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A Global Concentration in Engineering

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Abstract

Globalization of industry and academics has created the need for engineers with a strong international education. To ensure an in-depth global education, Michigan Engineering will build on best practices of existing programs to implement a Global Concentration that takes into consideration the requirements of an engineering curriculum. This paper explores the design, development, implementation, and evaluation phases of the Global Concentration.

Focus will be on five salient features: a) flexibility of the framework to enable all engineering disciplines to be involved b) required international experience c) global engineering course content d) required cross-cultural course for engineers on global understanding e) evaluation mechanisms for the Global Concentration. The program will focus on interactions with China, UK and Mexico due to their competitive importance and existing programs in those regions. The Global Concentration in Engineering will provide future engineering students a solid foundation in international education, and will develop a group of US engineers with global engineering and communication skills.

1. Introduction

Globalization of technology, international operation of industries, global research ventures, global mergers, international communication networks facilitating information flow, global travel, are all factors motivating a focus on educating engineers for a global environment. Practicing engineers are increasingly asked to deal effectively with foreign suppliers, co-workers, and clients. When on global assignments for companies such as Motorola, Ford, GM, Daimler-Chrysler, Procter & Gamble for example, an engineer must possess not only technical skills but also cross-cultural skills based on knowledge of the “other” culture and their own cultural biases. To increase the global competence of the US technical workforce and to train US engineers for leadership positions in the worldwide arena, many US institutions are now integrating international education into the engineering curriculum.

Engineering schools are at various levels for the integration of international education into the engineering curriculum. International exchange programs and international internship programs, specialized summer programs for engineers, short term “cultural discovery” tours, participation in international engineering consortium arrangements such as the Global Engineering Educational Exchange Program (GE3) and the International Association for Exchange of Students for Technical Experience (IAESTE) are some common approaches to international engineering education. The number of student participants varies from institution
to institution ranging from few to more than 200. In developing the Michigan Global Concentration Model, we examined some of the best practices prevalent in US institutions.

Section 2 of this paper describes best practices we have researched. Section 3 presents the model paradigms for Michigan that we have distilled from the best practices. The program details are in Section 4. Following in Section 5 are the development and implementation details. The administration of the program is presented in Section 6 followed by Summary and Conclusions in Section 7.

2. Best Practices

The following programs are cited for the depth of their global involvement in an engineering curriculum. They are listed in no particular order and we make no claim that this list is exhaustive. The authors welcome information on similar programs.

- **University of Rhode Island’s The International Engineering Program**
  Rhode Island’s rationale statement expresses the need for US engineers to be able to “work with peers and partners who view the world through differing cultural lenses,” and the danger of Americans not being able to meet “the qualifications of positions in global firms.” The Rhode Island program in German, French and Spanish is a five-year dual degree program in both engineering and language study. A corporate internship in Europe or Latin America is a requirement for the program. Rhode Island has developed relationships with subsidiaries of foreign firms in the Rhode Island area and with American firms heavily involved abroad for creating the international corporate training program. An advisory board is also established.

- **Worcester Polytechnic Institute’s Global Perspective Program**
  Worcester Polytechnic Institute’s Global Perspective Program emphasizes international team projects involving both faculty and students. Undergraduates majoring in engineering, science, management and liberal arts complete sponsored projects at foreign sites. In 1998-99 half of their junior class participated in projects abroad accompanied by more than 20 different faculty members. Team projects take place in sites such as China, Ireland, Thailand, Switzerland, Italy, Denmark, Melbourne, and Puerto Rico.

- **University of Illinois’ International Minor in Engineering Program**
  The University of Illinois’ International Minor in Engineering Program is a flexible framework that enables all engineering disciplines to participate in the 21 credit hour requirement. Only 12 of the 21 credit hours can be used towards language studies and at least one 300 level political science or economic course must be included. There is also a required study/work abroad experience in the selected region of focus as a fulfillment of the International Minor. Courses taken for the International Minor can be used to fulfill social science and humanities requirements. Regions for focus include Africa, China, France, Germany, Great Britain, Japan, Latin America, Carribbean, Middle East, Russia/Easter Europe, and South/Southeast Asia. Emphasis is on courses in language, history, culture, political science, and economy of these regions. The overseas experience is in the form of study abroad or international internship rather than international team projects involving faculty and students.

- **Georgia Institute of Technology’s Global Innovation for Engineers Program**
The Global Innovation for Engineers Program focuses on Graduate Education and combines a Masters in Engineering or Computer Science with a foundation in international management, cross-cultural communications and teamwork skills. The focus on the global electronics industry allows consideration of the specific needs of the discipline.

