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## The Rationale for Developing Global Competence

Alan Parkinson

Brigham Young University, parkinson@byu.edu

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### Cover Page Footnote

The author wishes to acknowledge the comments and suggestions of the attendees of the NSF Summit on the Globalization of Engineering Education held at the University of Rhode Island, November 2008.



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# The Rationale for Developing Global Competence

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Alan Parkinson  
*Brigham Young University*

## ABSTRACT

This paper addresses three questions related to the rationale for global engineering education. These questions are, Why do engineering students need to have a new set of skills, which we will collectively refer to as “global competence?” What does it mean for students to have global competence? and, What are the most important attributes of global competence? In answer to the first question, we discuss the forces and events of the past 20 years which have driven the globalization of engineering. In answer to the second question, we present 13 dimensions of global competence. To answer the third question, we present survey results from engineering educators and leaders in industry regarding the relative importance of these dimensions. We then discuss some implications of the answers to these questions.

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## 1 Introduction

This paper addresses three questions related to the rationale for global engineering education. These questions are, Why do engineering students need to have a new set of skills, which we will collectively refer to as “global competence?” What does it mean for students to have global competence? and, What are the most important attributes of global competence? In answer to the first question, we discuss the forces and events of the past 20 years which have driven the globalization of engineering. In answer to the second question, we present 13 dimensions of global competence. To answer the third question, we present survey results from engineering

educators and leaders in industry regarding the relative importance of these dimensions. We then discuss some implications of the answers to these questions.

## 2 Global Competence: Why is it Needed?

The first part of this paper deals with the need for global engineering education. Specifically, what has happened in terms of the environment and context of engineering to make it different from how it was a generation ago? We address this question from several perspectives: formative world events, recommendations from credible sources, examples of globalization from engineering disciplines, and global challenges confronting humankind.

### 2.1 Formative World Events

The globalization of engineering has resulted from 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. The 1990's saw the development of a digital worldwide data network based on optical fiber. At the time, a single fiber pair could replace hundreds of equivalent copper lines; fiber transmission rates have continued to increase from Mbps in the 1990's to Gbps and even Tbps today.<sup>1</sup> Extensive wireless networks are also a product of this time period. These have been especially important in developing countries, as they have made it possible to leapfrog over the need for landline infrastructure. The wireless

industry hit a landmark in 2007 with one billion wireless handsets shipped that year.<sup>2</sup> Computer processing speed has continued to follow Moore's law, doubling roughly every two years, and data storage costs have fallen by a factor of 1000. Further, systems which were configured largely as stand-alone machines or were tied to a local network now have worldwide network access.

Along with the physical means of transmission, during the last 20 years the Internet has developed as a way to share and organize data and facilitate communication among geographically diverse groups. It is estimated the Internet grew by 100% per year during the 1990's. Since 2000, Internet users have grown 300%, with a 500% percent increase in Asia, to an estimated 1.6 billion users worldwide.<sup>3</sup> Servers have grown from approximately 25 million in 1998 to 540 million today.<sup>4</sup>

Advanced CAD systems also represent a noteworthy technological achievement. These systems have made possible high fidelity representations of products (including design intent, manufacturing process plans, etc.) which can be shared, via the Internet, with design groups across the world. In some respects, a common CAD system becomes a lingua franca for product development which ties widely dispersed design and manufacturing groups together.

Along with enabling technologies, a number of political events have fundamentally changed the geopolitical landscape in ways which promote globalization. One of these events was the breakup of the Soviet Union in 1991, whereby the 15 member states of the Soviet Union declared their independence. Many of these former members of the Soviet republic have moved towards democratic governments (with varying success) and free-market economies. With the end of the cold war, relationships between the Eastern bloc nations and countries in the West were able to move from confrontation to cooperation and participation in the world economy.

Another major political event impacting globalization was the formation of the European Union (EU) in 1993. Now with 27 member states,

the EU has grown to become one of the largest single markets in the world, with nearly 500 million citizens and a combined \$16.8 trillion economy, representing 23% of the world's gross domestic product.<sup>5</sup> Through a common set of policies and laws, the EU promotes freedom of movement of people, goods, and capital, all fundamental elements of global trade.<sup>6</sup> During the past two decades China and India, countries which comprise 36% of the world's population, have adopted market economies and opened their doors to foreign investment.<sup>7</sup>

Concurrent with these developments, the 1990's saw the formation or growth of several important economic institutions which promote world trade; among these are the World Trade Organization (WTO), the International Monetary Fund (IMF), and the World Bank. The WTO, formed in 1995 as a successor to the General Agreement on Tariffs and Trade, has grown to include 153 nations<sup>8</sup> representing more than 95% of world trade. A primary purpose of the WTO is to promote free trade among member states by lowering tariffs and eliminating protectionist policies. After years of negotiations, China joined the WTO in 2001. The IMF and World Bank provide capital in the form of loans to developing nations. To qualify, these nations must adopt economic policies which promote trade, such as abolishing import licenses and tariffs, providing for protection of property and permitting foreign direct investment.<sup>9</sup>

What has all this meant for world trade? Quoting from a report from the WTO, "in 2006 the volume of world merchandise trade grew by 8% while the world gross domestic product recorded a 3.5% increase. This confirms the trend of world merchandise trade growing by twice the annual growth rate of output since 2000."<sup>10</sup> In the U.S., foreign trade in goods and services has grown from \$1.7 trillion in 1995 (sum of imports and exports) to \$4.0 trillion in 2007, with imports exceeding exports by \$700 billion.<sup>11</sup> For comparison purposes, the gross domestic product of the U.S. was estimated to be \$13.8 trillion in 2007.<sup>12</sup>

