# 1. EMERGING SIGNIFICANCE OF COMPETENCIES AND ATTRIBUTES OF GLOBAL ENGINEERS

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## *Summary*

*With Globalization becoming a reality in almost all spheres of our lives, the concept of a Global Engineer has been gaining in importance. This paper first illustrates the globalization of the Engineering Profession. The importance of preparing Global Engineers and details of a couple of studies on Global Engineers are next described. The global competencies and attributes of global engineers are next identified. The formats of global engineering partnerships and the challenges and obstacles to participating in international experiences are indicated. The importance of global research partnerships and international curricula are highlighted. In recent times, globalization is among the criteria for determining the quality of higher education institutions. A partial list is provided of higher education institutions worldwide which focus on global education. Finally the results of an ongoing survey by ASEE of Global Competencies are included.*


## 1. Introduction

Several things have happened, in terms of the environment and context of engineering, to make Engineering Profession and Education different, from how it was a generation ago. Parkinson identifies a confluence of trends and events which have taken place over the past two decades. These include "advances in telecommunications and other enabling technologies (made possible by engineers), political events which have opened up many formerly closed societies, the adoption of economic policies which have promoted free trade, and the expansion of multi-national corporations". "Advances in communications and computers have been a powerful driving force for globalization".

## 2. Globalization of the Engineering Profession

Yating Chang et al point out that "Increasing economic globalization is transforming the very nature of the engineering profession". They point out that "The profession now routinely deals with globally distributed manufacturing and multinational design and marketing teams. To flourish in this environment, future engineers need not only be proficient in the technical subjects, but also be informed about international technological trends and business practices and familiar with languages and cultures".

The National Academy of Engineering in its Report entitled *"Educating the Engineer of 2020: Adapting Engineering Education to the New Century,"* concludes that "U.S. engineers must become global engineers. The engineer of 2020 and beyond, will need skills to be globally competitive over the length of her or his career."

There have been significant changes in the Practice of Engineering as a Profession in the new millennium:

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- Constraints imposed by environmental considerations
- Customization demanded by diverse customers
- Opportunities offered by technology developments in several sectors
- Availability of sophisticated diagnostic and computational tools
- Wide choice of materials
- Implications of Globalization, such as , for example, Innovation as the basis of Competitiveness

In a recent Report on *Engineering for a Changing World*, James Duderstadt, former President and Dean of Engineering at the University of Michigan, stresses the importance of a *global perspective* for engineering practice.

Patricia Galloway, former President of the American Society of Civil Engineers, addresses globalization issues in her book, The 21st-Century Engineer, A Proposal for Engineering Reform: "Globalization involves the ability to understand that the world economy has become tightly linked with much of the change triggered by Technology".

Sigrid Berka quotes Duncan : "It is absolutely essential for the citizens of the United States to become fluent in other languages-and schools, colleges and universities must include producing bilingual students as a central part of their mission". Nelson Mandela has said, "If you talk to a man in a language he understands, that goes to his head. If you talk to him in his own language that goes to his heart."

Christina Niedert points out that "the global workplace has already become a reality for engineers. Products are often designed for a global market, and research and development are conducted across the globe by multinational teams. Production is typically outsourced to manufacturers and suppliers worldwide. Thus, engineers today have to be prepared to work in any part of the world, to collaborate in intercultural teams and to communicate in languages other than their own native language".

### 3. Importance of Preparing Global Engineers

Alan Parkinson provides the following three quotes to stress the importance of preparing Global Engineers:

- William Wulf, former President of NAE: ... "Engineering is now practiced in a global, holistic business context, and engineers must design under constraints that reflect that context. In the future, understanding other cultures, speaking other languages, and communicating with people from marketing and finance will be just as fundamental to the practice of engineering as physics and calculus".
- Duane Abata, Former President of ASEE: "Outsourcing is affecting engineering and all the facets that encompass engineering, including research, design, marketing and service...This is a major revolution in engineering education. We must internationalize our curriculum, to include not only the study of mathematics and the sciences but intercultural interaction as well. We must mold our students to be entrepreneurs, and spirited international adventurers, as well".
- Ken Kohrs, former Vice President of Ford Motor Company: "What's the relevance of globalization to you personally, and to your future in engineering? I can answer that in one word: ***"Everything"***. No matter what area of engineering you enter, your ability to remain on the leading edge, and to progress in our organization, will depend largely on your capacity to connect and communicate globally".

### 4. The UK Study on the *Global Engineer*

The March 2008 UK Study focusing on Incorporating global skills within UK higher education of Engineers addresses six key questions (in Part I):

- What is meant by the global dimension of engineering?
- What is the global dimension of engineering education?
- What are the drivers for increasing the global dimension across higher education?
- What do global skills look like?
- How does development education fit within the global dimension?
- What are the key barriers to change and what opportunities exist to overcome these barriers?

