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Internationalization of Engineering Education

Abstract

Providing global skills to engineering graduates is an urgent need. This paper points out that efforts to internationalize engineering curriculum through add-on courses like study abroad programs are not enough because, even if they are effective, they still serve fewer than 20 percent of the graduates. The paper proposes a way to provide global competencies to all engineering graduates by partially reforming the engineering curriculum. The need for global competencies in engineering graduates and the reasons for the need are discussed first. Some components of an enlarged set of knowledge and skills that graduates must have to be globally competent engineers are then presented. Strategies for teaching the global skills and strategies for assessment of the graduate global skills are also discussed.

Introduction

The National Academy of Engineering [1] in its editorial "*Globalization and Engineering"* says**:**

> Globalization is not a new phenomenon. Carthage, Rome, the Ottomans, several European powers, and mercantile city-states had multicontinental trading networks made possible by a combination of economic power, military power, and the latest technology.

But, it also says,

> The globalization we are experiencing today is unprecedented in its magnitude and reach. The whole world has become a market for the economies of many countries, and globalization is transforming not only the location and organization of production and services, but also social and economic patterns

This unprecedented globalization has transformed the nature of the engineering enterprise, the character of engineering profession and the profile of the engineer of the future. Engineers are expected to function effectively as they face new, ever-changing work environments that include globalization, outsourcing and emerging technologies. In the current global environment engineers are required to work with engineers from different nations in the transformed multilingual, multicultural, and multicontextual business environment, their traditional skills need to have a global dimension and additional skills – skills that will give engineers a global mindset are required. Most engineering schools are offering a number of programs such as study abroad or work abroad, but these add-on programs have limitations and constraints. In fact, over 80% of engineering students do not participate in add-on international engineering programs.

Industry has begun to respond to the transformation by developing business strategies, which include global teams, offshoring and outsourcing. But the educational establishment has not caught up to suit the transformed nature of the engineering enterprise in the globalized economy. Engineering education has not changed yet. In a previous paper[2] presented at the ASEE 2007 annual conference, entitled *Globalization and Engineering Education for 2020* the authors have discussed these issues and the need for reforming engineering education to make it globalized

education and have outlined some essential features of global engineering education. This paper, a follow-up of the ASEE paper, discusses the kind of transition engineering education has to go through, to prepare graduate engineers with the required new profile to perform successfully in the engineering enterprise. The authors believe that a truly global education rests on the development of a global perspective, within individual students, faculty and the university community. In this paper the authors suggest effective methods for providing engineering graduates this perspective. They present ways of preparing engineering graduates with an enlarged set of knowledge, skills and competencies required for them to function effectively in the emerging global engineering environment. The components of the enlarged set of knowledge and skills and the need for such enlarged set of knowledge and skills are also discussed.

Background

The world is going through rapid changes. These changes have affected businesses and transformed the nature of businesses. A number of external forces are driving this transformation of businesses. Some of these drivers are:

- Rapid advancements in technology
- Rise of new kinds of technology
- Globalization and the increasingly global nature of businesses
- Growing complexity of socio-technical systems[3]

Of these forces, globalization has had the greatest impact on the engineering enterprise and engineering education because technology capability alone would not guarantee successful engineering performance. Globalization has changed radically the way businesses operate – the way the businesses produce and sell their products and the way offer their services[4]. It has transformed the nature of the engineering enterprise, the character of the engineering profession, and the profile of the engineer of the future. Consequently, the engineers of tomorrow will be expected to function differently from today as they face new changing work environments. Kenney and Dossani[5] say,

> The career of the engineer of the future is likely to take one of two directions. Engineers employed in organizations will necessarily be required to coordinate projects having global workforces. The critical words in the previous sentence (*to which current engineering education pays little attention*) are "coordinate" and "global." [Italics added]

The new profile of an engineer requires new set of skills. Engineering education has to change to impart this new set of skills. Industry has begun to respond to the transformation by redefining business strategies and with new expectations for the skill sets of engineers. But these changes have had little effect on engineering education - the way engineers are taught and trained[6].