These technological, political and economic developments have all contributed to the growth and influence of multi-national companies. To illustrate their size, Steger writes, “51 of the world’s 100 largest economies are corporations; only 49 are countries. Accounting for over 70% of world trade, [multi-national corporations] have boosted their foreign direct investments by approximately 15% annually during the 1990s.”<sup>13</sup> A free flow of goods and capital across national boundaries encourages companies to develop international operations to decrease costs and develop new markets. Indeed, for many companies, globalization represents not just an opportunity but an imperative if they are to remain competitive. As examples of the importance of global markets, 67% of Hewlett Packard’s revenues, 79% of Intel’s revenues, and 60% of General Motor’s revenues in 2007 were from abroad.<sup>14</sup>

## **2.2 Recommendations from Credible Sources**

In the previous section we described world events which have helped drive the globalization of engineering. In this section we present comments from a number of sources regarding what should be done in light of these events. These sources were selected as representative of many which might have been chosen.

A recently released report entitled, *Engineering for a Changing World*, authored by James Duderstadt, former president and dean of engineering at the University of Michigan, examines the major forces acting as drivers of change in engineering and discusses how engineering education must respond.<sup>15</sup> According to Duderstadt:

...it is important to stress the importance of a *global perspective* for engineering practice. Key is not only a deep understanding of global markets and organizations, but the capacity to work in multidisciplinary teams characterized by high cultural diversity, while exhibiting the nimbleness and mobility to address rapidly changing global challenges and opportunities.

He indicates that the goal of American engineering schools should be “to focus more on quality, producing engineers capable of adding exceptional value through innovation, entrepreneurial skills, and *global competence*” (italics added).

Patricia Galloway, former president of the American Society of Civil Engineers, addresses globalization issues in her book, *The 21<sup>st</sup>-Century Engineer, A Proposal for Engineering Reform*, where she writes,<sup>16</sup>

A solid understanding of globalization is key to an engineer’s success in today’s global society. Globalization involves the ability to understand that the world economy has become tightly linked with much of the change triggered by technology; to understand other cultures, especially the societal elements of these cultures; to work effectively in multinational teams; to communicate effectively—both orally and in writing—in the international business language of English; to recognize and understand issues of sustainability; to understand the importance of transparency while working with local populations; and to understand public policy issues around the world and in the country in which one is working. It will be these fundamental capacities that will enable 21<sup>st</sup>-century engineers to develop into professionals capable of working successfully both domestically and globally, highly respected by the general public and regarded...the world over as professionals of the highest order.

A comprehensive study on international engineering education was commissioned by Continental AG, a large industrial supplier to the automotive industry.<sup>17</sup> Continental asked eight universities, known for their engineering programs, to identify critical factors necessary for educating tomorrow’s engineering workforce. A main recommendation of the study is that “global competence needs to become a key qualification of engineering graduates.”

As an additional perspective from industry, Theodore Kennedy, founder of the engineering construction firm BE&K Inc., and a National Academy of Engineering member, writes,

Businesses need graduates who know something about working with others—not just teamwork, which is a given—but a basic understanding that our culture is not the only one around! ...We must prepare engineers to be global citizens. ...They must learn to translate ideas and plans into reality for cultures that may not look, sound or dress the way we do. Unless we can do that, a large part of our engineering business will soon leave our shores.”<sup>18</sup>

### 2.3 Four Examples of Globalization in Engineering

To illustrate the breadth of the globalization in engineering, we present here examples from four different disciplines.

#### Mechanical Engineering

The example from Mechanical (and Aerospace) Engineering involves the development of the Boeing 787 “Dreamliner.” This plane represents the most successful introduction of a commercial jetliner for Boeing, with over 800 orders received from customers in 32 countries. Figure 1 shows where parts of this plane will be manufactured.<sup>19</sup> It is clear from this figure that the 787 is a globally developed and manufactured product, with major subassemblies of the plane coming from the United States, Canada, Italy, Korea, Australia, Japan, England, Sweden and France.

Although Boeing has been very successful in obtaining orders for the 787, production of the aircraft has been hampered by delays, with first flight of the aircraft currently 24 months behind schedule. Based on news reports, it appears much of the delay is associated with managing the global supply chain.

