CAETS

International Council of Academies of Engineering and Technological Sciences, Inc.

Educating Engineers

A Statement by the International Council of Academies of Engineering and Technological Sciences, Inc. (CAETS)
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Technology is a critical driver of economic development today, and globalization promises to bring that relationship to all societies of the world. Engineers are crucial for effective technology management; educating engineers who can adapt successfully to the ever-changing fields and complexity of technology and technology-based systems is a significant challenge. Identifying and sharing the experiences of innovative approaches to engineering education and the new knowledge of how people learn were the themes of the Symposium of the 2013 CAETS Annual Meetings hosted by the Hungarian Academy of Engineering and held in Budapest on June 27, 2013. Based on expert presentations and deliberations of the CAETS delegates, the findings and recommendations included herein were formulated and approved by the CAETS Council on June 28, 2013.

CAETS is the International Council of Academies of Engineering and Technological Sciences, Inc. It consists of those national academies of engineering and technological sciences that have satisfied an agreed set of criteria for membership. It was established in 1978 and was incorporated as a charitable non-profit corporation in the District of Columbia (US) in 2000. Its Articles of Incorporation, Bylaws and Operating Procedures set down its objectives and governance arrangements. These documents and its membership and achievements are posted on the CAETS website, www.caets.org.

Introduction

It is well known from economic studies that technology plays a central part in economic development. With the evolution of the Internet and the pervasive use of Information Technology, globalization has become a potent force and powerful new multi-national companies have emerged on the global scene. The G-8 group of nations has evolved to G-20. Most of the societal grand challenges, such as energy, sustainability and cyber security, require global solutions. We must therefore prepare engineering graduates for this new environment. "Education should endorse and foster curiosity, which takes courage and patience...We need to let students discover their own solutions." (Erno Rubik, HAE) We need to educate "renaissance engineers" – those who understand not only how things work but also how the world works. "The future cannot be predicted, but futures can be invented!" (Dennis Gabor, Nobel Laureate)

The world needs to act locally, but think globally. Rapid population growth and its impacts on energy consumption, food production, urbanization, traffic problems and environmental pollution are most evident on a local scale, but can have global impact. Engineers have been key contributors to the creative and innovative processes used to address these problems in developed economies, but a lack of capacity to act plagues less developed parts of the world. In order to be able to surmount the present global malaise and foster future development of the global economy, we need to provide well-trained, broadly capable engineers throughout the world. At the heart of this, of course, is the role of universities. Universities must play an essential role in effecting change, and this will require radical changes of operating models, degree programs and research programs.

It is unlikely that there will only be one agreed approach to engineering education, but there are many important elements that should be infused in different models. There is a need to encourage and promote multidisciplinary cooperation and student-centered learning. Risk taking, the inclusion of persons of diverse experience, and the encouragement of students to play active roles in their own education must be embraced as desirable goals in higher education. New social, technological and business innovations are needed that will enable us to design approaches that are effective both locally and globally.

Developing attractive and challenging engineering education programs of this kind will create, hopefully, increased interest in the engineering profession from young people. In many countries, the prestige of engineering studies is at a low point. We must be able to recruit and motivate the best and the brightest from each generation, and we must provide the educational experiences to enable them to engage societies' great challenges.

Education Models and Research

The participants of the international CAETS/HAE Symposium "Innovative Approaches to Engineering Education" held in Budapest on June 27, 2013 were introduced to the engineering education strategies of several countries around the globe, in particular from Australia, China, Germany, India, South Africa and the United States. They also were briefed on several pioneering education, organizational and research approaches. Notably:

- The Aalto University in Finland is building a new university concept, where art and science meet technology and business. Aalto is a merger of three universities with an operating model, degree programs and research that encourages and promotes multidisciplinary cooperation and student-centered learning for broad-based engineering education.

- The CDIO model posits that an engineering graduate should be able to Conceive-Design-Implement-Operate complex value-added engineering products, processes, and systems in a modern, team-based environment. The CDIO Initiative is a contemporary reform of engineering education designed to let the real engineering world be the framework for teaching and learning at university from start to finish. The CDIO syllabus integrates personal and social skills with technical knowledge and expertise. The aim of CDIO is to educate students who are able to:

  – master a working knowledge of technical fundamentals;

  – lead in the creation and operation of new products, processes and systems; and

  – understand the importance and strategic impact of research and technological development on society.

- Digital Enterprise Technologies (DET) is the collection of systems and methods for the digital modeling of the global product development and realization process in the context of life cycle management. These constitute effective tools for researchers and practitioners, and they are now being used to advance engineering education as well.

- Efforts to improve engineering education may be informed in the future by efforts to understand learning and education from the perspective of natural science of the brain. "Brain Science and Education" posits that learning is a process to form neural circuits by receiving external stimuli, and education is a process to control and supplement external stimuli and prompt learning. It applies new methodologies for high-level brain-function imaging to understand the intra-brain mechanism of learning and education as neuroscience.

Findings and Recommendations

The CAETS participants recognize that the Engineering Community has an essential role in promoting central issues of engineering education, such as quality of education, accreditation of engineering qualifications, regional agreements, establishing substantial equivalance, curriculum (including interdisciplinary system-based subjects) and innovation. It recommends that:

1. Engineering education for the new century must prepare engineers to deal with initiatives in technological development as well as contribute to the conditions of social welfare of humankind.

2. Many, if not all, of society's grand challenges – sustainability, energy, security – require engineering solutions on a global scale. To create those solutions, engineers must be educated to embrace the new reality of ubiquitous global interconnectivity, the pervasive use of Information Technology, the flow of people as well as information around the globe, and the rise of multinational powerhouse companies with multinational employees and global reach.

3. Engineering education must provide a bridge between science and technology, while recognizing that engineering is a unique activity unto itself. The need for integrative thinking should be an important part of training future engineers.

4. Engineering education must reflect the interaction of engineers in industry and academia; universities must forge cooperative alliances with industry and national laboratories to promote the value of an engineering education.

5. Engineering education must be based on up-to-date research and innovation in educational practices. Innovations such as problem-based learning, experiential learning and online learning should be key parts of the curriculum, and entrepreneurial thinking should be part of the culture of engineering schools. Students should be provided opportunities to experience and learn collaboration/teamwork and leadership, cross-cultural understanding, communications and information fluency and project management. Opportunities for research experiences for undergraduates in engineering should be facilitated to develop a culture of inquiry, invention and discovery.

6. Universities should provide the resources, time and rewards to faculty for engaging in innovative engineering education practices.

7. Life-Long Learning for engineers must be encouraged and should address disciplines that bridge the elements of science and technology, account for the globalization of engineering, and are sensitive to national interests and values as well.

8. Accreditation should be based on the outcomes realized by graduates. It is recognized that an engineering qualification, with its broad fundamental base, must be the starting point of a career path in one of many areas of engineering specialization through structured development and lifelong learning. A broad base will allow maximum flexibility and mobility for the holder to adjust to changing needs.

9. Engineering education has to promote the better understanding of the need for technological and scientific advice in policymaking.

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International Council of Academies of Engineering and Technological Sciences, Inc. (CAETS)

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Internet: www.caets.org
E-mail: caets@nae.edu

William C. Salmon, Secretary/Treasurer
112 Pleasant Grove Road
Locust Grove, Virginia 22508 USA
Mobile: (1) 703-527-5782

CAETS Records
National Academy of Engineering
2101 Constitution Avenue, NW
Washington, D.C. 20418 USA