INTERNATIONAL REQUIREMENTS IN CDIO PROGRAMS

Patrick H. Oosthuizen

Department of Mechanical and Materials Engineering
Queen's University, Kingston, Ontario, Canada

ABSTRACT

Engineers are today involved in many ways in international projects. This may involve, for example, having various components of a large and complex engineering system produced in different countries, these components then being brought together at some location where the system is assembled. Another way in which international interaction in engineering occurs is where the design of a system is done in one country and the manufacture and assembly of the system is done in other countries and the whole process is planned and monitored in yet another country. There are many other ways in which engineering tasks are undertaken in an international environment and the practise of engineering in such an environment is becoming more and more common. Some preparation for working in an international environment, therefore, should be included in engineering programs. In this paper some of the ways in which engineers work in an international environment are reviewed and discussed and methods for including consideration of working in an international environment in an engineering program are discussed. The fact that the CDIO Syllabus clearly mentions international considerations only in 3.2 COMMUNICATION IN FOREIGN LANGUAGES is discussed. CDIO, with its international membership and commitment to the development of curricula that consider all aspects of engineering, would seem to be an ideal organization to develop methods for bringing such international considerations into engineering curricula and this is also discussed.

KEYWORDS

Internationalization, Syllabus, University Engineering Programs, Engineering Education, CDIO.

INTRODUCTION

Large numbers of engineers are today involved in many different ways in projects that require them to work in an international environment. Some of the ways in which engineers work in an international environment are:

1. By working on international development projects in or with workers from developing countries, the work usually being supported by governmental or non-governmental aid agencies. This work is often concerned with water supply, housing or medical related problems.

2. By working on projects in foreign countries on behalf of a home based company under contract to some level of government in the foreign country or to companies, either local or foreign, operating in these countries. Examples of the type of work involved in this area are the design and construction of hydroelectric plants, dams, bridges, transportation systems, and processing plants that support local mining operations.

3. In opening new manufacturing plants in foreign countries, these plants being designed to meet a demand in the home country, and in the training of local workers for these plants. In some cases this will involve the engineer spending significant periods of time in the foreign country while in other cases it will only involve a number of relatively short visits to the foreign country.

4. Implementing modifications to existing products designed for and previously only sold in the home country that will make them acceptable for sale in foreign countries. This may involve modifications to meet differing government regulations and modifications that ensure that the product is socially acceptable in these countries. Work in this area often involves interacting with people in the foreign country who will be selling and in some cases manufacturing the modified product.

5. Working on projects in the home country in which part of the design process will be subcontracted to engineers in foreign countries. Examples of this are the subcontracting of cfd studies to workers in India and the subcontracting of significant portions of the design of new automobiles to engineers in Eastern Europe.

6. In working on complex engineering systems in which large parts of the system are manufactured and in many cases largely designed in a number of different foreign countries around the world. Modern commercial aircraft are examples of this type of activity. Both Boeing and Airbus now have large parts of their new aircraft produced and designed in various different foreign countries.

7. In working for home based companies whose work is largely undertaken in foreign companies. Examples are exploration and mining companies who operate mainly in foreign countries.

This is by no means a complete list of the ways in which engineers undertake work in an international environment. It will also be noted that there is overlap between some of the areas listed above. Of course, work of this nature has long existed but has not involved the majority of practicing engineers as is the case today in many countries.

To illustrate how great the number of companies involved in producing a complex modern system, consider the Boeing 787 Dreamliner. Some of the companies involved in this project include:

- the flight deck and fuselage will be manufactured by Boeing at Wichita,
- the wings and the fuselage fairings will be manufactured by Boeing in Winnipeg, Canada,
- the fin will be manufactured at Frederickson
- the moving leading and trailing edges of the wings will be manufactured by Boeing at Tulsa and at Boeing Australia.
- manufacture of the centre wing box and installation of the wells will be undertaken by Japan's Fuji Heavy Industries.
- the mid-forward section of the fuselage and the fixed section of the wings will be manufactured by Kawasaki Heavy Industries
- the wing box will be manufactured by Mitsubishi Heavy Industries .
- the all-composite nose section will be built by Spirit Aerosystems of Wichita.
- the main and nose landing gear will be supplied by Messier-Dowty of Velizy, France
- the landing gear actuation systems will be provided by Smiths Aerospace
- the electric braking system will be supplied by Goodrich and Messier-Bugatti.
- the pilot controls will be provided by Kaiser Electroprecision
- the common core system (CCS) will be supplied by Smiths Aerospace UK
- the integrated standby flight display.will be supplied by Thales
- the flight control electronics, autopilot and the navigation package will be provided by

Honeywell, of Phoenix, Arizona,
- the mid-section and rear-section of the fuselage including the tailplane will be manufactured by a joint venture company, Global Aeronautica, set up by Vought Aircraft Industries and Alenia Aeronautica
- the cabin lighting, which will include a 'simulated sky' ceiling effect produced by arrays of light-emitting diodes (LEDs) which can change in colour and brightness will be supplied by Diehl Luftfahrt Elektronik
- the passenger doors will be provided by the French company Latecoere
- the nacelles and thrust reverser will be provided by Goodrich
- the primary power distribution system, auxiliary power unit, environmental control system, primary and remote power distribution system and the electrical power generating and start system will be supplied by Hamilton Sundstrand of Windsor Locks Connecticut

Another recent example is the Siemens' share of a contract to supply 100 high-speed trains to China. They will supply a number of components such as various pieces of electrical equipment and the chassis. The Siemens work will be undertaken in Krefeld-Uerdingen, Germany, in Nuremberg, Germany, in Graz, Austria, and in Shanghai, Tianjin and Jinan, China.