Part 2 provides a framework and guidance for incorporating the global dimension within student learning including:

- Embedding within the curriculum.
- Innovative partnerships and strategies for collaboration at national and international levels.
- Extra-curricular learning.

### 5. Jack Lohmann's Study on *Global Engineer*

Georgia Tech has developed a model program for educating and developing the global engineer. Jack R. Lohmann, Vice Provost of the Georgia Institute of Technology, began by asking "Can we define a 'global engineer'?" He continued with his belief that the global engineer must be "...culturally sensitive, socially aware, politically astute....speak foreign language." He went on to address the urgent need for research on engineering in a global context and explained: "the phenomenon of global engineering is still emerging. There is a need for a theoretical foundation on learning behaviors and models, as well as on organization processes and management methods."

### 6. Excerpts from International Accreditation Board Prescriptions

The Japan Accreditation Board for Engineering Education prescribes as one of the desirable attributes of an Engineer "An ability and intellectual foundation to consider from a global and multilateral viewpoint". The ABET Engineering Criteria 2000 out of a-k attributes prescribes " the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context".

### 7. A List of Global Competence Dimensions

Alan Parkinson defines a new set of skills, which he collectively refers to as "global competence", and has compiled a list of 13 dimensions of global competence:

1. Appreciation of other cultures
2. Ability to communicate across cultures
3. Familiarity with the history, government and economic systems of several countries.
4. Ability to speak a second language, at a conversational level.
5. Ability to speak a second language at a professional (i.e. technical) level.
6. Proficiency in working in or directing a team of ethnic and cultural diversity.
7. Ability to effectively deal with ethical issues arising from cultural or national differences.
8. Understanding of cultural differences relating to product design, manufacture and use.
9. Understanding of the connectedness of the world and the workings of the global economy.
10. Understanding of the implications of cultural differences on how engineering tasks might be approached.
11. Some exposure to international aspects of topics such as supply chain management, intellectual property, liability and risk, and business practices.

12. Experience of practising engineering in a global context, whether through an international internship, a service learning opportunity, a virtual global engineering project or some other form of experience.

13. Ability to view themselves as "citizens of the world," as well as citizens of a particular country; appreciate challenges facing mankind such as sustainability, environmental protection, poverty, security, and public health.

*According* to Grandin/Hedderich (2009), globally competent engineers need to have a sound technical understanding and must be able to work interdisciplinarily, as well as effectively, in global teams and therefore, they must be competent in crosscultural communication. This latter skill is defined by Grandin/Hedderich **(2009)** in terms of five dimensions: Being:

i. mobile, open, flexible, tolerant;

ii. knowledgeable about other places in the world;

iii. culturally aware and attuned to and accepting of difference;

iv. multilingual; and

v. perceptive of difference in terms of engineering cultures."

Christina Niedert, in summary, proposes that "globally competent engineering graduates

- must have acquired foreign language skills which enable them to speak at a conversational level and within a technical environment,
- can communicate across cultures and are aware of cultural differences in communication,
- can appreciate and accept other cultures in order to avoid ethnocentrism,
- have some knowledge of other cultures (their history, government, and economy)
- can work effectively in intercultural/ multicultural teams.
- understand how approaching engineering tasks may differ across cultures".

### 8. Formats of Global Engineering Partnerships

Alan Parkinson discusses the following prevalent formats of promoting the education of Global Engineers:

- ☐ Dual Degree
- ☐ Exchange
- ☐ Extended field trip
- ☐ Extension
- ☐ Internship or co-op
- ☐ Mentored Travel
- ☐ Partner sub-contract
- ☐ Project-based Learning / Service Learning
- ☐ Research Abroad

### 9. Challenges and Obstacles for participation in International Experiences

Yatin Chang et al have identified the following challenges and obstacles to integration of international experience into mainstream engineering programs at academic institutions:

- Difficulty in scaling
- Negative impact on time to graduate
- Negative impact on finances
- Lack of faculty incentives
- Unclear outcomes assessment
- Rigid curriculum structure

Grandin and Hirleman have reported the proceedings of The Summit Meeting on the

Globalization of Engineering Education on November 5-6, 2008, convened in Newport, Rhode Island, in which a group of 23 distinguished engineering educators participated.

Donna Kimmel stresses the importance of global skill sets as we consider engineering education for the coming decades: "There is a need to move beyond an appreciation and respect for differences to synergistic global collaboration to create a culture of success". Hasbro identified a crucial success factor as "the ability to collaborate and communicate with a large network of technology providers, inventors, vendors, manufacturers and peers worldwide".

### 10. Global University Research Partnerships

Sigrid Berka points out that "Conducting research in two countries involves different approaches and equipment, including university institute research and applications in industry. All of this being accomplished in a foreign culture and language, helps to tackle grand challenges like engineering better medicines or providing a safer environment from various angles and thus adds enormous value to the outcome."

The University of Rhode Island and Technical University of Braunschweig, have been offering a dual degree graduate program since 2004. The purpose of the program was to allow students of each university to acquire both a *Master of Science* degree from URI and a *Diplom* from the Technical University of Braunschweig. It requires students to conduct research in, at least, two institutions (one of them abroad), and leverage the advancement of science and engineering for its participants.

