MECHANICAL ENGINEERING PROGRAM AT THE UNIVERSITY OF GUANAJUATO IN MEXICO

Jerome H. Hemmye
Western Michigan University
Kalamazoo, MI.

Luz Antonio Aguilera
FIMEE
University of Guanajuato
Apdo. Postal 215-A
Salamanca, GTO, Mexico
36730
Tels. 4 648-0911
Fax 4 647-2400

ABSTRACT
Gold and Silver mining was begun in Mexico within fifty years of the Spanish conquest. The Mining Engineering and the Chemical Engineering needed to extract those valuable metals from the ore have been taught in Mexico from those early colonial days. To meet the colony’s needs for roads and structures, Civil Engineering followed as an academic discipline. Textiles and much later petroleum extraction and refining followed as important industries and they too were included in several Mexican university programs.

The gradual industrialization of what is now Mexico brought with it a critical need for engineering education on a broader scale than was traditionally available.

Less than forty years ago there was no Mechanical Engineering program in the State of Guanajuato, Mexico. The immediate needs of a Federal Oil Refinery and a Fossil Fuel Power Plant led to the establishment of a modest program utilizing practicing engineers as faculty, on loan part time, from the refinery.

The evolution of the program from its earliest days is traced to the present program which includes a doctoral program which is rated among the top three public programs in Mexico.

INTRODUCTION
To comprehend the current state of Mechanical Engineering Education in Mexico an examination of the evolution of the Mechanical Engineering program at one of the leading universities in Mexico may prove helpful, particularly to those international companies planning operations in Mexico.

On the first day of October, 1732 Jesuits officially established what is now the University of Guanajuato. It remained an ecclesiastical University until 1867 when the establishment became a National College. Secular topics including Mining Engineering and Civil Engineering had long been taught since there are many silver and gold mines near or under the capital city. The name was changed to The University of Guanajuato in 1945. It was from these roots that the Engineering campus currently located in the city of Salamanca grew.

It was not until the middle of the last century that any sizeable industry existed, other than Mining and Construction.

NOMENCLATURE
- ABET, Accreditation Board for Engineering and Technology
- CENEVAL, National Center for Higher Education Evaluation
- CFE, Federal Electrical Commission
- CONACYT, The Council on Science and Technology (Mexican)
- FIMEE, The Faculty of Mechanical, Electronic and Electrical Engineering
- ITSEM, Monterrey Technical Institute
- OEA, Organization of American States
- PEMEX, Mexican National Petroleum Organization
- UNAM, the National Autonomous University of Mexico

INDUSTRIALIZATION
Early in the twentieth century long time president Porfirio Diaz encouraged foreign industry to establish facilities in Mexico. While generally good for the economy, these “satellite” industries imported to Mexico their own engineers. In the late nineteen fifties and the early sixties the Mexican
Government essentially nationalized the basic industries and the producers of basic products. [1]

While a number of young Mexicans from wealthy families were studying abroad, few chose to study engineering until the nationalization created a need for technicians and engineers at home. Recognizing the limited supply of Mexican engineers, the director of the now nationalized petroleum refinery located in Salamanca, Guanajuato encouraged his lead engineers to form a school to train candidates for employment in the refinery.

EARLY DAYS

In 1961, the director of the PEMEX refinery with a group of engineers made serious plans to establish a special school to train the engineers needed to run the refinery and the neighboring fossil fuel power plant. At that time, little attention was given to the broader need for engineers in Mexico. By 1964 the plans had progressed to the point where comprehensive entrance examinations were given to 50 of the brightest prospective students for the school. From this group the candidates with the very best qualifications were selected. The first student body consisted of 23 candidates, including two women. It is interesting to note that women are still an important component of the student body.

At that time, the faculty was made up of practicing engineers from the refinery who were released to teach part time. Classes were taught in the facilities of a secondary school, after regular school hours. The curriculum was heavily oriented toward mathematics and applied sciences with the schedule based on a yearly program, five years in duration.

ECONOMICS AND POLITICS

In 1967 financial problems at PEMEX forced the refinery to reconsider its support for the nascent institution and the faculty approached the University of Guanajuato for financial assistance. An additional problem was the need for more adequate facilities than those provided at the secondary school. The University petitioned the President of the Republic for financial aide and for the funds necessary to construct a campus. [2]

As part of the plans for the Salamanca campus, the school received about 6,250 square meters of land from PEMEX. An additional 8,750 square meters were recently (1999) added to the land in Salamanca. Meanwhile, the University authorities made some efforts to move the Mechanical and Electrical programs to the state capital of Guanajuato City. The pressure to move was relieved when PEMEX noted that the refinery was a grand laboratory where practical experience in all fields of engineering could be taught.

