and globalization that it is not possible to cover all the information in four, five, or even six years. Therefore, it makes sense to teach the truly essential and fundamental knowledge that can be provided in five years and then prepare students to engage in learning over their entire career. Third, over-specialization of engineering education at an early stage may constrain career choices at a later stage and could limit innovation, and it may make the engineering degree less attractive to highly capable and motivated students. And last, a five-year degree would make a statement that engineering education is collaboration between universities and industry. Thus planning for the five-year degree should involve the engineering profession and leading companies to achieve the desired result: highly educated, innovative, and productive engineers who will be professionally successful and contribute to Chile's continued expansion of the economy and industry. I should say that there is no empirical evidence for these observations, but they are based on my experience with civil engineering education and career development in the U.S. However, recent reports and papers about the future of engineering and engineering education point to similar observations.

My impression is that the PUC faculty has reached a consensus that the engineering degree program should be changed to five years. The support for the change appeared to be less at the University of Chile.

An important consideration for U.S. engineering programs is accreditation by ABET Inc., and the issue of accreditation is relevant to the Mecesup project. The accreditation process requires programs to be specific about their goals and the expected educational outcomes. As discussed above, an assessment and feedback mechanism must be used to improve the program on a continuous basis. When done well, these processes have the potential to improve the quality of how engineering is taught, provide students with relevant design experience, and prepare them for life-long learning. The accreditation process recognizes that education does not end upon graduation and that industry has a critical role in training recent graduates as professional engineers. Motivated by the trends outlined above, ASCE is advocating a B.S. degree plus 30 units (which would be eight to ten semester-length courses) of post-graduate education as a

minimum requirement for a professional engineer. In the U.S., professional licensure is the responsibility of the individual states, so the changes in requirements will take some time.

ABET accredits engineering programs at the basic level (four-year B.S. degree), or the advanced level. In the U.S., very few programs accredit at the advanced level; nearly all civil engineering departments seek basic level accreditation. Until recently, ABET did not allow a program to accredit at both levels, basic and advanced. Since my visit, however, ABET has removed the ban on dual level accreditation[4], although the Engineering Dean's Council of the American Society of Engineering Education[5] was opposed to the change. Nevertheless, it is unlikely that civil engineering programs at major research universities will seek advanced level accreditation because the M.S. degree serves students interested in a research and academic career paths as well as a professional engineering career.

Another recent change is that ABET has discontinued review of international degree programs for substantial equivalency. In its place, ABET intends to review and accredit engineering programs at international universities as they now do in the U.S. In this regard, the civil engineering programs at the University of Chile and PUC may seek accreditation in civil engineering. The six-year program and the proposed alternatives for a five-year program exceed the requirements for basic level accreditation. Therefore, I recommend that the universities seek advanced level accreditation of the civil engineering diploma. Not only would ABET accreditation confer international authority for the degree, it would be one of the very few advanced level civil engineering degree programs and perhaps the only one, at least in the near future, from internationally ranked research universities.

Recommendations

1. The University of Chile and Pontificia Universidad Católica de Chile should continue the strategic planning and detailed implementation for changing the first degree in civil engineering so that it can be completed in five years.
2. Coordination between the two universities is important for systematic change of the engineering degree to be successful within Chile. The leadership of the two schools should encourage and support such collaboration.
3. As part of the planning for changing the engineering degree, the universities should engage the engineering profession and industry so that graduates receive complementary professional experience and training in the early years of their career.
4. The government, universities and profession should consider developing an engineering licensure system that is based on education, experience, and examination. This will enable Chilean engineers to apply for reciprocity with other countries when working on global projects.
5. ABET accreditation of the engineering degree program is worthwhile and is recommended for both universities. Since the first degree will be at least five years, the programs should seek advanced level accreditation in civil engineering.

[4] http://www.abet.org/dual.shtml
[5] http://www.abet.org/Linked%20Documents-UPDATE/Dual/EDC%20Res%20on%20DualLevelAccreditation%20Ltrhd%201.pdf