An assessment of the specific added values of the international study, research and work experience provided the following ten "added" learning outcomes:

1. Broadened scope of research skills or methods
2. Encountering different engineering cultures
3. Leveraging gains abroad for engineering success at home
4. Continued international student/faculty collaboration
5. Being prepared for the global work place
6. Gaining more depth and breadth by benefitting from complementary offerings
7. Raising one's linguistic proficiency skills
8. Developing intercultural competence
9. Strengthening self-efficacy
10. Growing as a person

### 11. Internationalisation of the Curricula

Many policy makers consider the internationalisation of the university and of the curriculum as the key component of internationlisation. It is important for the university to remain competitive among its counterparts worldwide, and to enhance its profile in the global marketplace. Its graduates have to be equipped to work in an increasingly interdependent world – in multicultural settings, both at home and abroad, in professional roles requiring knowledge and understanding of the global context.

The contributions of an internationlised curriculum to the university are many :

- enhanced quality, in terms of acquisition of professional skills, strengthening of foreign language learning, expansion of the range of courses, inter-cultural communication skills.
- new approaches to student learning
- integration of faculty and students with overseas qualifications and experience
- new knowledge or new perspectives and the full use of the human resources of the

university

- *enhanced marketing profile*
- graduates empowered to work in the global context

An OECD study has provided the following definition of Internationalised Curricula : Curricula with an international orientation in content, aimed at preparing students for performing professionally/ socially, in an international and multicultural context, and designed for domestic students, as well as, foreign students.

### 12. Internationalisation as a measure of quality:

International competition in higher education has served to include internationalisation as a measure of quality. The Working Group Three of the Network : Higher Engineering Education for Europe, H3E-WG3, is convinced that international orientation is a major measure of the quality of all future engineering education programs. Internationality has come to mean the capability of equipping graduates with competencies applicable in a world where national borders no longer hinder the global flow of technologies and products. It is also the ability of the academic communities to attract and integrate intelligence of any nationality, seamlessly.

### 13. Higher Education Institutions focusing on Global Engineering Education

Wikipedia provides a list of higher education institutions worldwide which have a special focus on Global Engineering Education. This list is provided in Annexure I.

### 14. The Findings of the ongoing ASEE Survey

This study has resulted in a total of 20 competencies associated with the attributes of a global engineer. These are listed in Annexure II.

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## Annexure I

### A (partial) List of Higher Education Institutions with a focus on Global Engineering Education

(From Wikipedia)

These are some higher education institutions around the world that focus on global engineering education

- Purdue University, USA
- International Engineering Program at the University of Rhode Island
- RMIT University, Australia
- Centre for Engineering Education, Universiti Teknologi Malaysia, Malaysia
- Shanghai Jiao Tong University, China
- Universität Karlsruhe, Germany
- Worcester Polytechnic Institute, USA
- Virginia Polytechnic Institute and State University, USA
- University of Texas at Austin, Cockrell School of Engineering, USA
- University of Wisconsin Madison, College of Engineering, USA
- University of British Columbia, Canada
- Spanish University of Distance Education - UNED, Electrical and Computer Engineering Department - DIEEC, Spain
- Pforzheim University], Germany
- Kogakuin University, Tokyo, Japan

## Annexure II

### Global Competencies identified by the ongoing ASEE Study

1. Demonstrates an understanding of engineering, science, and mathematics fundamentals
2. Demonstrates an understanding of political, social, and economic perspectives
3. Demonstrates an understanding of information technology, digital competency, and information literacy
4. Demonstrates an understanding of stages/phases of product lifecycle (design, prototyping, testing, production, distribution channels, supplier management, etc.)
5. Demonstrates an understanding of project planning, management, and the impacts of projects on various stakeholder groups (project team members, project sponsor, project client, end-users, etc.)
6. Demonstrates an understanding of the ethical and business norms and applies norms effectively in a given context (organization, industry, country, etc.)
7. Communicates effectively in a variety of different ways, methods, and media (written, verbal/ oral, graphic, listening, electronically, etc.)
8. Communicates effectively to both technical and non-technical audiences
9. Possesses an international/global perspective
10. Possesses fluency in at least two languages
11. Possesses the ability to think both critically and creatively
12. Possesses the ability to think both individually and cooperatively
13. Functions effectively on a team (understands team goals, contributes effectively to team work, supports team decisions, respects team members, etc.)
14. Maintains a positive self-image and possesses positive self-confidence
15. Maintains a high-level of professional competence
16. Embraces a commitment to quality principles/standards and continuous improvement
17. Embraces an interdisciplinary/multidisciplinary perspective
18. Applies personal and professional judgment in effectively making decisions and managing risks
19. Mentors or helps others accomplish goals/tasks
20. Shows initiative and demonstrates a willingness to learn.

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