There have been a number of studies of methods of bringing international considerations into engineering education, references [1] to [7] being a small sample of typical such studies. Unfortunately many of these existing studies limit themselves to considering only one possible approach. References [8] and [9] discuss various possible approaches.

When discussing the internationalization of engineering education programs other forms of internationalization are often implied. An example is the attempts that are being made to find internationally acceptable evaluation criteria for engineering programs that when implemented would ensure that an engineering graduate from one country would be accepted as having being educated to a standard that allows them to work anywhere in the world without having to take further professional examinations. Considerations such as these are not part of the present discussion.

IMPLICATIONS FOR ENGINEERING EDUCATION

In order to work effectively in an international environment the graduate engineer needs to be able work effectively and productively in international teams. The graduate engineer needs to appreciate and respect the fact that there are cultural differences between countries and that these differences need to be recognized and taken into account when developing and working in international teams. The graduate engineer needs to recognize that engineers in different countries may have somewhat different approaches to engineering and that they may have somewhat different engineering skills. In addition, the engineer must clearly recognize that having a different approach and somewhat different skills does not make these engineers from other countries inferior in any way and, depending upon the job being undertaken, they may in some areas provide an advantage. The engineer should also realize that when working in international teams communication problems can arise that are not connected with language problems but arise from different social behaviour. In working on international projects the engineer should also realize that differing societal needs and differing governmental regulations must be taken into account. It is also important for the engineer to realize that they may have to deal with societies in which the use of bribes and other forms of 'behind the scenes' payments are part of the conventional process of doing business. Dealing with such situations requires the application of high ethical standards but with an understanding of how such situations have arisen. These considerations indicate that some preparation for working in an international environment should be included in engineering programs.

Engineering programs should, therefore, introduce students to the reasons why engineering projects, in so many cases, have become international and also introduce students to the need to be able to work effectively in international situations. Engineering programs should introduce students to the importance of being aware of societal differences that while very important are often very subtle, and should lead to awareness of the problems that may arise when working internationally.

INTRODUCING INTERNATIONAL CONSIDERATIONS INTO ENGINEERING PROGRAMS

There are a number of possible ways of introducing engineering students to the skills and personal outlooks required to work effectively and productively in foreign countries and with engineers and other professionals from other countries. Among these potential approaches are:

1. Have class discussions and student prepared brief reports on the reasons why engineering has become such an international activity.

2. Have students work in project teams that have members from institutions in other countries. While it is desirable for team members to meet in person, much can also be learned from having the team members communicate by e-mail.

3. Arrange to have students spend a period of study or work in a foreign country and arrange to have these students share their experiences with other students upon their return.

4. Have students undertake international development type projects. Projects that require that local societal needs be taken into account are particularly important.

5. Have engineers with experience working internationally address the students and discuss their experiences.

6. Have class discussions of the ethical and other problems that can arise when working internationally.

7. Introduce case studies of problems that have arisen in international engineering projects. Problems experienced by Airbus and Boeing in the development of their newer projects and of the legal problems experienced by a Canadian engineering consulting company in undertaking international projects are examples of the types of cases that can be considered. Case studies of this type can be introduced in a special course on working internationally and/or they can be introduced at appropriate points in standard engineering courses.

The introduction of a course that is concerned with the practice of engineering in an international environment and with the skills required to work effectively in such an environment into the curriculum is one approach to introducing the methods discussed above into an engineering program. This course could include topics such as international cultural differences and their influence on the success of international teams and international ventures. The course could involve a combination of project work, class discussions, case studies and talks by experienced engineers. However, the introduction of such a course should not exclude the discussion of aspects of the practice of engineering in an international environment in conventional courses in the program.

There are a number of potential ethical issues that can arise in the practice of engineering in an international environment. Some of these have already been discussed but others do exist. For example, in times of economic downturn should every effort be made to maintain the operations in the home country if this is at the expense of the international operations that have been established to support the home operation? The ethical aspects of government regulations that favour home operations over international operations in these times can also be considered.

Whatever procedures are adopted to develop student awareness of the practice of engineering in an international environment, the end result should be graduate engineers who are comfortable when working in an international environment, who understand that there are societal and regulatory differences between countries that need to be accounted for in undertaking work of this type, and who are accepting of the fact that different groups may have different strengths and weaknesses.

