Summary of "Transforming Engineering Education: Creating Interdisciplinary Skills for Complex Global Environments" (6-9 April 2010, Dublin Ireland)

1. Introduction

In early April 2010, 140 educators, education administrators, industry representatives and government officials gathered in Dublin, Ireland for a four day summit on the future of engineering education. The summit was organized jointly by IEEE and IBM.

Reflecting the increasing interdisciplinary nature of engineering and engineering education, the conference attracted individuals from engineering disciplines as well as from business and law. Participants included academics, academic administrators, representatives of industry, and government officials.

The pre-conference invitations reminded participants of the significant changes in the business climate wherein engineers operate, and reviewed recent trends in engineering education. These include the increased number of regions where sophisticated engineering work is performed, and the resulting migration of engineering work to new areas; the rise of the service economy and its impact on engineering; and the increased recognition that successful engineering projects require engineers that are not only very good within the disciplines that educated them, but have the ability and propensity to engage in cross disciplinary work, communicate effectively with multiple audiences, and work alongside professionals in law, business and public policy.

2. The Need for Transformation

During the conference, the question was posed as to **why a transformation of engineering education is needed**. Attendees provided several answers:

(1) We observe a decline in interest in engineering as a program of study and career path among young people in several major industrial countries. This decline may lead to future shortages that would become a limiting factor for engineering projects and engineering companies;

(2) Industry signals that many entry level engineers lack necessary skills. Industry representatives reported on growing needs to train entry-level engineers, especially in communications and in the legal and economical framework within which engineering work is performed;

(3) There are clear indications that the business environment has changed, and that the engineering education system may not have kept pace. For example, the rise of the *service economy* was mentioned as a factor that has not yet been adequately reflected in the engineering curricula. These curricula were shaped historically when engineering was associated almost exclusively with manufacturing, not with services.

3. Broad Themes

3.1 Several common broad themes were evident in many presentations and panel sessions. They included the following:

(1) Increasingly, engineers face challenges that involve large scale, complex systems requiring strong interaction with non-engineer experts and the public;

(2) Current engineering curricula rarely address such challenges; the curricula appear overly focused on preparation in mathematics and physics, and on engineering science;

(3) Making engineering education cross-disciplinary is a difficult but worthy challenge.

3.2 Many speakers discussed the **desired skills of graduating engineers**. In addition to the mastery of their principal subject matter, the following skills were described as needed:

(1) Ability to communicate effectively – to technical and non-technical audiences;

(2) Ability to self educate

- (a) Ability to 'process' large volumes of information – sift through and generate relevant knowledge
- (b) Ability to understand that education of engineers continues for a lifetime;

(3) Ability to work in heterogeneous teams (including virtual teams) and to converse with professionals in law and business;

(4) Willing to take risks, experiment, and be innovative.

3.3 Additional discussion on desired skills and experiences

3.3.1 Communication skills

Of all the desired skills of graduating engineers, the need for improved communication skills was the most discussed. Speakers described several potential advantages of improvements in this area, including:

(1) Better public discourse on science and engineering;

(2) Helping communities understand the potential and impact of proposed engineering projects;

(3) Increasing the understanding of engineering among young people and their parents and teachers with potentially positive impact on young people considering engineering as a career path.

3.3.2 Global Engagement

There was wide agreement on the need to increase global understanding and engagement by students and professors. Proposed ways to achieve this goal included:

(1) Semesters abroad

(2) Participation in Engineers without Borders and similar projects

(3) Study of languages

These approaches may not be effective in developing countries.

3.3.3 Engagement with the local community

It was observed that many curricula operate with little regard to the communities wherein they reside. Increased engagement with the local community may serve to concretize the engineering experience, and inject a sense of reality into what in many curricula has become a rather abstract experience.

4 Observations on the Engineering Curriculum

4.1 After some discussion, the prevailing model of the different stages of the engineering curriculum was defined as follows:

- Undergraduate education – broad background for entry level engineering practice
- M.S. level education – specialization for professional practice
- Ph.D. level education – preparation for specialized R&D

4.2 There was wide agreement that the engineering curriculum is "jam packed" and that we have great difficulties in removing old subjects and materials from the curriculum, even when proposals are accepted for adding new material and specializations. Effective methodology to refresh existing curricula is missing.

4.3 Several speakers focused on the impact on technology on the curriculum.

4.3.1 The ability of students to discover and process on-line information provides new teaching and learning opportunities. It also requires that new skills in the area of information retrieval and assessment become part of the student skill set.

4.3.2 Distance learning and online delivery are becoming more popular. We need to understand the impact of these delivery methods on quality and efficiency of teaching and learning.

4.3.3 Scientific computing software has emerged as a tool in engineering design, but its impact has not yet been fully recognized in the engineering curriculum.

4.3.4 Increasingly, engineers write software, both for prototype development and for production. The impact of this trend, and the need to pay more attention to software engineering themes in other engineering curricula, are not fully settled.

4.4 Additional Observations on Curricular Reform

4.4.1 There were several opinions on the nature and scope of the required curriculum change. In the opinion of some meeting participants, significant changes are possible without a major overhaul of the curriculum, for example by imbedding new themes in existing offerings.

4.4.2 If curriculum improvement is to be made 'continuous' (as many attendees desire) we need to be able to measure it. We need to identify the metrics by which curricular reform will be assessed.

4.4.3 If engineering education is to change, the university reward system will have to change as well. Improvements will need to be aligned with the reward system. At present many schools weigh scholarly publications, graduate student advising and research funding much more than excellence in undergraduate education.

5 Relations with Industry

While it is recognized that feedback from industry to academia is needed, at present this feedback is often indirect and ineffective. Improvements that should be considered:

5.1 Co-op and industry internships for students.

5.2 True exchanges of faculty with industry – a professor spends a year in an industrial facility and an industry practitioner spends a year at the university. These reciprocal exchanges are at present rare (some faculty spend sabbaticals with industry but very few individuals from industry establish true residencies in universities).

6 Technical education for non-technical majors

While engineers need to learn how to talk to non-technical audiences, non-technical audiences also need to be exposed to some level of understanding of engineering. At present, academic departments in the humanities and the social sciences provide routine "service courses" to engineering students. It is necessary, but at present rare, that engineering departments provide service courses on engineering and technology to students to humanities and social sciences. In fact, engineering departments have the *obligation* to provide engineering literacy courses and laboratories to non-engineers. For example, political leaders of the future, many of whom would not be engineers, should possess at least a minimal level of engineering literacy.

7 Next Steps

Attendees recommended the following next steps:

7.1 Development of a program by the conference sponsors for follow-up activities.

7.2 These activities would include:

7.2.1 Development of a concrete list of 'desired but missing' skills, mostly by industry;

7.2.2 First iteration: find out what <u>training</u> industry is already paying for, and label this training as "important for industry";

7.2.3 Identify what in this training set is appropriate for the academic curriculum (not all topics desired by industry are necessarily on this list);

7.2.4 To encourage development of ‘desired but missing’ skills, develop a set of recommendations and resources for schools, regulatory bodies, and accreditation agencies.

7.3 Recommendations for development of ‘desired but missing’ skills will be expressed in the following formats (probably in a web portal on the subject):

7.3.1 As “best practices”

7.3.2 As repositories of case studies

7.3.3 As proposals for stand-alone courses (along with detailed curricular materials and on-line resources)

7.3.4 As proposals to imbed skill training in existing curricula (with examples and training materials).

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