- **University of Connecticut’s EUROTECH: An International Program in Engineering**
  The EUROTECH program concentrates on Germany. Its five-year curriculum confers a B.S. in Engineering and a B.A. in German. It offers courses in German that include technical topics, one-credit modules conducted in German on engineering topics, summer internships with German firms in Connecticut, and a six-month internship in Germany.

- **Clemson University’s The Engineering Program for International Careers (EPIC)**
  The key features of the EPIC program is an emphasis on foreign language study which includes a business/technology oriented “summer immersion” program, to provide competency in French, German, Japanese or Spanish. This is combined with at least two work terms of industrial internships at a company’s domestic site and at the overseas site.

- **University of Michigan Engineering Global Leadership Honors Program (EGL)**
  In the EGL program, students select an area of regional focus such as South America, Western Europe or China. Humanities and social science courses must concentrate on this region. These classes span a range of topics including history, economics, and political science. In addition students must complete two years of language study to complete the cultural core. A cornerstone of the program is the team projects where teams of business and engineering students consult for a major corporation. Some of these projects are done overseas in countries such as China, Japan, Mexico, UK, France and Germany. Like the Georgia Institute of Technology program, this program has concentrated on a single discipline, manufacturing in this case.

Many important factors emerge from this study–some common to all programs and others unique to a specific program. All the programs place an emphasis on the overseas learning experience. The international industrial internship experience is a common feature to all the programs. Variations of the industrial internship program range from an independent internship in an industry abroad, to two work experiences in the same company (one at the domestic site and the other at the international site) to team projects involving global teams working together at an international location. Connecticut’s EUROTECH program brings out the value of linking with international companies in the state. Georgia Institute of Technology’s Global Innovation Program and the University of Michigan’s Engineering Global Leadership Program illuminate the value of discipline focus. University of Illinois’ flexible framework in the International Minor in Engineering Program enables all engineering disciplines to participate. Foreign language, cross-cultural and global communication studies emerge as important factors for providing engineers with global education to complement their technical education. The University of Michigan’s Engineering Global Leadership Honors Program shows the value of inter-disciplinary team projects. Observations from the exploratory study of these existing models proved to be an invaluable resource for designing the Michigan Global Concentration.

3. **Michigan Model for Global Engineering Education**

Based on the benchmarking and experience with the Engineering Global Leadership Program we established a set of design paradigms for the program.
3.1 Audience

An important design issue is target audience. As we saw earlier, some successful programs are flexible enough to address a wide student population, while others narrow to a specific discipline or language. We choose to address a large audience, as in the Illinois model. The Engineering Global Leadership Honors Program already exists for manufacturing, and our desire is to expand on lessons learned from that and other benchmarked programs to support a broad subset of the student body.

We originally hoped to include undergraduate and graduate students in the model. However, only the undergraduate program provided the flexibility necessary to achieve the richness of experience that we wanted. As a result, we have chosen to address the program to all undergraduates in the College of Engineering.

3.2 International Experience

All successful program include a required overseas experience. This experience can be garnered from study abroad programs, internships abroad, or team projects abroad. The ideal situation would be team projects as developed by the Tauber Manufacturing Institute. However, we do not believe that there will be sufficient spaces available in those programs to place all students from the Global Concentration. The established study abroad and internship abroad program allow us to scale up numbers.

3.3 Required Language

The objective of the language requirement is to break students out of the parochial thought processes common to most Americans. Industry executives we interviewed stated that rarely does a student’s specific language background prove useful. If they learned a second language, they are likely sent to a region where that language is not spoken. Nearly all business is conducted in English. However, they also state that having a second language makes the student more likely to work well in any other culture. For this reason we will require basic language skills of all students in the Global Concentration.

3.4 Regional Focus

We chose to focus on three regions of competitive importance to the US. We limited the regions to allow substantive interaction with partner schools and industries in those regions as is done in the University of Rhode Island model. The selection of regions is based on importance to the future economy, current Michigan relationships, and a diversity of opportunities for students. The regions selected are China, Mexico/Latin America, and the United Kingdom.

China: With nearly 25% of the world population, and one of the world’s oldest civilizations, China in recent years has attracted foreign investments. Major joint ventures are being formed with some of the world’s largest companies such as GM, Ford, GE, IBM, Boeing, Coca-Cola,
and Motorola. The University of Michigan College of Engineering has close partnerships with Shanghai Jiao Tong University and the Hong Kong University of Science and Technology. With the rising momentum of US interest in China and our close partnership with two major institutions, China is a natural choice.