The realization that engineering education has not changed is global, not pertaining to just the US. Green and Hammer[7] say,

> Australian education systems, including universities, are failing to develop employability skills such as communication, problem solving, ongoing learning, creativity, cultural understanding, entrepreneurship and leadership

Engineering education of today is still rooted in the skills required to support the work environment of the 1950s when manufacturing was the predominant engineering activity. Engineering education has not changed to meet the needs of current work environment where service sector dominates the economic activities[8]. This is clearly reflected, as table [Table 1] below shows, in the glaring differences in the perceptions the industry and education have of the skills engineers need.

Table 1. The emphasis given by employers and by academics to the desired skills of university graduates[9].

	Business	University
Communication skills	1	7
Capacity to learn new skills	2	5
Capacity for cooperation	3	8
Capacity to solve problems	4	3
Ability to apply knowledge	5	4
Capacity to work alone	6	6
Theoretical knowledge	7	1
Capacity to use computers	8	2
Understanding of ethics	9	12
General business knowledge	10	11
Specific work skills	-11	9
Broad background general knowledge	-11	10

Not long ago, when engineers were working in mostly regional operations, the above skills were sufficient for them to perform effectively but not now in the current global business environment. In order to give engineers the global mindset, engineering education must have appropriate curriculum that will impart an enlarged set of skills. Many institutions have attempted to give students this global perspective through a number of programs. But an international team of scholars from eight universities in six countries on four continents says in a report [4] on a study on globalization and the educational reform needed,

> Incorporating such preparation into engineering curricula, however, has proven to be a major challenge because of the highly sequenced and content-demanding nature of the curriculum. Consequently, international preparation is often addressed by "add-ons" such as minors and certificates, or it is relegated to short summer experiences abroad. Nonetheless, some engineering programs are finding ways to incorporate language preparation, coursework in global studies, and transnational design into the engineering curriculum in more integrated and immersive approaches [116, 117, 118]" (p.31).

With such add-on programs there are several limitations and constraints. For instance, while study abroad programs provide an opportunity to gain global experience and an understanding of other cultures and perspectives, they have limitations: First, only a small percent of students go on those programs. Gerhardti[10] observes: " …with about 15 million native born Americans annually in higher education, only about 130,000 annually engage in an international experience abroad, with only 3,000 of those in engineering programs." Also the team of international scholars[4] observes, "Unfortunately, the number of students participating in these programs remains relatively small [123]." Such programs are expensive and have other constraints. It is not a possible option for all students. Engineering education is currently, therefore, not preparing at least 80 percent of students for the global business environment. The question then is what about global experience for the other more than 80 percent students for whom study abroad programs are not an option. A way of giving global competencies to students here at home is to give it to them as an integrated component of their regular curriculum.

Secondly, the question is how effective are such [study abroad] programs in preparing students with the necessary skills for the global business environment. The international team of scholars[4] observes:

> Institutions may offer a variety of programs designed to prepare students for the global workplace, but there is insufficient research to document whether these programs actually do prepare students to practice on a global scale [p. 1] and
>
> …there is a significant lack of knowledge about proven theories and effective practices for instilling global competence. Most programs are thoughtfully designed and carefully implemented, but they are seldom rigorously and scientifically evaluated for their educational impact. Does learning a second language really matter? How long and what kinds of international experiences are best? Should international coursework be required? What subjects are needed and when should they be taken? Increasing the knowledge base of proven theories and effective practices for instilling global competence in engineering graduates, indeed all graduates, needs to be a major priority [p. 41].

These problems in the current efforts in preparing students for the global workplace lead to the requirement that engineering education be reformed by including appropriate knowledge and skills training programs to ensure that the 80 percent of engineering graduates who are now left out of the internationalization efforts are also covered and prepared for the global workplace. The critical realization should be that the curriculum must ensure that all engineering graduates would be globally competent.

Global Competencies

"Preparation for global practice is generally not viewed as central to the education of an engineer."[4].

To meet the challenges of globalization of engineering practice engineers need to have, in the broadest sense, two essential competencies:

- High level technical competency
- The ability to work with an international team of engineers in a multicultural, multilingual, and multicontextual business environment.