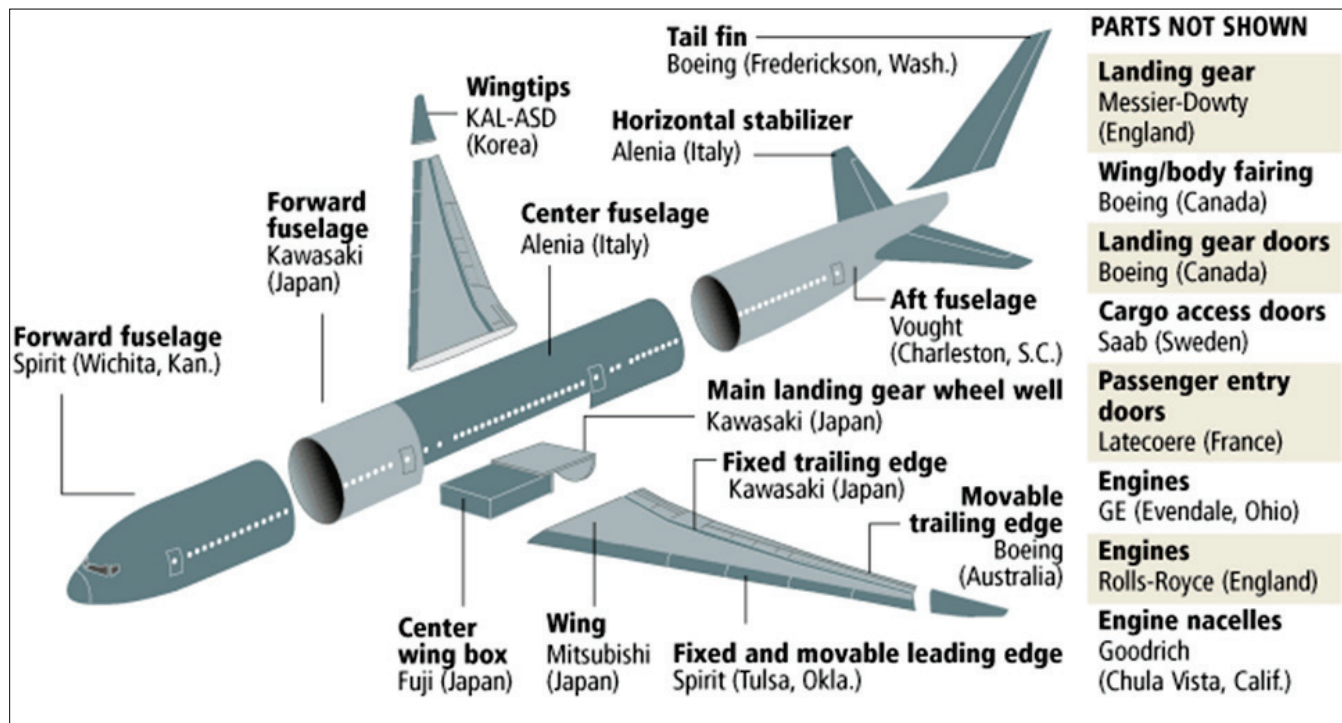


Figure 1 Subassemblies of the Boeing 787 showing country of origin. Used by permission.<sup>19</sup>

Electrical Engineering

Rather than focus on a particular company or product, the example from Electrical Engineering focuses on an entire industry: electronics. The term “electronics” is used in a broad sense to include all computer and communication devices as well as electronics for automotive, industrial/medical and military uses, and consumer electronics. A graph showing the value of electronic shipments by region is given in Figure 2.<sup>20</sup> In the graph, the value shown for each region is the system value of the finished electronics produced in that region. If, for example, Hewlett Packard assembles a PC in the Americas using a motherboard, disk drive and

memory cards produced in Asia, the value of the finished PC is credited to the Americas. If the value of components were credited to the region of origin, the graph would be much more heavily weighted towards Asia. Total market size is estimated at \$1.2 trillion.

The graph shows that 37% of electronics production in 2006 came from Asia (China and Asia in the graph), 10% from Japan, 18% from Europe, and 33% from the Americas. The projected growth of Asia is shown. Clearly the electronics industry is a global industry which will continue to shift towards Asia in the next decade.