**Mexico:** Geography and economy tie Mexico to the US. The North Atlantic Free Trade Agreement (NAFTA) has brought new challenges to US industrial cooperation with Mexico. In addition, a vast majority of US students take Spanish in high school and a Global Concentration leading to an expertise in Mexico will create a corps of technologists serving the needs created by the NAFTA Agreement. Michigan experience with the Engineering Global Leadership Honors Program indicates a strong interest in Latin America as a cultural core. Through the Global Engineering Educational Exchange Consortium (GE3) and Michigan faculty involvement, Michigan Engineering has developed a relationship with ITESM (Instituto Tecnologico y de Estudios Superiores de Monterrey).

**United Kingdom:** The University of Michigan is working with the Scottish government to establish a continuing education center near Edinburgh. If successful, the center will be a hub for the University of Michigan in Europe and will provide continuing engineering education and technology transfer for the European community. The selection of the UK will provide a base for global learning opportunity in Europe for US students and will enable US students with only English as the primary language to attain global knowledge about European technical and business practices.

### 3.5 Relation to Engineering Requirements

The success of the Global Concentration depends on the support of the faculty. This support requires that it not displace technical requirements of the engineering programs. In 1996 the College of Engineering began a process to overhaul its undergraduate curriculum in all fields. One result is that all majors have 16 credits of humanities and social science requirements, and 12 credits of free electives. The Global Concentration is designed to fit within these 28 credits. It does not impinge on technical requirements and provides the student with a coherent structure for their humanities/social science and free electives.

### 4. Program Details

Beginning in Fall 2001, undergraduate students in the College of Engineering have the option of doing a Global Concentration in Engineering. Note that electing the Global Concentration is optional; not a degree requirement. A Global Concentration in Engineering will be engaged simultaneously with a student’s engineering degree.

The following 10 criteria were proposed as Global Concentration requirements for admitted students (currently subject to approval):

1. Each undergraduate student wishing to complete a Global Concentration must declare the selected region (China, Mexico, UK etc.) and develop a plan for the Concentration in consultation with the designated Global Concentration advisor and the undergraduate departmental advisor.
2. An audit sheet will be assigned to each student to track progress until completion of the program. Upon completion of the program the audit sheet will be signed by the administrator of the global concentration, the departmental undergraduate advisor, and the assistant dean responsible for undergraduate student records.

3. The complete requirement for a Global Concentration is 28 credit hours of course work at home and abroad + study/internship/team project abroad.

4. Advanced Placement credits may not be used to fulfill the 28 credit hour requirement for the Concentration. They can be used to determine selection of student’s courses (e.g. if a student’s AP credits indicate that he/she has had 2 years of college equivalent Spanish, he/she can select courses other than language).

5. Of the 28 credit hours; 8 credit hours (2 courses) are to be on language study and 8 credit hours (2 courses) must be upper level or 300 level courses.

6. The 2 credit hour course on cross-cultural understanding is a requirement for the Concentration.

7. Students can fulfill the 8 week international experiential learning through studying abroad, an overseas industrial internship or overseas team project.

8. The term “Global Concentration” will appear on the student’s transcript.

5. Program Development

Major tasks involved in development of the Global Concentration include:

- Assessing global course work available at Michigan and from foreign partners
- Development of the required cross-cultural course
- Development of the international experience program
- Evaluation mechanisms

5.1 Selection of Global Courses

When selecting the courses for the global concentration, we used the following guidelines: Our recommended courses selected from the home institution and our partner institution abroad should enable a student to fulfill his/her humanities, social science, free elective and technical elective requirements. Furthermore, to prepare students for the global industry-specific to their field of interest, a wide spectrum of courses dealing with global energy, manufacturing, business, communication, and language were selected. The following course samplings from our China section will give an idea of the rich resource of courses that are available for our students. The same methodology of course compilation for our students will be applied to our focus areas of UK and Mexico.

The following section gives an idea of the wide selection of courses that we found to be available for providing global education to engineers

Recommended Courses: University of Michigan
Language: There were close to 30 courses being offered at the University of Michigan on the Chinese Language. Courses include:

Cultural, Political Science and Economic Courses: Recommended courses from the University of Michigan course offerings included:


5.2 Developing a Cross-culturalization Course for Engineers

An integral component of the Concentration will be the development of a cross-cultural course on global understanding for engineers. The course content is described in Table I. Initially the cross-cultural course will be offered as a 2-credit-hour course.