ADMINISTRATION

One of the Mechanical Engineering students who graduated from the program in 1969 returned from graduate studies in UNAM with his MS degree and was named director of the school. Over the years, Arturo Lara has played a seminal role in the maturation of the program. [3] Lara, returned to the United States for his doctoral degree in 1980, and has subsequently served three terms as director for a total of 15 years until 1991 when he was chosen to fill a University post equivalent to that of provost.

Other young Mexicans were selected to study abroad with the intent of building a full time, well trained faculty for the program. In fact, several of the students have returned to the campus with masters and doctors degrees and became leaders. One, Dr. Jose de Jesus Razo replaced Dr. Lara as the director of the faculty.

The program of support for outstanding advanced degree candidates is still administered by CONACYT. Because of the success of the CONACYT sponsored study abroad, and the lessened demand for faculty due to the now available supply, the number of those being supported has diminished. Many of the newer faculty members at FIMEE are now graduates of Mexican Universities. The reduction in the numbers is also likely due to the current economic conditions in Mexico.

PROGRAM DEVELOPMENT, BACCALAUREATE

There are few records preserved for the first several years of the program. It is clear that the emphasis was on mathematics and the sciences, in addition to the essential applied mechanical engineering courses.

In a short time, Federal and University of Guanajuato regulations brought modifications to the content although, in contrast to the few other schools addressing engineering, there remained a strong emphasis on mathematics, both theoretical and applied. [3]

The early program was based on a five year schedule of study which was later (1976) reorganized into a trimester curriculum. Three trimesters of study are taught in a year. This plan is not to be confused with the quarter system where a normal academic year consists of three quarters of work. Nominally, four and one half years of academic study are required to complete the course work.

Admission to the program continues to be based on the applicant’s performance on the rigorous entrance examination. Factors such as need, family relations, or political connections were, and are still given no consideration, contrary to some North American impressions.

The present program of classes in Mechanical Engineering conforms to the ABET specifications for 2003-2004 quite closely although there is no currently declared intent to seek accreditation. This conformity should provide some comfort to industries planning expansion to Mexico.

The following table, taken from the Plan of Studies for Mechanical Engineering [4], details the classroom hours and credits involved in the six general groupings of material used at the University. This new curriculum was initiated in the autumn of 1999.
Note that the current ABET guidelines call for “one year of a combination of college level mathematics and basic sciences…”, “one and one-half years of engineering topics, consisting of engineering sciences and engineering design…”, “and a general education component…” [5] The general education component of the ABET requirements is less well defined than the other requirements, yet the Mexican national requirements for this component are easily met.

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Classroom hours</th>
<th>Trimester Credits</th>
<th>Semester Credits (equiv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Sciences</td>
<td>800</td>
<td>145</td>
<td>48</td>
</tr>
<tr>
<td>Engineering Sciences</td>
<td>935</td>
<td>182</td>
<td>60</td>
</tr>
<tr>
<td>Applied Engineering</td>
<td>760</td>
<td>138</td>
<td>28</td>
</tr>
<tr>
<td>Engineering Specialization</td>
<td>120</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>Social Sciences and Humanities</td>
<td>180</td>
<td>36</td>
<td>7</td>
</tr>
<tr>
<td>Interdisciplinary &amp; Administration</td>
<td>180</td>
<td>36</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>2975</td>
<td>561</td>
<td>187</td>
</tr>
</tbody>
</table>

Table 1
Mechanical Engineering Subject Material Distribution

There are 2975 classroom/laboratory hours and 561 trimester credits required in the program. This is the equivalent of 187 semester hours (over 50 credits more than most North American Universities require.) This table demonstrates in excess of a year of college level mathematics and basic sciences, almost two years of engineering sciences and design, plus a general education component. The Interdisciplinary and Administration table entry can also be used towards satisfying a general education component. The program nominally requires four and one-half year for completion which is practically identical to that encountered in most Mechanical Engineering undergraduate programs in the rest of North America. Typically, not all student complete their program in four and one half years. The capstone course is quite rigorous and tends to require more time than is allotted.

There are four program options in the curriculum: Mechanical Design, Dynamics. Manufacturing, and Thermo fluids. A fifth option, Mechatronics, mentioned later, will be added to the selection next academic year.

**PROGRAM DEVELOPMENT, GRADUATE**

The masters program was initiated at FIMEE in 1975. The objective of the program [3] was “…to develop human resources with experiences in research and development technology that will contribute to the solution of real problems, at both the regional and the national level.” At that time, the University recognized the national role it must play.

Initially, the graduate faculty included MS and PhD faculty, part time, from UNAM as well as newly returned graduates from graduate programs outside Mexico. Financial support for this stage of development came from CONACYT (Mexican) and OEA (International) sources. Until the introduction of the graduate program at FIMEE, only UNAM in Mexico City and ITSEM in Monterrey had postgraduate programs in engineering. [7]

In 1987 the doctoral program in Mechanical Engineering was initiated under the guidance of Dr. Arturo Lara, by that date there were a sufficient number of the faculty with doctoral degrees to support the program. Several of the current faculty at FIMEE are products of that initial class of candidates.