The ability to work with an international team requires many different skills. Therefore, just making engineering graduates technically more competent with no regard to the new additional skills required to meet the challenges of globalization would not be good enough. Kenney and Dossani[5] say

> Whether U.S. engineers become entrepreneurs or global project managers, they will need an educational system that provides them with the tools to succeed. … Thus, engineering education cannot continue as usual…. , more of the same education, such as lengthening the curriculum by a year to improve students' technical skills, is unlikely to address the problem of offshoring [an offspring of globalization].

To work in a multicultural, multilingual work environment engineers need an expanded set of knowledge, skills and competencies that would give them the global mindset. Curriculum that would give engineering graduates such an expanded set of skills would include education and training that would provide them several non-engineering skills sets. Osorio, Satzinger, & Mete[11] say:

> The globalization of engineering education means providing students with an enlarged set of knowledge and skills required to address the situations encountered in this large domain.
>
> This includes inculcating foreign languages skills, knowledge of foreign laws, practices and customs or knowledge of foreign environments, resources and needs.

Lloyd et al[12] observe, in connection with an innovative program titled *A Dispersed Design Team Approach for the Globalization of Engineering Education* that Michigan State University (MSU) and the University of Texas Pan American (UTPA) collaboratively offer,

> in addition to the many technical issues the engineering design process normally encounters, extra-technical issues of leadership, power, trust, language, time differences, cultural differences, communication, and education

In defining the kind of skills engineering graduates need Grindel[4] observes:

> While engineers in Switzerland are respected for their analytical skills and problem solving skills, these skills are currently not sufficient to underpin the country's global competitiveness. … The ability to work effectively as part of multidisciplinary and international teams must be taught as early as possible and in subject-specific ways. In addition, the globalization of the engineering profession demands an improved intercultural sensitivity and linguistic versatility for engineering professionals to navigate diverging approaches and views and negotiate solutions [p.24].

Universities around the world are aware of the need for such additional skills and are trying to provide them. For instance, The University of Wollongong[9] has designed its programs to instill in its graduate, in addition to the generic qualities expected of all graduates, like knowledge in a discipline, appropriate ethical standards, and defined professional skills, the following attributes:

- a capacity for, and understanding of teamwork;
- an ability to logically analyse issues, consider different options and viewpoints and implement decisions;
- an appreciation and valuing of cultural and intellectual diversity
- ability to function in a multi-cultural or global environment

A close look at the discussion above would give the following as some of the competencies that form part of the enlarged set of knowledge and skills required:

- Foreign language skills
- Multiculturalism
- Knowledge of foreign business environments and business cultures
- Foreign laws
- International markets

The reasons for needing these knowledge and skills are discussed briefly below.

Foreign language skills

Foreign language skill is an important element of global competency, as without it one cannot even communicate in a foreign country. English is spoken in many countries – many countries in Europe, and most countries in Asia. In many countries in Europe, including Eastern European countries, English is being taught as a second language. It is increasingly becoming a common language especially in science and engineering around the world. In many universities in Europe, all universities in India and most universities in South East Asia engineering is taught in English. In spite of it, ability to speak the language of the host country is a great asset for practicing engineering and doing business in a foreign country. The team of international scholars[4] observes:

> Linguistic ability is a crucial element of cross-cultural competence. The inclusion of language courses will significantly further engineering students' understanding of the economic, political, and cultural dynamics of globalization. [p. 38].

Realizing the importance of the language skills in the present environment the National Academies, in its editorial in one of its news releases[13] on a new report [titled International Education and Foreign Languages: Keys to Securing America's Future] from the National Research Council, says,

> "The nation's infrastructure for international and foreign language education is weak at a time when the United States faces unprecedented demands for globally aware citizens and professionals," said Janet L. Norwood, chair of the committee that wrote the report, a

> counselor and senior fellow at the Conference Board Inc., and former U.S. commissioner of labor statistics. "… a comprehensive strategy is essential for building greater knowledge of world cultures and national capacity in a wide range of languages.

