An Integrated Approach to Engineering Education Worldwide

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INTRODUCTION

In this era of rapid advancement and near explosive growth of technology, their impacts on the well-being of society world-wide increasingly depends upon the quality of the engineers it produces. Thus, engineering education incorporating a global perspective becomes a priority. This paper focuses on the close relationship of universities, engineering societies/institutes, international corporations to meet the demands of the 21st century.

Moving toward the new century and beyond, global competition will become more intense, particularly in the areas of business and technology. These conditions, viewed in the light of limited human and natural resources, will call for engineering innovation. This will require co-operation and collaboration among the nations of the world. Now is the time to address changes to engineering education incorporating global perspectives in response to these new challenges. The key action items serving as a guide for revamping or reforming the system are close relationships among universities, engineering societies/institutes, international corporations and governmental agencies. While many far-sighted advocates of engineering education have already begun restructuring their programs, this presentation attempts to extend that effort to a much wider community through the American Society for Engineering Education.

UNIVERSITIES

Each university should identify and establish a long-range global vision through self-examination of its academic activities, indicating their strengths and weaknesses. In the area of curricula enhancement, strategic planning must accentuate courses including foreign languages, cultural development, social and political sciences, psychology, behavioral science, business management and ethics. It is recognized that many of these courses can be included within ABET guidelines as well as within a general education core which is required at many universities. However, the breadth necessary is likely to exceed the minimum requirements. These topics are necessary to ensure that students are prepared for the broadened world of engineering in a global environment following their educational experiences. These programs should be subjected to periodic review for modification and/or remodeling. An external advisory panel comprising practicing engineers would be helpful for this review; these panels should be formed for each discipline of engineering on a campus and should meet regularly to provide input to the departments.

University administrators should develop methods to recruit and retain international students. Over the years of their college education, international students can assist in liberalizing and broadening the concepts and outlooks of American students. They can help promote and instill in the American students an understanding and awareness of the international aspects of global conditions, particularly as related to engineering(1). This will serve as an introduction to other cultures and, upon graduation, these former students can assist engineers and their organizations as they become involved in global projects. A feasible plan to accelerate cultural exchange is to encourage students to live in dormitories with intermingling of international and

American students. For example, the University of Toledo has completed an “International House”, a

residence hall with significant areas for cultural, social and recreational activities specifically for such purposes.

International exchange of scholars, faculty and graduate students can effectively promote cultural exchange and technological transfer. The secondary author was a visiting professor at the National Taiwan University several years ago (during a sabbatical). It was a rewarding experience to communicate with Taiwanese students and to learn some aspects of their academic lives. This experience was beneficial to all involved. The time and effort spent making arrangements and seeking financial support for travel and living expenses did not diminish the benefits of the experience.

Gradually, joint research projects and sharing of laboratory equipment can result in shortened completion time and save financial resources required to create technological innovations. However, the success of a university mission depends largely upon its faculty reward system. The multi-faceted duties of faculty need to be prioritized and rewarded according to contributions to the goals of the institution in this global environment for years to come.

ENGINEERING SOCIETIES/INSTITUTES

Engineering societies/institutes commonly promulgate standards and codes for general practice. These are important in design, construction, and manufacturing with regard to saving material resources, improving quality control, achieving cost-effectiveness and providing safety for the users. They also sponsor regional and international conventions, seminars and conferences where students, faculty and practicing engineers can exchange information and ideas. These activities can increase the visibility for individuals, provide valuable referrals, and indicate employment conditions and trends; additionally, these meetings foster recognition, respect and enhancement of professional credentials.

Both authors are members of various engineering societies. The primary author served as president of the Toledo Section of the American Society of Civil Engineers; during hhis tenure, he promoted close relationships between professionals and students. This provided an awareness of the responsibilities of the professionals by the students.

In technical and professional practices, engineers must be aware of ethical mores and codes of various nations where they develop working relationships, and must have knowledge of relevant legal requirements and standards in field inspection, and/or testing practices, as well as in areas of business practices, insurance, etc.(2). With regard to global standardization of engineering measurements, the engineering societies should be more responsive in promoting the use of international units. Unfortunately, one of the leading technological nations, the USA, is still out-of-step with the rest of the world(3). Standardization can be adopted in manufacturing, engineering practices, safety, construction, etc., and certainly facilitates technological transfer and provides additional advantages.