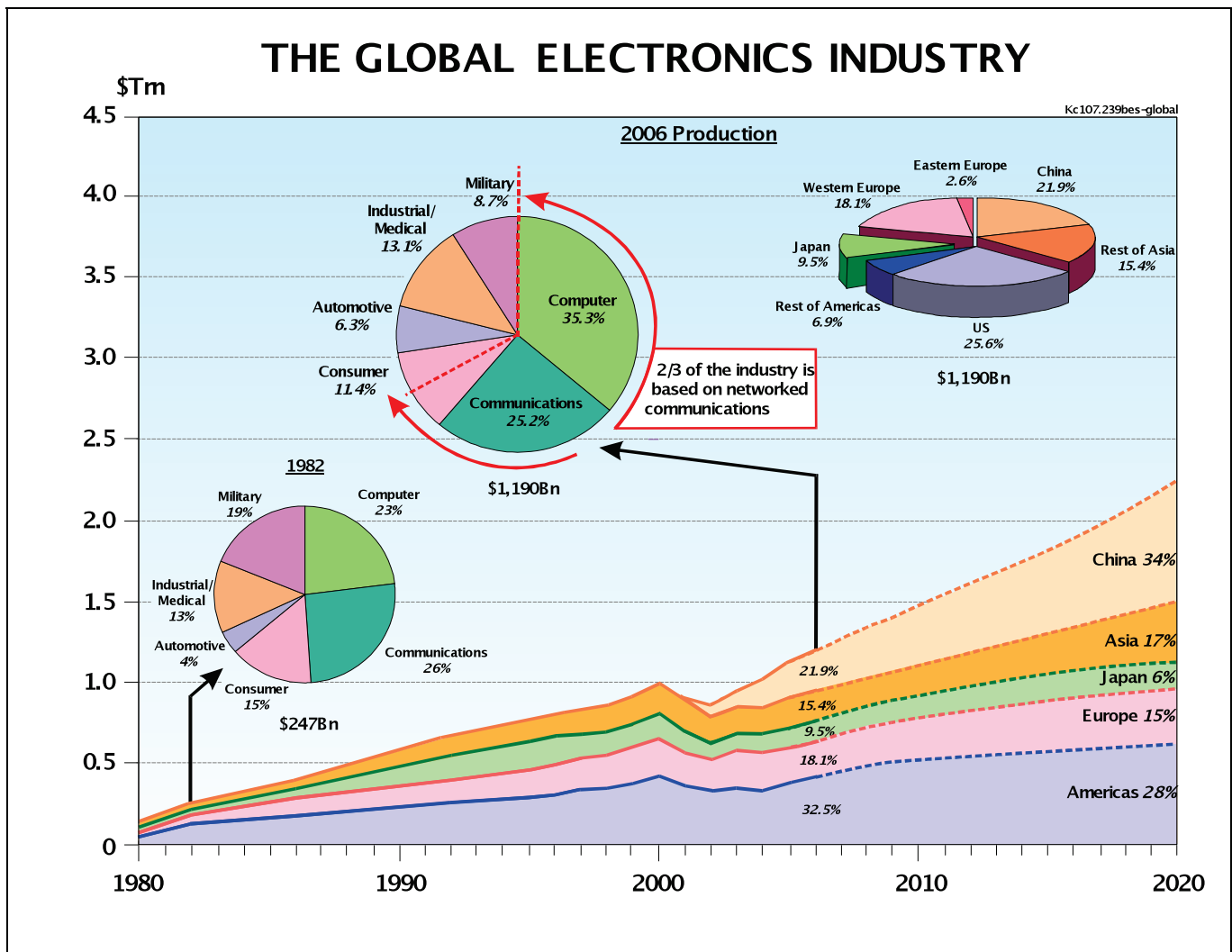


Figure 2 The Global Electronics Industry. Totals represent the system value of finished electronics produced in that region. Based on 2006 data. Used by permission.<sup>20</sup>

A diagram showing the geographical distribution and sales of the top 100 electronics companies is given in Figure 3.<sup>20</sup> All of the companies shown in the figure design and distribute products for worldwide markets.

Canon are fierce competitors in the ink jet printer market but are collaborators in the laser printer market. A worldwide presence implies worldwide employee recruiting. HP now operates research laboratories in Palo Alto, United States; Beijing,

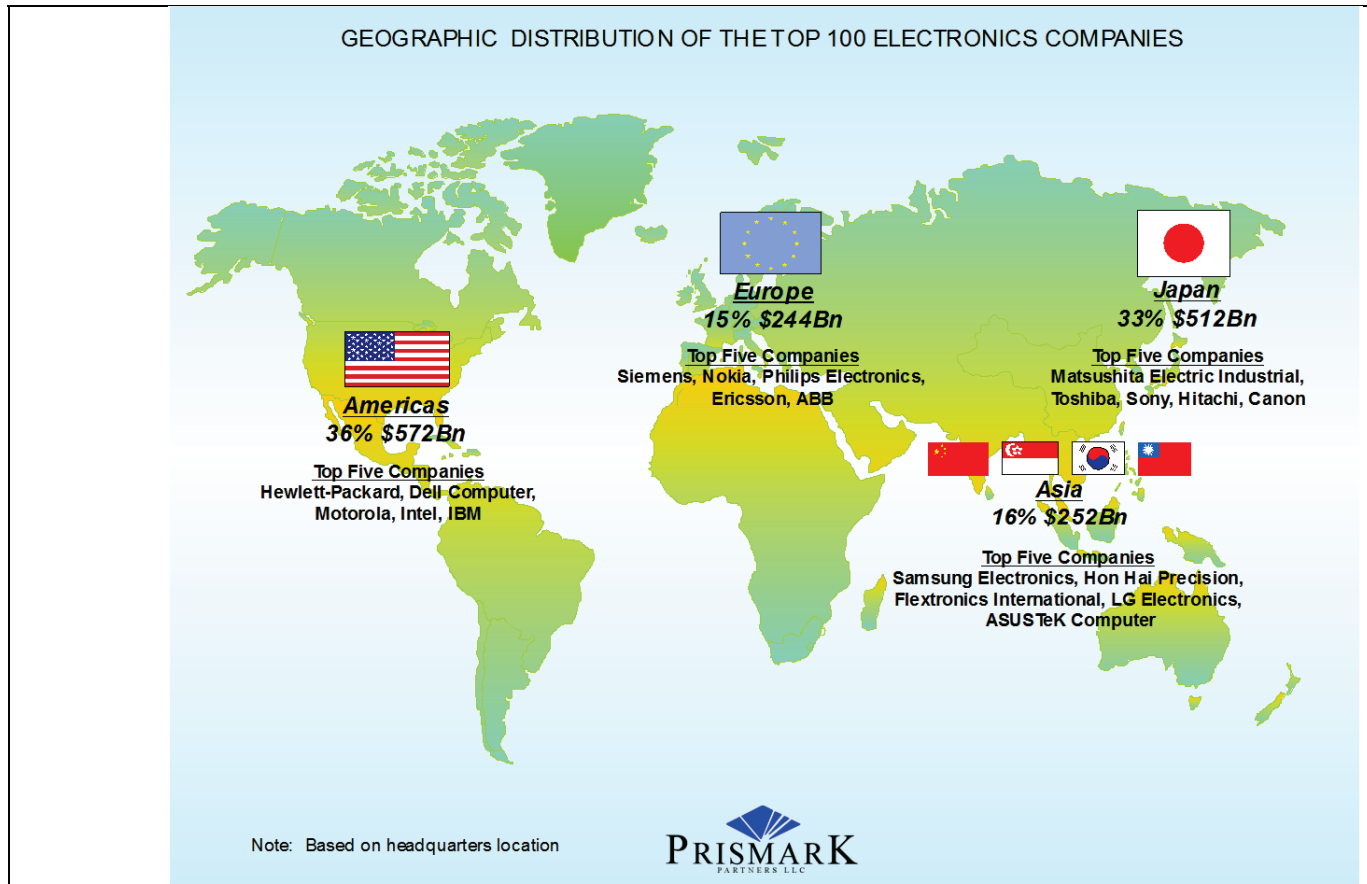


Figure 3 Geographical distribution and revenues of the top 100 electronics companies, based on 2006 data. Used by permission.<sup>20</sup>