Linguistic ability - the ability to speak in a language – alone is not sufficient for communication. Communication even in the same language can be misinterpreted and misused when dealing with people in different cultures. Montabaur[14] presents an interesting example of this case. She says, an American Vice President on a conference call to an international sales team in Italy said" "It would be great if you could send me the report by the end of the week," The team agreed but the report did not arrive on Friday and when the VP expressed his disappointment, the Italian team did not understand why, and said "You said 'it would be great' -- meaning good if you get the report and not a problem if you don't. Right?". This is a classic illustration of how communication in the same language could have cultural connotations. Although English is spoken in many countries that it is not their language could be used as an excuse. Campigotto[15] says,

> Keep in mind that even if the other party is willing to use English, this is often a means by which the true intent can be obfuscated by a lack of clarity, hidden behind the excuse that English isn't their mother tongue.

Multiculturalism

As Osorio, Satzinger, & Mete[11] say, "Cultural diversity is a fact of professional life. Engineers are being employed in even greater numbers by multinational and transnational corporations and are routinely working across national and cultural boundaries". Multicultural environment in the US engineering enterprise is not new. Even before the advent of globalization US workforce included engineers from different countries. But, globalization and the increasing need for more engineers have not only accelerated the development of the multicultural environment but also changed the nature of the environment. Every year about 60 000 H-1B visas are issued to people from other countries with different cultural background and there is a growing demand for increasing the quota. The increasing inflow of engineers from other countries will increase the extent of the cultural diversity within the country. Until recently most engineering graduates were to work within the country and deal with this cultural diversity within US. Now, offshoring – an offshoot of globalization – is forcing businesses to work with the multicultural cultural environment outside the US in different countries in different cultures as they move the manufacturing and research to other locations. In this case as Lucena and Downey[16] observe:

> Globalization challenges US engineering students to prepare for work in a culturally diverse environment where they will encounter non-US engineers defining and solving problems.

Working with a culturally diverse work force in a foreign country in a different culture is very different from working in a multicultural workplace within your own country and within your own culture. To work harmoniously with colleagues in such an environment, global perspective with a clear understanding of the cultures of people working with is becoming essential not only in organizations that are multinational but also in every organization. Montabaur[14] discusses five stages of adjusting to live in a different culture and gives some tips for cross-culture success.

Living and working in a different culture away from home requires more than just tolerance and adjustment to other cultures. It needs extra efforts to reach others, understand others' perspectives and assimilate them to work harmoniously with them[14]. There has never been more need for it than now. Montabaur writes:

> "There has never been a more important time for the world to reach out to each other and be more than just tolerant but willing to learn," said British, President and founder of Munich-based Trust in Business.

Knowledge of foreign business environments and business cultures

William Wulf, President, US National Academy of Engineering, observes,

> Engineering is global, and engineering is done in a holistic business context. The engineer must design under constraints that include global cultural and business contexts -- and so must understand them at a deep level. They too are new 'fundamentals' [in engineering] [Cited in Director[17]].

The way businesses are conducted varies from country to country. Even multinational corporations with a defined set of goals and objectives and business culture have to work within the business culture of the host country. To work within the business culture of a country, businesses need a good understanding of the business culture in which they operate. Osorio, Satzinger, & Mete[11] say

> The reason for needing language skills, *for understanding foreign customs and laws* is to be able to better conduct business in an efficient manner, recognizing opportunities and avoiding obstacles. [Italics added]

Cultural differences make people behave, mean, and do things very differently. Hall[18] gives an example:

> When you see a Japanese colleague say "yes" to a proposal they oppose and have no intention of implementing, you know that there is a cultural reluctance to say "no" bluntly to appear rude, but you can start to see the logic of the situation and the underlying similarities we share.