Generally speaking, every nation has its standards of practice for engineers. Consequently, this may create a hurdle in cross-licensure requirements for engineers participating on inter-national projects. Should a minimum standard of technological and engineering competence in design, analysis, manufacturing, safety and environmental issues, regulations governing the use of the electronic super-highway, etc. be established by the societies/institutes? Such issues may facilitate innovation in science and engineering, such as adoption of uniform (global) ethics and codes, which will elevate the engineering profession to a higher level.

CORPORATIONS

Multi-national corporations, usually listed in Fortune 500, have clients, competitors, business dealings, and even satellite offices and manufacturing facilities overseas. In order to fulfill technological needs, these companies must turn to human (as well as capital) resources that can provide a combination of engineering expertise and broad-based skills. For example, some knowledge of language, cultural, social and religious aspects, and a global outlook are necessary as multi-national teams form to work toward common goals. This may be termed "International Experience"(4) which can best be accomplished by establishing inernational internships (or in-house training at a satellite facility), or sending trainees to institutions of higher learning in the mother country for advanced research and studies. The company will reap the benefits after employees complete these programs and contribute more effectively to the goals of the corporation.

Exchanging faculty, students and practicing engineers from universities and corporations is an effective way to expose them to engineering practices in other countries and to promote technological transfer. Corporate executives and technology specialists who accept university appointments as "Industrial Professors"(5) can participate directly in specific educational projects. Such programs may include agile manufacturing, environmental technology, social, cultural and human behavior, engineering management, international relationships, etc. Corporations should seek ways to make participation in these programs financially feasible, such as requiring participation for career-track development and advancement. In universities, faculty should be encouraged to use their sabbatical leaves for corporate assignments to enhance global awareness of technological advances. This creates a win-win situation for industry and academia; it can have far-reaching positive effects in the quality of engineering education world-wide.

Both authors have been active in consulting. Not only does this keep one current with the various codes, but provides examples of modern engineering practices to be used in the class-room. This further provides students with an insight of the applications of the principles they are learning, and serves to steepen their learning curves once they become employed following graduation.

GOVERNMENTAL AGENCIES

The era of global competition in technology and engineering is upon us. To remain indistrially competitive and to excel requires research and development which requires closer relationships among academia, industry and government(6). Financially-constrained universities, once pillars of research activities, have seen their sources of funding (both internal and external) shrink and evaporate. Research and development sections of international corporations are also subject to down-sizing and re-direction to meet short-term profit objectives. Given the changing directions and magnitudes of support for research projects by the federal government, a host of agencies, councils, committees, etc. remain as sources of funding. Consequently, university-industry-government partnerships must be created to exploit opportunities in collaborative research. Some may be local or regional, others will be national and/or international alliances established through the "Internet" or information/electronic super-highway. For example, on type

of consortia can combine the resources of universities, industry and federal facilities into a national laboratory to facilitate effective, efficient high-quality research.

A leader in funding such programs is the National Science Foundation which operates and incorporates concepts of partnerships by bringing governmental agencies, industries and

universities to cooperate on diverse research projects. There are other agencies(5) such as the Engineering Research Center, and Science and Technology Center which follow similar concepts. The funding from these centers should be awarded through open competition and granted to parties based upon peer-review of their proposals. These cooperative centers can serve to increase regional, national and international economic development, actively focus on effective technology transfer and practical knowledge deployment, especially to the smaller, emerging, advanced technology industries where many innovations and jobs are created. Current federal support and the concept of alliances can lead to a significant improvement in engineering education world-wide for the future. Corporations can benefit by funding such alliances since the results obtained are expected to enhance profit margins once the results of the research are implemented. Federal governments can assist by offering tax incentives for contributions to such alliances. Additionally, federal agencies can greatly facilitate movement of international students, trainees, professionals and scholars between countries. This will serve to accelerate technological transfer and diffusion.

The authors were granted (applied) research contracts jointly by the Federal Highway Administration (FHWA) and the Ohio Department of Transportation (ODOT). The results of these investigations brought about a change in the installation procedures for presact reinforced concrete box culverts. This change was the deletion of shear transfer devices between adjacent culvert sections which reduced material costs and lead to a shortened construction time, which saved taxpayer monies. These contracts also provided support for graduate students, and led to the publication of technical papers.

CONCLUSION

The interaction and inter-relation of universities, engineering societies/institutes, international corporations and federal agencies would be a significant step in facilitating the improvement of engineering education to enhance world-wide competition/cooperation. Hopefully, these suggested actions/relations, when fundamentally well-planned and progressively executed, will speed progress and lead to global wealth and prosperity.

Based upon the authors' practical experience, academic experience, and successful efforts to cross barriers, we endorse "An Integrated Approach to Engineering Education Worldwide."

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BIOGRAPHICAL SKETCHES

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