What does the global nature of the electronics industry mean for a U.S. company like Hewlett Packard (HP)? First, it means HP must compete with multi-national companies (Hitachi, Siemens, Sony, Philips, etc.) operating in global markets. It implies that HP must develop and deploy assets (such as engineering resources) wherever it is most efficient to do so, in order to remain competitive over the long term. It suggests HP may engage in partnerships to further realize the advantages of scale or to acquire specialized expertise. HP's relationship with Canon is instructive in this regard. HP and

China; Tokyo, Japan; Bristol, England; Haifa, Israel; Bangalore, India; and St. Petersburg, Russia. Obviously it now finds such talent worldwide.

#### Civil Engineering

Upon first consideration, it would seem Civil Engineering might be less affected by globalization. After all, buildings, bridges and other such works are designed for a specific site and built on that site—they cannot be manufactured off-shore.



However, if we look at where the largest, most revolutionary structures are being built, we find that the center of activity is in Asia and the Middle East. For example, Table 1 lists the tallest completed skyscrapers in the world, along with country and date of construction; of the 15 tallest buildings, 13 are located in Asia or the Middle East. Table 2 shows the world's longest cable-stayed bridges. Of the 15 longest bridges, 12 are in Asia. Similar results could be shown for steel arch bridges and suspension bridges—a high percentage of the largest are in Asia.

**Table 1. Tallest Buildings in the World<sup>21</sup>**

	Tallest Skyscrapers (excluding antennas)	City	Country	Ht (m)	Year
1	Taipei 101	Taipei	Taiwan	509	2004
2	World Financial Center	Shanghai	China	492	2008
3-4	Petronas Towers	Kuala Lumpur	Malaysia	452	1998
5	Sears (Willis) Tower	Chicago	USA	442	1974
6	Jin Mao Tower	Shanghai	China	421	1999
7	Two Int'l Finance Center	Hong Kong	China	415	2003
8	CITIC Plaza	Guangzhou	China	391	1997
9	Shun Hing Square	Shenzhen	China	384	1996
10	Empire State Building	New York	USA	381	1931
11	Central Plaza	Hong Kong	China	374	1992
12	Bank of China Tower	Hong Kong	China	367	1990
13	Almas Tower	Dubai	UAE	363	2000
14	Emirates Tower One	Dubai	UAE	355	1999
15	Tunex Sky Tower	Kaohsiung	Taiwan	348	1997

**Table 2. Longest Cable-Stayed Bridges**

	Cable-Stayed Bridges	City	Country	L (m)	Year
1	Sutong	Nantong	China	1088	2009
2	Stonecutters	Hong Kong	China	1018	2008
3	Tatara	Honshu	Japan	890	1999
4	Pont de Normandie	Le Havre	France	856	1995
5	Incheon-2	Inchon	South Korea	800	2009
6	Chongming	Chongming	China	730	2010
7	Nanjing-3	Nanjing	China	648	2005
8	Nanjing-2	Nanjing	China	628	2001
9	Jingtang	Zhou Shan	China	620	2008
10	Baishazhou	Wuhan	China	618	2000
11	Mingjiang	Qinzhou	China	605	1999
12	Yangpu	Shanghai	China	602	1993
13	Xupu	Shanghai	China	590	1997
14	Mieko Chuo	Nagoya	Japan	590	1998
15	Rio Antirio	Rio	Greece	560	2004

To illustrate further the global nature of advanced structural design, recently five structures which are considered to be among the most “arresting” buildings in the world have opened in Beijing: Terminal 3 of the Beijing International Airport, The Bird’s Nest Olympic stadium, shown in Figure 4a, the National Aquatics Center, the National Center for the Performing Arts, and the Central Chinese Television (CCTV) Tower, shown in Figure 4b.

What are the implications for Civil Engineering? Radical new designs often push and define the state-of-the-art; they may require new analysis techniques, new materials and new construction techniques. Connecting the two 50 story columns of the CCTV tower with a large cantilevered “corner” structure required innovative design and construction methods. Many of these structures are being designed by international design firms which employ engineers from different countries. The state-of-the-art in design and construction of large structures is no longer primarily a U.S. or European activity—it is a global activity with a focus outside the U.S.



a)



b)

**Figure 4** a) “Bird’s Nest” Olympic Stadium, b) The Central Chinese Television Tower. Both structures are located in Beijing, China.

### Chemical Engineering

As an example from Chemical Engineering, we will mention the operations of a medium size chemical company: Celanese Corporation. Celanese is an integrated producer of specialty and intermediate chemical products such as acetyl intermediates, polyvinyl alcohol, emulsion polymers, technical polymers, cellulose acetate and food ingredients. The company operates on five continents, including 40 locations in Europe alone. Global operations include manufacturing, research and development, and administration. Sixty percent of its sales come from outside the U.S. The company just completed its newest chemical processing plant, located in Nanjing China, and shown in Figure 5.