According to Hall management practice is predominantly dominated by Anglo-Saxon worldview with "*universalist*" orientation. In universalist orientation "the rules and obligations to a wider society are a strong source of moral reference"[18]. Many societies outside the Anglo-Saxon world are "*particularist*" societies "where the particular circumstances are much more important than the rules. The bonds and obligations of relationships are stronger than any abstract rule, and the response to situations may change according to the circumstances and the people involved. Relationships are to be protected, even at the cost of bending or breaking rules".
Also, Hall observes cultures differ in how they do business. *"Individualistic cultures"* [like those in the Anglo-Saxon world] choose the individual even at the expense of the teamwork, whereas "*Collective cultures"*, [like that of the Japanese] "choose the group and often pay the price in a submerging of individual initiative and creativity". Understanding of the differences in cultures

and respect for different worldviews are important for conducting business in a different culture. Often combining the two [one's own and the host] cultural perspectives would lead a better way of doing business in the chosen culture. Hall[18] observes:

> This to me is the essence of diversity, whether from culture, gender, race or age - the freedom to be equally valued for that difference, and the freedom to come together to create something more than any one of us could have done alone.

Knowledge of foreign laws

Laws vary from country to country. Understanding of the law of the country of operation is crucial to avoid legal implications. Lack of knowledge of local laws could create problems that could be avoided with an awareness of the local law. Mar-Yohana[19] describes two cases, which serve as good examples of the problems that lack of knowledge of local laws and regulations could cause. In the first case, in India, the software developed in India could not be tested in India but had to be sent to the US for verification because of regulatory issues. In the second case, in Mexico, when a management person from the US wanted to show a manufacturing management program implemented in one facility in Mexico to people in another facility of the same company the company did not allow it because of labor union regulations that did not allow employees of one facility to know what happens in the other. Prior knowledge of the local laws and regulations could avoid such unexpected turns and save time, money, and worry for the business.

Knowledge of international markets

Cheap labor in the developing economies like China and India is not the only reason for offshoring. One of the main reasons many businesses go for offshoring is the huge and growing market these economies offer. Mondics[20] writes,

> … the possibility that rapidly developing countries in Asia could become huge markets have pharmaceutical companies eager to do more business there. … According to IMS Health, an international data-gathering service based in Connecticut, sales of prescription drugs in China reached $9.5 billion last year, and they are growing annually about 28 percent.

Tan[21] notes " MOFCOM's survey also indicates that the paramount reason for multinationals to expand their investment in China lies in the high development speed and huge market in all industries of China". If market is an important reason to choose a location understanding of the chosen market becomes a critical need. The market needs, consumer behavior, and marketing strategies vary in different countries. With the size of markets in China and India knowledge of local markets will help design products just for the local market. A good knowledge of international markets is a vital part of response to globalization.

While the huge market is a good reason to offshore that is not the only reason for acquiring knowledge of international markets. Kenney and Dossani[5] say:

> "Finally, Americans must understand that, just as proximity to sophisticated markets conveys advantages to them, the development of low-cost economies conveys advantages to engineers in other countries. In other words, countries like China and India are rapidly developing markets with unique engineering situations, and American engineers could benefit by becoming familiar with those environments so they can capture value from them, rather than assuming that all high value-added new ideas will necessarily emerge in developed countries. This implies that, at the very least, internships (and perhaps early career paths) should be increasingly global. Some universities have already begun to respond to these challenges. The Asia Technology Initiative at Stanford University, for example, places engineering students in summer internships in Bangalore, Beijing, and Tokyo."

While acquiring foreign cultural perspectives and knowledge of international markets, it would be sensible to remember what Campigotto[15] says:

> Ultimately, to achieve positive results it is important to demonstrate awareness of the other culture and empathy for the foreign market, without losing the uniqueness and message inherent in the company's culture.

Teaching and Learning Strategies

We have discussed some important competencies that a global engineer should have and engineering education should provide. The question that inevitably arises is how do the engineering schools do this. Osorio M., Satzinger M., & Mete O[11] ask: "But the question is…How do we fit the teaching of these skills and competences into an already crowded curriculum?" This question arises because the first thought that occurs, whenever we think of adding new knowledge, skills, is to have add-on courses. We saw earlier that many schools have responded to the need of giving graduates international experience by adding courses on top of the existing curricular courses. We also saw earlier that the add-on syndrome does not necessarily work! At least there is no proof that it works[4]. Green and Hammer[7], while discussing developing the necessary graduate employability skills, say:

> One common concern among teaching staff is that skills development will have to occur at the expense of content or disciplinary knowledge. This is not necessarily so, according to Bradley Bowden, who is head convener of a large first-year management course that includes a significant focus on skill development. Bowden argues that the employability skills highlighted by the Business Council of Australia are the same skills students need to develop to engage critically with their chosen discipline. In any case, he says, academics may make the mistake of focusing too heavily on content without showing students how to identify problems, develop research skills, critically assess what they read, develop arguments and write papers.