While there are a number of graduate students in the program with undergraduate degrees from FIMEE, most students are from other states, with a few international students as well. A large fraction of the graduates from the advanced studies programs return to their home state to teach in universities there. FIMEE is providing faculty with advanced degrees for other Mexican universities as an alternative to sending their faculty abroad for graduate study. In many cases, graduate classes are arranged so that teaching faculty can travel to the campus from near-by states while doing advanced degree studies.

**RESULTS**

Success is measured through the success of the product. The product is the individual graduate. It is extremely difficult to make an objective evaluation of the alumni for many reasons. Anecdotal evidence of success is, however, abundant.

In general terms, graduates of the bachelors program have been sought by Mexican Universities and industry as well as international industrial employers. Students who have applied for graduate study in Mexico as well as at overseas universities have been almost universally accepted.

For example, a US based international company hired a BS student who had done an internship with them. After graduation, he was almost immediately placed in charge of the mechanical systems within the local plant. In a short time the home office was calling on him to solve mechanical problems in operations in South America as well as in the United States. He is now based in Florida and is responsible for all new plant construction as well as revisions in the southern hemisphere, including Africa.
At the other end of the scale, a doctoral graduate who completed his doctorate at FIMEE now holds a middle management position with a US Space related operation in California. (He was born in the United States where his parents were doing graduate study.) He has provided a number of internships for FIMEE graduate students in the agency where he works. 

Already cited, one of the first graduates from the program (Dr. Arturo Lara) is now the director of the Guanajuato State Council for Science and Technology, after serving as dean of the FIMEE campus, and later as Provost for the University of Guanajuato.

Several years ago, as a result of a nation wide CONAYCT examination in competition for scholarships, one MSME student from FIMEE placed number two out of over 870 competitors. [7] He is now finishing his Doctoral program at Manchester. Furthermore, another MSME student from FIMEE placed fourth in the same examination. He is finishing his Doctoral program at Western Michigan University. Incidentally, both men plan to return to Mexico, hoping to teach and share their expertise locally.

In 1987 the MSME post graduate program at FIMEE was recognized at the best in the country by CONAYCT. The Masters and the Doctoral program are on the CONAYCT register of outstanding graduate programs. [7]

Over the years, FIMEE graduates have frequently held first and second place in the national examinations sponsored by CONACYT and CFE at the BS as well as at the MS level. In addition, the two highest scores achieved to date in the examination sponsored by CENEVAL (similar to the GRE) were earned by graduates of the FIMEE Mechanical Engineering program.

In October 1999, the journal Contenido [8] published an article in which the four most distinguished Mexican public universities with world class programs were examined. The Mechanical Engineering program at FIMEE was recognized as “outstanding”.

An international corporation established an advanced design unit in a nearby city. They promptly hired six recent doctoral graduates as well as three or four masters graduates, several of whom were temporarily assigned to New York State where they were given additional specialized training.

Currently there are six FIMEE graduates doing advanced studies in the United States of America, three studying in the United Kingdom, one in Canada, two in France, one in Spain, and one in Japan. This is total of at least 16 students who are continuing their studies outside Mexico. There are currently ten students who are working on their MS program at FIMEE. The number of FIMEE graduates studying at other universities in Mexico is unknown. It is estimated that approximate 15 percent of the students in Mechanical Engineering at FIMEE go ahead for advanced studies.

**FINAL OBSERVATIONS**

Not unlike higher education programs around the world, FIMEE suffers from chronic budget problems. The cost of text and reference books is a constant concern. While politicians seem prepared to finance buildings they are reticent about furnishing funds for maintenance and furnishing laboratories. In spite of these difficulties, FIMEE has been able to maintain its reputation among Mexican and international employers.

FIMEE has shown great foresight in establishing excellent computer facilities for both faculty and students. This has resulted in continuing the traditional emphasis on high level mathematical analytical skills and “virtual” laboratory work where suitable equipment is not available. A continuing effort to expand and improve library resources has considerably expanded the holdings. One of the current requirements for graduation is the donation of a suitable reference book to the library.

In the past there was a tendency to use graduating engineers in positions of administration on the production lines. There is evidence of wider use of entry level engineers at a higher level of engineering competence by industry in Mexico. The situation is similar to that common in North America a decade ago.

A subsequent paper will present a discussion of the newly established “Mechatronics” program which involves the Mechanical Engineering and the Electronics Engineering Departments at FIMEE. This new effort is in part an answer to industrial demand for expertise in this arena.

**ACKNOWLEDGMENTS**

The authors would like to express their appreciation to René Rivas, current dean of the FIMEE faculty for his cooperation. To Dr. Arturo Lara for sharing some of his experience and data concerning the program. In addition, we wish to recognize Manual del la Torre and Dr. Eduardo Aguilera for the support, data and observations they have provided.

**REFERENCES**

[2] Archives of the University of Guanajuato, February 12, 1971