Global Engineering Education Trends and Their Impacts on Brazilian Engineering Programs

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Introduction

There have been strong evidence and discussions about the need to redesign engineering curriculum in many countries throughout the world. For example, Landis[1] suggests a future in which most engineering tasks will involve the development and use of automated design tools, by both engineers and technologists. Hill[2] argues that the current system of engineering education was established with "old-era" industrialization as the framework for engineering and manufacturing, and that to meet the needs of the new era, a transformation of the curriculum is needed. As recognized by several authors (e.g., Kulacki and Vlachos[3]), the coming of the post-industrial society will further increase the demands for a flexible curriculum capable of adapting to quickly changing circumstances and to the requisites of a predominantly information-based culture. Of course the processes of curricular reform must encompass aspects beyond the older narrow curricular issues such as number of credits, disciplines, areas of specialized training, etc. As was pointed out by the National Science Foundation[4], there is a consensus that all aspects of engineering education should be reexamined, including the learning and teaching processes, the learning environment, the effectiveness of engineering education, the preparation of students for lifelong learning, and the use of technology in education. Based on these broader concerns, this paper will present some recent influences of the discussions and trends in engineering education that have been occurring in developed countries (DC) over the processes of curricular reforms that have been taking placing in Brazil. With the aim of better understanding the ideas to be discussed, a short explanation of the framework the Brazilian engineering education system will be presented.

The 'Brazilian Engineering Education System

Brazilian engineering education has traditionally been influenced by developed countries. In a first stage, from the second half of the nineteenth century up to 1950, the major contributions to Brazilian engineering programs has originated in Europe, especially France. Therefore, nowadays there are still some similarities between Brazilian engineering programs and European engineering programs, such as the five years required to complete the curriculum; the emphasis on a strong scientific foundation, etc. But primarily during the last three decades, the U.S. engineering education model has had a major impact. This situation can be explained by the origin of several professors and the education of others in the US. Some groups of those professors assumed leadership positions at top universities, and in government and official research agencies. Thus, many Brazilian scientific and educational policies were based on American experience.

In Brazil around 40% of total enrollments at the undergraduate level is publicly owned. The majority of the institutions which adopted the "research university model" is found in the public education system, which also accounts for the graduate programs throughout the country. In the last **30** years, two important government actions had a great influence on engineering education system. An official university reform was established in 1972 by the Ministery of Education and was implemented throughout the public education system. This reform adopted the credit system and the semester period, and offered to students the possibility of choosing to register in a whole spectrum of disciplines. Another significant impact of that reform was a change from the centralized administration of programs to a departmental structure. Since that time there has been a significant growth in the emphasis on scientific and technological research in the Brazilian universitary system, usually coupled with the creation of graduate programs.

Another major shift in Brazilian engineering education occurred after the publication of a resolution by the Federal Education Council in 1976. This resolution defined major groups of disciplines in the engineering curriculum, encompassing the basic sciences, the sciences of engineering, the professional disciplines of each engineering speciality, and the disciplines of general training. Six large engineering areas were established, part of the curriculum concerned with the basic sciences, sciences of engineering and disciplines of general studies common to all of them. The minimum total number of hours required for each group of disciplines, including laboratory practice was also defined. Between 1977 and now this curricular model has been adopted by engineering colleges as a whole in Brazil. The standard minimum curricular requirements have established a total number of 240 credits (3600 hours) for the Brazilian engineering programs. As a result, each engineering program has little option to introduce specific subjects of its own interest, since it would require more credits beyond that already high number.

Within the context of the educational framework described above, several curricular reforms have occurred since 1990 in some well-known Brazilian engineering programs. Despite the small number of experiences selected for discussion herein, those engineering colleges represent important models for engineering education and have been copied by other programs throughout the country.

International Trends in Engineering Education and its Impact on Brazilian Engineering Programs

In our view, the main issues concerning the modern educational reforms that occurred in undergraduate engineering courses in DC were based on recognizing problems in the following critical areas:

1) the adequacy of the traditional eight semester curriculum, an issue often discussed in the U. S.;
2) the difficulties in finding a compromise solution between analysis (scientific emphasis) and synthesis (design emphasis) in the curriculum;
3) the difficulties of students with introductory disciplines like calculus, chemistry and physics;
4) the compartmentalized curriculum, which lacked an interdisciplinary content;
5) not enough, if any, industrial practice and experience embedded in the curriculum;
6) insufficient hands-on and laboratory experience in the curriculum;
7) absence of societal factors, especially those concerning ethnic and cultural diversity;
8) student lack of adequate communication skills upon graduation;
9) difficulties in strengthening extra-engineering training, such as that related to managerial, ecological, social and political areas;
10) lack of support and incentives for faculty teaching at undergraduate level;

Some of these critical issues also occur in Brazilian engineering programs, which is easy to understand since we have adopted university models which are similar in many aspects. Of course, each engineering college has followed its own path to surmount the critical problems presented earlier, which has resulted in a series of proposals and documents reporting these experiences. Despite the diversity, there are some common proposals . that constitute general trends.