The same argument could be applied to developing global competencies. Green and Hammer[7] point out

> The consensus among higher education scholars is that skills-based teaching works best when it is embedded within disciplinary teaching rather than taught in remedial workshops or as generic stand-alone courses by specialist learning advisers.

The consensus seems reasonable given that "Current estimates place the half-life of engineering knowledge—the time interval in which half of what an engineer knows becomes obsolete—at between 2.5 and 7.5 years, with an average estimate of 5 years"[22]. The Griffith Business School at Griffith University in Australia[7] has a model for doing this:

> One example is the Griffith Business School, which is implementing a new approach to learning development. The aim is to ensure that all students acquire a common set of employability skills to a verifiable standard in their first year of study and that skills development continues to the completion of each degree program.

A problem in taking this approach, which is a perennial one and a universal one with any innovation or reform in education, concerns faculty. Green and Hammer[7] write,

> Yet, as Simon Barrie, higher education researcher at the University of Sydney, points out in his survey of Australian universities, many lecturers remain uncertain about how to teach and assess graduate attributes appropriately within a disciplinary context

The Griffith Business School at Griffith University in Australia[7] has found a solution for this, which can be applied to developing global skills as well:

> What is clear from the Griffith experience is that the departure from a traditional emphasis on disciplinary content requires new ways of thinking about teaching. This is why the Griffith Business School is also investing in staff development.

If the above approach of integrating global skills within the disciplinary content is found to be too challenging to implement one less effective, nevertheless better than no efforts, would be to identify liberal art courses that would provide knowledge and skill in global skills and use them as electives.

Whichever approach is taken, one very useful method of giving real-world global skills to engineering graduates is to adopt or adapt the program Michigan State University (MSU) and the University of Texas Pan American (UTPA) have implemented[12]. Lloyd, et al[12] describe the program:

> The INTEnD program is a multidisciplinary research and education program. The course imparts transcultural communication skills and multi-media communication skills to engineering students working in engineering design and manufacturing teams that are industrially-sponsored, geographically-dispersed and culturally -disparate.

Integrating global competencies into disciplinary content is a challenging solution to the problem and faculty in engineering institutions are exploring ways to do just that. For example, the University of Wisconsin – Madison is responding to the National Research Council's Engineer of 2020[23] and Engineering Grand Challenges[24]; both document the need for these global

competencies. The College of Engineering (COE) at UW-Madison implemented an internal proposal process titled, COE 2010[25]. Half of the eleven funded proposals involved developing global competencies. The courses had a variety of designs. In one project, students will travel together as a group to China with UW-Madison instructors; they will take required engineering and technical communication courses and travel around to experience the culture. In another project, students can take required engineering and communication courses when they are in another country because the required courses are now available by web-conferences. In a third example, first-year students are learning about engineering through investigating grand challenges in the global society. In all course, the instructors are intentionally addressing global competencies and helping students develop them.

Other examples illustrate the creativity with which faculty are integrating global competencies into the disciplines. First, technical communication faculty are piloting some curricular modules. One asks students to research a specific culture, engineering company, and workplace expectations. They share their work in a brochure and presentation. Second, faculty are using case studies that involve international issues related to teaching and learning; these are from the Diversity Institute[26], part of the NSF-sponsored Center for the Integration of Research, Teaching, and Learning (CIRTL).[27] Faculty are also designing new case studies based on their own and their students' international experiences. Finally, faculty have developed a graduate course titled, Teaching Science and Engineering: International Faculty and International Students; this CIRTL course is especially for future faculty.