**Figure 5** New Celanese chemical plant located in Nanjing China.

In response to the survey which is discussed later in this paper, the senior vice president of operations for Celanese, James Alder, wrote the following about globalization:

Global competence or a strong interest in becoming globally competent is a clear differentiator in an engineer’s ability to progress in their career. Gone are the days when someone could be U.S. centric and reach a senior leadership position or even have a relatively secure job...Those that have the interest and capability to move abroad significantly expand their long term career opportunities. In the chemical industry, for example, there are tens of thousands of Chinese engineering graduates every year. These engineers have an incredible drive to succeed so they can achieve “Western standards of living.” Engineers in more developed countries need to realize who their future competition is and respond accordingly.<sup>22</sup>

### ***2.5 Global Engineering Challenges***

The previous discussion has centered largely on economic justification for global competence—the need for U.S. engineers and companies to adapt to an increasingly competitive global engineering environment. There are, however, critical challenges facing humankind which provide additional and perhaps even more compelling reasons for engineers to be globally competent.

The National Academy of Engineering, with support from the National Science Foundation, has released a set of “Grand Challenges for Engineering.”<sup>23</sup> In introducing these challenges, the report states,

The century ahead poses challenges as formidable as any from millennia past.

As the population grows and its needs and desires expand, the problem of sustaining civilization’s continuing advancement, while still improving the quality of life, looms more immediate. Old and new threats to personal and public health demand more effective and more readily available treatments. Vulnerabilities to pandemic diseases, terrorist violence, and natural disasters require serious searches for new methods of protection and prevention. And products and processes that enhance the joy of living remain a top priority of engineering innovation, as they have been since the taming of fire and the invention of the wheel.

Foremost among the challenges are those that must be met to ensure the future itself. The Earth is a planet of finite resources, and its growing population currently consumes them at a rate that cannot be sustained. Widely reported warnings have emphasized the need to develop new sources of energy, [while] at the same time preventing or reversing the degradation of the environment.

Among the grand challenges listed, many are directed towards mitigating the effects of humans on the environment and/or providing for a sustainable means of human existence. These challenges include 1) making solar energy economical, 2) providing energy from fusion, 3) developing carbon sequestration methods, 4) managing the nitrogen cycle, 5) providing access to clean water, 6) restoring and improving urban infrastructure, 7) securing cyberspace, and 8) preventing nuclear terror.

What do these challenges have to do with global competence? Nearly all of these challenges are global in nature: they cut across ethnic, cultural and national boundaries, and they require cooperation among nations and peoples if they are to be solved. As the Grand Challenges report notes, “governmental and institutional, political and economic, and personal and social barriers will repeatedly arise to impede the pursuit of solutions to problems.” Engineers must not only be able to navigate these barriers if progress is to be made, but, as members of society who understand the technologies involved, they must provide leadership in developing, negotiating and implementing solutions.

### **2.6 Summary: Global Competence: Why is it Needed?**

The previous sections have discussed world events, recommendations from engineering leaders, examples of globalization taken across a range of disciplines, and the critical challenges facing humankind. We believe the evidence is persuasive in demonstrating that engineering increasingly takes place in a global context. The engineers who will be the leaders of the future will often manage and direct global engineering activities. They will need an expanded set of skills to do this. In the next section we discuss what some of those skills should be.

## **3 Global Competence: What Does it Mean?**

Many of the previously mentioned studies argue that engineers should develop “global competence.” Although this term is becoming more widely used, it isn’t always clear what it means. A good discussion of “the elusive concept of global competence” is given by Grandin and Hedderich.<sup>24</sup> Lohmann et al., Hunter et al., and Deardorff all give definitions for this term that emphasize skills such as cultural empathy, foreign language ability, or the ability to practice one’s profession in an international setting.<sup>25,26,27</sup> Downey et al. discuss global competence in terms of being able to work effectively with others who define problems differently.<sup>28</sup> Based on definitions found in the literature, experience running study abroad programs, and stated

objectives of courses and programs which prepare students to be globally competent, Parkinson et al.<sup>29</sup> proposed 13 dimensions or attributes of global competence, some of which are specific to the engineering profession. These follow.

Global competence means engineering graduates,

1. Can appreciate other cultures.

*Explanation:* This attribute is focused partly on understanding and avoiding *ethnocentrism*, the idea that one's own culture is superior to all others. "All cultures, to some degree, display ethnocentrism, which can be the greatest single obstacle to understanding another culture."<sup>30</sup> Engineers may be susceptible to a particular form of ethnocentrism: the assumption that if their country is more technologically advanced, their culture must be superior. Engineering graduates need to be aware of these potential problems and develop the capacity to appreciate and be sensitive to other cultures.

2. Are able to communicate across cultures (understand cultural differences in communication regarding such things as status, formality, saving face, directness, the meaning of "yes", non-verbal cues, etc.).

*Explanation:* Communication in some form is the foundation upon which most engineering activities build. To avoid misunderstandings, the substantial influence of culture on how people communicate should be understood.

3. Are familiar with the history, government and economic systems of several target countries.

*Explanation:* This dimension refers to understanding important elements of the context of a society. For example, as students visit factories in China owned by Taiwanese companies, how is their

appreciation of this situation deepened by knowing the history of China and Taiwan?