<table>
<thead>
<tr>
<th>Table 1: Cross-Cultural Preparatory Course for Engineers (2 Credit Hours)</th>
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<tbody>
<tr>
<td>I Globalization of Technology</td>
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<tr>
<td>• Importance of global experience for engineers—Academic, Industrial and Government Perspective</td>
</tr>
<tr>
<td>• China, Mexico and UK: Why these regions are vital from the global technical point of view</td>
</tr>
<tr>
<td>• Overview of US and foreign industries in China, UK and Mexico: Regional importance in</td>
</tr>
</tbody>
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the global economy and current US policy for cooperative/competitive ventures in the three regions.

### II People, Culture and Academic/Business Practices
- Selected video presentations on people and significant aspects of these regions relevant to technologists. (e.g. Confucianism, Taoism; The European Union Today; NAFTA)
- University systems in China, UK, Mexico: A Comparative Study with US Higher Education Systems. Focus on Differences and Similarities
- Business culture in China, UK and Mexico—Significant Differences
- The practical living experience—Telephone, Transportation, Health Systems, Currency and Banking System

### III US Culture: “Know Thyself”
- What does it mean to be an American? Understanding US culture before entering another cultural dimension

### IV Phenomenon of cross-cultural Refraction
- Definition of cultural refraction as the change that inevitably occurs when we move from one cultural dimension to another
- Student and faculty experiences will be analyzed to illustrate the change

### V Global Philosophy and Global Engineers
- How to learn from other cultures
- Attributes of the Global Engineer: US leaders with Global skills (Invited speakers—corporate/government/academic leaders in global leadership positions will be invited to give invited lectures

Taking into consideration the global course content, the required cross-cultural course and the overseas industrial experience, a sample program for the Global Concentration in Engineering may be as seen in Table II. The special engineering field of the student in this sample is Automotive Engineering.

#### 5.3 International Experience

An integral component of the concentration is the international academic or industrial team experience. The site of the international learning experience for our students will be at our selected peer institutions abroad and at the overseas sites of our industrial partners. For our academic experience abroad, institutions in China, Mexico and UK were selected based on our institutional relationships. For China, it was Shanghai Jiao Tong University and the Hong Kong University of Science and Technology; for Mexico, it was Instituto Tecnologico y de Estudios Superiores de Monterrey (ITESM); for UK, it was Imperial College, Bristol University and Manchester University in addition to our new ties with Scottish institutions.

For industrial internship positions we formed close ties with the International Association for Exchange of Students for Technical Experience (IAESTE) and AIESEC. Both IAESTE and AIESEC have student organizations at the University of Michigan.

These organizations encourage student participation in international industrial internships and to foster a close link to the national organizations,
For industrial team projects we looked to the Tauber Manufacturing Institute. The Tauber Manufacturing Institute at the University of Michigan conducts summer team projects as a required experience for a 150 student program. During the summer, students participate in a 3.5 month, paid, multidisciplinary team project where students and faculty teams work at a company site to solve substantial manufacturing challenges. The projects are designed to complement classroom learning with practical experience. The intent is to have students with different strengths working together to increase the team’s ability to meet diverse challenges and allow the students to learn from one another, integrating business and engineering skills on the job. A pair of faculty advisors mentors each project team and regularly visits the industry site. Combining the complementary skills and talents of different students, and supplementing these combinations with faculty support results in powerful teams capable of solving problems relating to current issues facing industry today. Each year a number of projects are located overseas with examples in China, Mexico and UK as well. They are often facilitated by cooperation with US corporate partners such as Ford, GM, Alcoa, Allied Signal and Leybold. Our strategy was to build on the experiences of the Tauber Manufacturing Institute and to utilize their expertise in setting up global teams.

5.4 Sample Curricula

Table 2: Sample Program for the Global Concentration in Engineering  
(Focus Interest: China/UK/Mexico)  
Special Engineering Field (Focus interest: Automotive Engineering)  
28 credit hours (Location: Home and Abroad) + Overseas Industrial Team Project

<table>
<thead>
<tr>
<th>Semester Courses (16 credits at University of Michigan)</th>
<th>Semester Courses (12 credits at Shanghai Jiao Tong University (China), Monterrey Tech. (Mexico) or Herriott Watt (UK))</th>
<th>Industrial Team Project with US Auto Industry in China, Mexico and UK</th>
</tr>
</thead>
</table>
| • Required Cross-Cultural Preparatory Course for Technical students (2 credits) | • Two approved courses (tech. elective or free elective) beneficial for Automotive Engineering students to be taken in China, Mexico or UK (8 credits) | • Summer industrial Team project with e.g. GM or Ford in China, Mexico or UK or with a major Chinese/Mexican/English industry  
  Or  
  • International internship placement in China/Mexico/UK through IAESTE or AIESEC |
| • Two language courses in Chinese, Mexican (6 credits) | • Hands-on laboratory experience (1 credit) | |
| • Chinese/European/Mexican Technology Management (4 credits) | • Chinese/Mexican/European Civilization Course (3 credits) | |
| • Manufacturing in China, UK and Mexico (4 credits) | | |
In a similar vein, students in Chemical Engineering, Environmental Engineering, Biomedical Engineering etc. can individualize their Global Concentration curricula to conform to the global training needed for their particular discipline.