Assessment Strategies

To ensure that the efforts to provide global competencies have achieved the desired results, assessment is necessary. But, before assessment is attempted, learning criteria and learning outcomes for teaching global competencies must be defined. Downey et al[28] define the broad learning criteria for the global competency of the graduates as:

Learning Criterion	Through course instruction and interactions, students will acquire the knowledge, ability, and predisposition to work effectively with people who define problems differently than they do.
Learning Outcomes	1. Students will demonstrate substantial knowledge of the similarities and differences among engineers and non-engineers from different countries. 2. Students will demonstrate an ability to analyze how people's lives and experiences in other countries may shape or affect what they consider to be at stake in engineering work. 3. Students will display a predisposition to treat co-workers from other countries as people who have both knowledge and value, may be likely to hold different perspectives than they do, and may be likely to bring these different perspectives to bear in processes of problem definition and problem solution.

These broad learning criterion and learning outcomes could be further developed into more specific detailed learning criteria and learning outcomes. For each criterion, measurable benchmarks should be defined so that the competencies could be assessed more effectively and at multiple levels. For instance, the Quality Assurance Agency[29] of the UK has defined

Transferable Skills in terms of multiple skills, and for one of those transferable skills - Analytical and problem solving skills – has developed benchmarks as shown below:

Transferable skills

Skill: Analytical and problem solving skills

Criterion:

Courses should be designed so that, by the end of their degree programme, students should be able to demonstrate ability to analyse, synthesise, evaluate, and identify problems and solutions

Benchmarks:

- Threshold
  Students will have a basic ability to use relevant empirical and theoretical data in addressing tasks and formulating possible actions
- Modal
  Students will have the ability to process and synthesise empirical and theoretical data, create new syntheses and to present and justify a chosen position having drawn on relevant theoretical perspectives
- Best
  Students will have a well developed ability to process and synthesise empirical and theoretical data, to create new syntheses and to present and justify a chosen position having drawn on relevant theoretical perspectives

Second, there are two ways of measuring these learning outcomes. First, they could be assessed through some form of generic test, like the GRE and GMAT or the "generic graduate skills assessment test"[7] that the Australian universities use to assess graduate employability skills. Use of a generic test will have the disadvantages all standardized test are claimed to carry. If the generic test for global competencies is used, the test should not be a single end-of-program assessment test. The test should be conducted at every level [year] to assess the competency gained appropriate to the learning outcomes defined for that level.

A better way to assess will be to test for global competencies in each unit or course of the disciplinary content. This method of assessment would be more realistic and effective if the global competencies are integrated and taught within each unit of the disciplinary content rather than through add-on courses. UW-Madison faculty use a variety of assessments in the curricula used as examples above. Classroom assessments on individual assignments such as a presentation and brochure, or case study involve rubrics that clearly outline the expectations. Authentic assessments such as micro-teaching and statements of teaching philosophy are the norm in the graduate course.

For broader, program assessments such as the COE 2010 project described above, faculty are using college-wide electronic surveys and focus groups discussions involving both undergraduate students and faculty. Assessment guides learning, so assessment is "designed in."

Conclusion

Globalization is here to stay and will only expand. Providing global skills to engineering graduates is an urgent need. In this paper we have identified some of the competencies graduates would need to be global engineers and discussed the reasons for the need for those competencies; strategies for teaching those knowledge and skills; and strategies for assessing the global skills of graduates. A number of other things like methods of integrating the knowledge and skills into the discipline contents, detailed discussion on the development of learning criteria and learning outcomes for global competencies, more discussion of assessment of global attributes in graduates, faculty development schemes etc could be included in a more comprehensive paper. While we attempt to produce globally competent engineers it would be wise to keep in mind what the team of international scholars[4] says:

> Technically adept, culturally aware, and broadly knowledgeable, as well as innovative, entrepreneurial, flexible, and mobile — are we seeking global engineers or "super engineers"? Engineering is already a demanding program of study with its tightly sequenced, highly technical, and lengthy curriculum. And now we expect even more from engineering graduates? Instilling skills required for global competence will be challenging, but several promising trends have already laid the groundwork. [p. 33]

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