‘¯Firstly we realize a strong international trend towards a broadening of the education proposed for engineering students. For example, in 1980 the American Society of Mechanical Engineers reaffirmed goals “to broaden the horizons of individual engineers and foster effective means by which they may relate their work and talents to the interests of society.”

A report of the American Society of Civil Engineers[5] emphasizes that “the degree must provide a balance between those skills which enable the civil engineer to handle the complex, scientific, and technological aspects of the profession and those skills which enable the civil engineer to set policy, act as the entrepreneur, and be the organizational leader of the engineering process.”

Similar concerns appears in Europe, as suggested by Drewes and Romisch[6]. They understand that basic and general training at the university level should be designed as broadly as possible to ensure that a speedy acquaintance with different subjects is possible, thus recognizing that the aim of a university is not to train specialists at that early stage of education (undergraduate). The responsibility to society and environment is . considered a major concern in future-oriented educational programs.

These trends towards the general education of engineers can also be seen in the recent curricular reform processes in Brazilian programs. But several difficulties have arisen in too many aspects. The first relates to the problem of how to allocate new credits to an already fill curriculum. As stated previously, in Brazil we have a five-year engineering program. Even with this longer program, engineering students usually attend from 30 to 40 hours of classes per week. Thus, it is not pedagogically recommended to add any additional hours. On the other hand, no professor wants to cut what they see as essential courses to add those of less tangible professional value, Therefore, traditional academic inertia, the demands of an engineering degree, the overloaded curriculum and also, the lack of student interest -- are the main factors that prevent the inclusion of new broader training in brazilian engineering education. Furthermore, the increasing infrastructure deficit in Brazil inhibits innovations in the traditional curriculum centered around a technical framework.

In Brazilian scenario there have been few definitions of the goals of engineering education on a national basis. However, the top engineering colleges try to graduate a “conceptual engineer,” with a stronger emphasis on planning and design activities (Bringhenti[7]). Besides the curricular issues, there is clear evidence of the need to develop some skills and attitudes in engineering students. Some recent curricular reform processes (Barbosa and Lima[g]) suggested that graduates should be versatile, able to comunnicate with society, capable of self-discovery and self-expression, able to make decisions, prepared for lifelong learning and willing to assume a balance between self-interest and social interest.

In discussions of these needs, the question soon arose of how to improve in nontechnical, cross-functional areas while at the same time avoiding the deterioration of the technical education. Two possible solutions were proposed. The first was the distribution of this educational mission among the faculty, which “ should work with students these subjects whenever possible within each discipline. We think this proposal would be more efficient than the simple introduction of more humanities and social science disciplines in the curriculum. But, on the other hand, it would require greater cooperation among our professors. They would need an awareness to stress that all college courses can and should be taught in a liberal way, which emphasizes critical thinking and brings out the history and tradition of the subject, its social and economic implications, and the ethical and moral issues it raises.

The other possible alternative was based on continuing education. Actually, some professors do not believe that young engineering-students, between 17 and 22 years old, would gain enough interest to study those nontechnical subjects. But, after they have become engineers, and have grown in status and responsibility, it will become ever more necessary to broaden their outlook and mindset. As was pointed out by Mark and Carver[5] what makes lifelong education in the humanities and social sciences so appealing to engineers is that they can take up these subjects not when they are 18 years old and engrossed in technical disciplines, but when they are 30 or 40 and assuming positions of leadership, and the need for humanities has become clearer to them. Maybe a combination of the two aforementioned solutions would be the best option.

Another set of difficulties for curricular and educational reforms is concerned with engineering faculty and university policies. While most Brazilian universities claim that teaching and research are equally important, there is considerable evidence to the contrary. Since we adopted a "research university" model, it is common knowledge among faculty members that the primary criteria are funded research and articles published in refereed journals. On this issue, we have some similarities with the US experience, since the ideal profile of a Brazilian faculty member usually requires the following characteristics: a Ph.D. degree, preferably from a prestigious university; interest in publishing papers and obtaining research grants and the desire to work with graduate students. Of less importance is the ability to teach and a concern for the problems of undergraduates. In this context, the discussions of and needs for curriculum reform are difficult to undertake and will require in-depth instititutional changes.

Conclusions

This paper reviewed the main ideas and concepts that have been incorporated in some Brazilian engineering programs as a result of models adopted in developed countries, especially those from U. S. and Europe. Although they may share several similarities concerning educational goals and trends, the pace of curricular changing varies from country to country, usually being defined by cultural, economic and social aspects, as well as by the tradition of each engineering college. As a result of discussions and proposals that take place in developed countries, a broader educational view, including social, economic, and ecological understanding, has been established as a worldwide goal for engineering education. The proper way to incorporate these issues in the curricular reform processes occuring in Brazil has been a major concern and a challenging task for educators and professors.

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