5.5 Dissemination and Evaluation Phases

For dissemination purposes, a handbook on the Global Concentration Program is currently being prepared. The handbook will contain a syllabus for the Global Concentration in different engineering disciplines in the three regions—China, UK and Mexico. It will contain a section on the Requirements for the Concentration, application procedures and information on institutional/industrial sites abroad for academic and industrial team projects. The material will also be circulated through our Web site. A long-term plan will be to create a CD-ROM version of the University of Michigan’s “A Global Concentration in Engineering” Program. Dissemination of the model will be made through presentations at professional society meetings such as the American Society of Engineering Education (ASEE), National Association for Foreign Student Administrators (NAFSA), and the American Society of Mechanical Engineers (ASME).

To ensure the success of the Michigan model, an evaluator will monitor, assess and evaluate the program for planning, designing, implementing and evaluating. Evaluation was seen to be an integral part of Global Concentration activities. Documentation of activities leading to the development of the concentration and the various courses and experiences that comprise it was considered to be important. Documentation of how students grow as a result of their concentration experiences was also considered to be vital. Various techniques and approaches to classroom assessment and evaluation will be employed in the courses and workshops to be developed. These techniques will be drawn from the growing body of work on the scholarship of teaching. A formal review and evaluation of the products (such as the proposed handbook, syllabi, and CD-ROM based materials) will also be undertaken. In implementing the evaluation, a number of approaches will be used. Regular and on-going surveys (and tests) will be developed and fielded. Individual and group interviews of students and faculty will be undertaken as well. Given that the participants will be dispersed geographically during the educational program, a number of Internet-based approaches to data collection will be employed. These will likely include web-based survey approaches, as well as Internet facilitated interviewing. Another tool could be essays and journals written by the participating students. Care will be taken to see that the evaluation and education activities are synergistically integrated where possible.

6. Administration

6.1 Operation of the Concentration

The Administration of the Global Concentration will be done by the College of Engineering Advising and auditing of the Global Concentration requirements will be done by the Director of International Relations and Education in cooperation with chief undergraduate departmental advisors. Admission to the Concentration will be handled by the International Programs Office. International Programs Office will support engagements in China, Mexico and the United
Kingdom. Students may elect other regions with permission of the program, but will be responsible for all relationship building themselves.

6.2 Admission and Selection of Students

We will propose the following admissions guidelines.

1. A student must have completed at least one term at the University of Michigan College of Engineering to be eligible to apply.
2. A student must earn an overall GPA of 3.0 to be eligible for the concentration and this GPA must be maintained throughout the program.
3. A student may fulfill the overseas experiential learning requirement at any time following the sophomore year.
4. The target number for the first batch of students for the academic year 2000-2001 is eighteen. Students will be selected based on the strength of the application and an interview by a committee.

7. Summary and Conclusions

In the Global Concentration in Engineering, students gain knowledge about the language, culture, economy, business practices of China, Mexico and UK. Through their overseas experiential learning they gain knowledge of Engineering in another cultural dimension and/or of a foreign educational system. They learn to distinguish subtle elements like how culture may affect decision-making and professional behavior in an engineering environment. Hands-on experience in an industrial setting in a foreign country gives students a taste of future international assignments.

Acknowledgement

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Bibliography

1. URL: http://www.uri.edu/iep; University of Rhode Island: International Engineering Program.
2. URL: http://www.wpi.edu/Academics/Depts/IGSD/Projects/Washington;Worcester Polytechnic Institute: Global Perspective Program.
3. URL: http://www.engr.uiuc.edu/international/minor; University of Illinois: International Minor in Engineering Program.
4. URL: http://www.ece.gatech.edu/academic/gie; Georgia Institute of Technology: Global Innovation for Engineers Program.


6. URL: http://www.ces.clemson.edu/global/EPIC_Introduction; Clemson University: The Engineering Program for International Careers (EPIC).


8. URL: http://tmi.umich.edu; University of Michigan: Tauber Manufacturing Institute.

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