INTERNATIONAL CONSIDERATIONS IN A CDIO PROGRAM

CDIO, with its international membership and commitment to the development of curricula that consider all aspects of engineering, would seem to be an ideal organization to develop sound methods for bringing international considerations into engineering curricula. Of course, as mentioned before, a number of universities have adopted various approaches to try to internationalize their programs and have achieved varying degrees of success. However, none of these universities has had the benefit of working within an international initiative of the CDIO type which has collaborators from so many different parts of the world

At present the CDIO Syllabus only clearly mentions international considerations in *3.2 COMMUNICATION IN FOREIGN LANGUAGES* and today, this does not by itself seem to be an adequate way of bringing international considerations into the curriculum. Instead it would appear that this area of the Syllabus needs to be updated. It is suggested therefore that CDIO should establish a group that would evaluate what has been done in the area of trying to bring international considerations into engineering curricula and have this group also gather the views of CDIO member institutions on how this should be done. Based on this, the group should produce a set of recommendations as to how best to bring international considerations into CDIO curricula. They should also recommend how the CDIO Syllabus should be modified to more completely reflect the need to bring these considerations into the curriculum.

CONCLUSIONS

With engineering activities being increasingly undertaken on an international stage it appears that it is important to provide exposure to this in engineering educational programs. Some possible methods of doing this have been discussed here. A brief discussion of the need for CDIO to take an active role in developing improved methodologies for bringing international considerations into engineering curricula has also been given.

REFERENCES

[1] Renganathan, V., Gerhardt, L. and Blumenthal, P., "Incorporating global perspectives in U.S. engineering education," Proceedings 2008 ASEE Annual Conference and Exposition, Pittsburgh, 2008, 14 pages.

[2] Shivakumaraiah, L., "Impact of Maroon model on engineering education", Proceedings 2006 ASEE/IEEE Frontiers in Education Conference, San Diego, 2006, pp. T1D 1- T1D 7.

[3] Lehto, S. "Using the systems approach for reengineering engineering education for meeting the requirements of the global industry", Proceedings 2008 ASEE Annual Conference and Exposition, Pittsburgh, 2008, 27 pages.

[4] Masih, R.Y., "Preparing the Civil engineering education and profession for the next century", International Journal of Continuing Engineering Education and Life-Long Learning, Vol. 1, No. 4, pp. 391-398, 1991.

[5] Danielson, S., Hawks, V. and Hartin, J.R., "Engineering technology education in an era of globalization", Proceedings 2006 ASEE/IEEE Frontiers in Education Conference, San Diego, 2006, pp. S1C 20 – S1C25.

[6] Esparragoza, I., Friess, A. and Larrondo Petrie, M.M., "Global engineering education in the Americas: Challenges and opportunities", Proceedings 2008 ASEE Annual Conference and Exposition, Pittsburgh, 2008, 13 pages.

[7] Yeargan, J. and Hernaut, K., "The globalization of European engineering education: An American observer's perspective", Proceedings 2001 Frontiers in Education Conference, Vol. 3, Reno, 2001, pp. S2D 1- S2D 5.

[8] Craig, W.O., "Preparing the Engineering Technology graduate for the global marketplace", Proceedings 2008 IAJC-IJME International Conference, 2008, Paper 198, ENT 208, 5 pages.

[9] Holland, N. and Vasquez de Velasco, G., "The internationalization of undergraduate programs: A model program using reciprocal distance education, traditional study abroad programs and international internships", Proceedings 1998 Frontiers in Education Conference, 1998, pp. 595-599.

Biographical Information

Patrick H. Oosthuizen is a Professor Emeritus in the Department of Mechanical and Materials Engineering at Queen's University. He received his B.Sc., M.Sc. and Ph.D. degrees in Mechanical Engineering from the University of Cape Town and an M.A.Sc. degree in Aerospace Engineering from the University of Toronto. He has published more than 600 technical papers, many of these on engineering education, as well as text books on compressible fluid flow and on convective heat transfer analysis. He has received awards for his research including several best-paper awards, the 2001 Jules Stachiewicz medal for outstanding contributions to research in heat transfer in Canada, and the CANCAM award in recognition of outstanding achievement and technical excellence in thermofluids engineering. Professor Oosthuizen has supervised more than sixty M.Sc. and Ph.D. students. For his undergraduate teaching, he is a 7-time recipient of the Silver Wrench awarded by students in the Department of Mechanical and Materials Engineering at Queen's University and a 3-time recipient of the Golden Apple award from the Queen's University Engineering Society. Most recently he was honoured with the 2007 Queen's Alumni Award for Excellence in Teaching.

Corresponding author

Dr. Patrick H. Oosthuizen
Department of Mechanical and Materials Engineering
McLaughlin Hall, Queen's University, Kingston, Ontario, Canada K7L 3N6
Tel. 01 613 533 2573
FAX: 01 613 533 6489
Email: oosthuiz@me.queensu.ca