4. Speak a second language at a conversational level.

*Explanation:* Learning the language of another country is a key in developing a deep understanding of the culture and is an impressive gesture of goodwill and reaching out to cross cultural boundaries. Learning a second language also promotes tolerance for others who have learned English as a second language.

5. Speak a second language at a professional (i.e. technical) level.

*Explanation:* This attribute takes Dimension 4 a step further to being able to conduct engineering activities in a second language. This provides a significant reduction in the possibility of misunderstandings arising from poor translations or cultural gaps.

6. Are proficient working in or directing a team of ethnic and cultural diversity.

*Explanation:* Much engineering work is conducted in teams. As engineering work becomes more global in nature, engineering teams become more diverse and may include members of various ethnic, cultural and national origins. Developing this attribute relies heavily on developing communication skills across cultures (Dimension 2).

7. Can effectively deal with ethical issues arising from cultural or national differences.

*Explanation:* Ethical issues can be magnified when cultural issues come into play. For example, it is common in some cultures or countries for business to be conducted via bribes or kickbacks. Whereas in the U.S. such conduct is considered to be unethical and illegal, how does an engineer approach these

issues in a society that does not feel this way? Similar issues come up relative to safety.

8. Understand cultural differences relating to product design, manufacture and use.

*Explanation:* Being global often means designing, manufacturing and selling products in multiple countries. A deep understanding of customer needs can be heavily influenced by cultural values.

9. Have an understanding of the connectedness of the world and the workings of the global economy.

*Explanation:* This dimension relates to having a basic understanding that the world's economies are now very interconnected. How does demand for commodities in China affect prices in the U.S.? How do interest rates in Europe affect the exchange rate between the Euro and the dollar? How do exchange rates affect exports?

10. Understand implications of cultural differences on how engineering tasks might be approached.

*Explanation:* This dimension is closely related to the attribute of being able to work in diverse teams. As an example, how does Japanese culture influence how Japanese engineers approach manufacturing? How does Japanese culture affect how design decisions are made?

11. Have some exposure to international aspects of topics such as supply chain management, intellectual property, liability and risk, and business practices.

*Explanation:* These are all topics which can directly affect doing business abroad.

12. Have had a chance to practice 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.

*Explanation:* Whereas the other attributes focus on knowledge or understanding, this dimension focuses on practice. Many of the above attributes have to be practiced to achieve competence.

13. 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.

*Explanation:* Many of the greatest challenges facing humankind are challenges which cut across national boundaries, such as energy production, environmental protection, access to clean water, and security. Solutions to these problems will require cooperation across national boundaries.

Thus we can see that the term “global competence” can encompass a wide set of attributes and abilities. Since it might not be possible to develop all of these attributes within the constraints of a typically crowded engineering curriculum, it would be helpful to know which of these are most important. In the next section we provide some preliminary information in that regard.

## 4 Global Competence: What is Most Important?

To gain further insight into the attributes of global competence, a survey of their relative importance was conducted of persons in academia and industry. The survey asked respondents to evaluate each attribute according to the scale, 1—Not important, 2—Of Some Advantage, 3—Desirable, 4—Highly Desirable, 5—Essential.

Surveys were sent to attendees to the NSF Summit on the Globalization to be held at the University of Rhode Island, Nov 5-6, 2008. The

survey was completed by 15 individuals from 11 universities, 14 individuals representing 12 companies, and two respondents from government or ASEE.

The university respondents all held positions which would involve them in this issue—such as engineering deans, chairs, study abroad directors, or other university administrators. Thus it was to be expected that they would feel global competence was important. All of the industry respondents worked at the management level (several were retired) for companies which have global operations. Besides indicating how essential each attribute is to global competence, industry respondents also answered the question, “How important is it that the engineering graduates of today (in many cases, you own employees) are globally competent? The same scale was used to answer this question.

The relative importance of the attributes is shown in Figure 6, with separate bars for academia and industry. The chart shows relatively consistent rankings, given the small sample size, across academia and industry. Four of the top five attributes were common between the two groups. We also note that industry respondents indicated the importance of global competence for engineering graduates to be between “highly desirable” and “essential.”

Based on a sum of the rankings, the five most important attributes of global competence are that engineering graduates,

1. Can appreciate other cultures.
2. Are proficient working in or directing a team of ethnic and cultural diversity.
3. Are able to communicate across cultures.
4. Have had a chance to practice engineering in a global context, whether through an

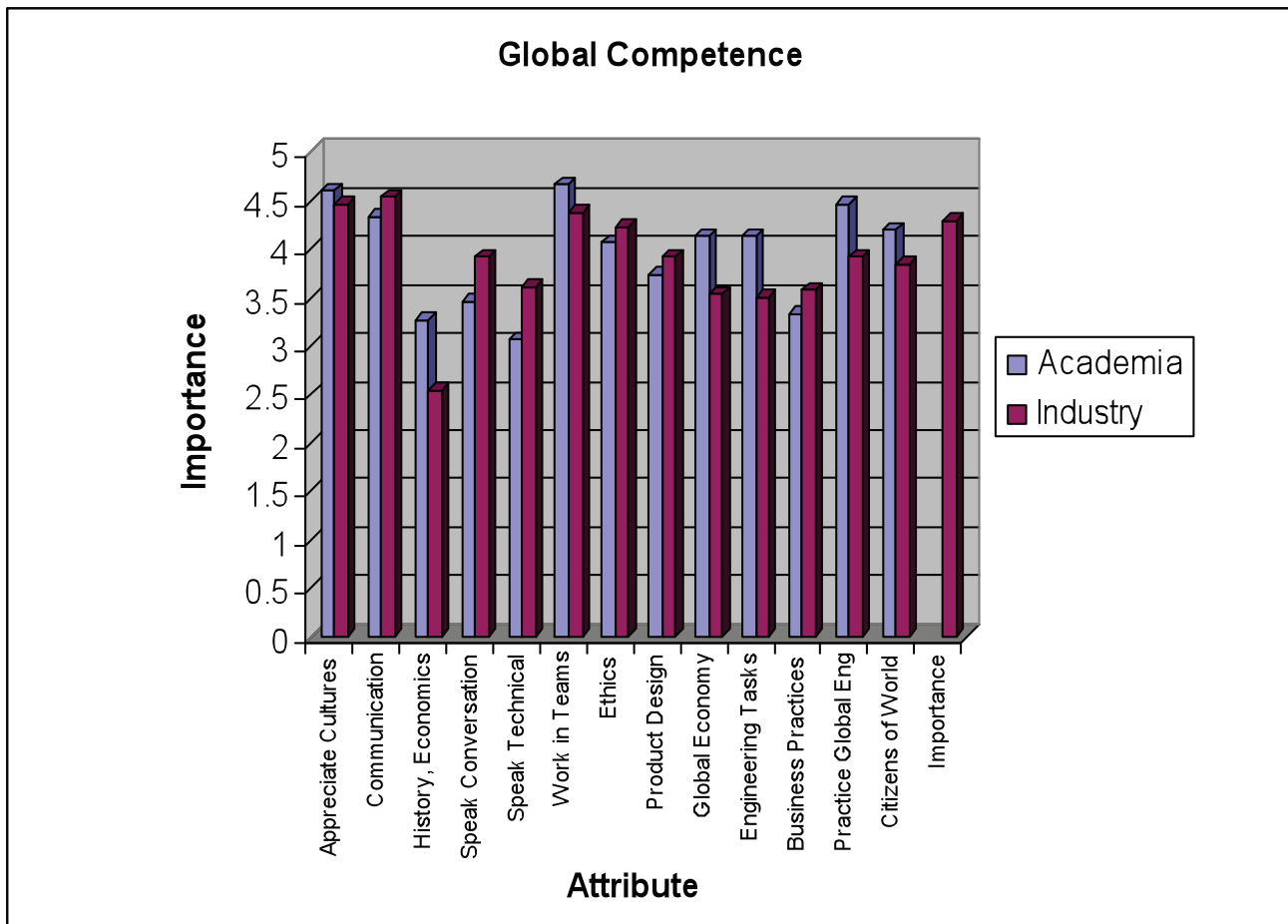


Figure 6. Relative importance of 13 dimensions of global competence as ranked by academia and industry.

Alan Parkinson

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international internship, a service-learning opportunity, a virtual global engineering project or some other form of experience.

5. Can effectively deal with ethical issues arising from cultural or national differences.

We note that 12 of the 13 attributes were ranked as “Desirable” (corresponding to a score of 3.0) or higher. Further information is provided in Parkinson et al.<sup>29</sup>

## 5 A Larger Question

So far we have discussed several questions such as: Why is global competence important? and, Which attributes of global competence are most important? These questions point to, but do not answer, another larger question: How can global competence be achieved? Regardless of the specific discipline, the curriculum for engineering is demanding and full, with more topics to be covered than there is time for. How can global competence be fit into a highly constrained program? Although a full response to this question is beyond the scope of the paper, some observations can be made.

First, if there is not time or resources to address all the dimensions of global competence, then it would seem to be of benefit to determine which dimensions are of the highest priority and to focus on those. Second, within the constraints of a crowded curriculum, it would be of benefit to identify areas where global competence could be integrated into the existing sequence of courses.

The results of the paper provide some clues as to ways this might be done. For example, the second most important attribute, “Engineering graduates are proficient working in or directing a team of ethnic and cultural diversity,” could be developed a number of ways, such as through a collaborative design experience, that would not have to require travel. Such an experience could involve having U.S. student teams collaborate with abroad student teams on a design project via video-conferencing and other Internet-based design tools. Since design activities are already a

part of the curriculum, it may be possible to integrate this type of experience more easily into existing programs. This kind of activity would also require students to learn about communication across cultures and give them a chance to practice global engineering skills, two of the other “top five” attributes.

Thus by defining global competence more precisely, engineering colleges could focus more specifically on the attributes they are trying to develop. By breaking global competence into smaller “chunks,” it may be easier to integrate it into existing programs or tailor learning activities to produce specific outcomes.

## 6 Summary

In this paper we have discussed the rationale for developing global competence. We looked at this from several perspectives. We discussed of the technological, geopolitical and economic changes that have been drivers for globalization. In light of these developments, we gave opinions from credible sources regarding what should be done. We presented examples from engineering disciplines, and mentioned the global nature of grand engineering challenges. We proposed and explained 13 separate dimensions of global competence. These dimensions encompass a broad set of attributes and skills. Since it may not be possible to develop all of these within the constraints of existing programs, we presented survey results from engineering educators and leaders in industry regarding the relative importance of these dimensions. Four of the five top attributes were common between the rankings of industry and academia. Industry respondents also indicated the importance of global competence for engineering graduates to be between “highly desirable” and “essential.”

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