Engineering trends to the XXI Century: the approach of Polytechnic School of Federal University of Rio de Janeiro

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Authors:

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Ricardo M Naveiro, Federal University of Rio de Janeiro, Rio de Janeiro ricardo@pep.ufrj.br
Eduardo Serra, Federal University of Rio de Janeiro, Rio de Janeiro serra@peno.coppe.ufrj.br
Maximo Masson, Federal University of Rio de Janeiro, Rio de Janeiro maxmasson@superig.com.br

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Abstract — *Engineering has deeply changed in the late st decades. The Professional engineer today is quite different from the former one and its formation is cast distinguishingly. Besides the involvement with design activities, the engineer is responsible for managing, scheduling and scientific assets. Am ong the several factors that interfere with this process, the changes in the production pattern are the most important. The introduction of new technologies with a high scientific content in the companies, the increasing complexity of products and the mark et globalization are some of the issues that must shape the pedagogical project of a XXI century engineer. The advent of new professions socially more attractive is an issue to take into account when analyzing engineers' perspectives for the future. All engineering schools must consider that their update and their effort to teach the "state of art" are the key issue to guarantee a good formation for their students. The Polytechnic School of Federal University of Rio de Janeiro, the ol der engineering school in Latin America, is completely involved in graduate an outstanding professional, capable to face all challenges placed by the global market. Companies increasingly distributed worldwide and project development being shared between companies and suppliers justify the opportunity of integrating student interchange programs into current engineering education. This paper enhances the role played by international agreements involving studying mobility. Double diploma with high level En gineering Schools and new engineering courses reflecting regional needs and opportunities are available in Polytechnic School. This work will discuss these issues regarding international activities and their influence in the quality of the engineer being f ormed in the country.* .

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Index Terms — *student mobility, double engineering degree, curricula improvement, teamwork*

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INTRODUCTION

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The world is casting a new commercial and industrial pattern. This new pattern is based on economical blocks and free trade zones that speed the movement of goods, services and people and making countries' borders transparent. The emerging industrial environment has introduced new production and distribution practices, new ways of trading and new services. The formation of economic and political international blocs, such as the NAFTA and the MERCOSUR are an example of this trend. Global virtual companies, internet and global logistics associated to decreasing costs of shipping makes possible to ship merchandise anywhere in 24 hours.

On the other hand, products must be successful in many different markets and companies must be responsive to changes in these markets. Companies increasingly distributed worldwide, and projects being developed in a cooperative basis by companies and suppliers, have shaped a new way of doing engineering in the current world and have placed the need for high qualified professionals that must be able to practice engineering anywhere.

In the latest two decades the world has observed a huge movement of industrial restructure. The need for tailored products manufactured in lower scale has modified the way products were fabricated, and has shaped a new productive pattern in the early nineties. New technologies, flexible automation, new management techniques and information and communication technologies were the main drivers of this wave of changes in the industrial environment. Some important facts in industry accompanied these changes as follows: fusion of companies in the auto market, technological agreements for cooperation in R&D, governance changes, companies networked and in partnership, and clean technologies were the most important.

The technical environment into which engineers will emerge in this century will be characterized by knowledge-based industries with high value added products. Products will increasingly rely on the application of scientific knowledge and on the use of mathematical modeling and simulation in the resolution of design problems. The conception of new products is a social process as quoted in the literature [1] [2], and is considered much more effective communication and collaboration, an environment for negotiation and decision in which members have a shared understanding, knowing what is relevant to communicate and how to present information in useful ways. Engineers must coordinate and make compatible the exchange

of data, information and knowledge between very different contexts when involved in project teams.

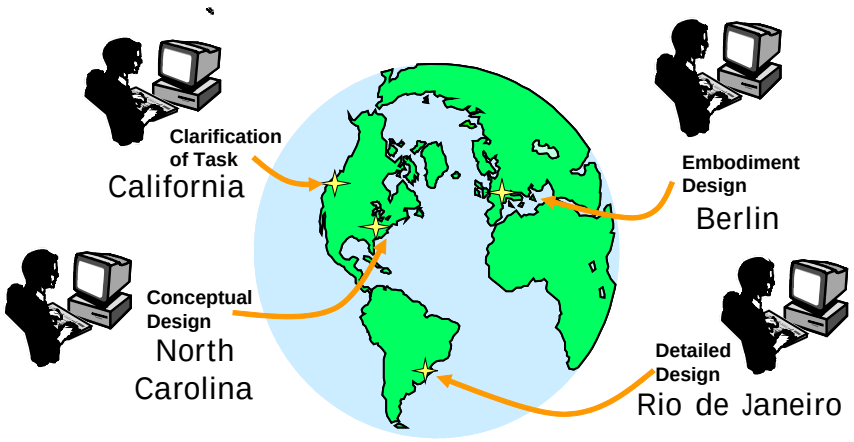

Figure 1 - Virtual design teams enabled by collaborative design tools

THE CONTEXT OF ENGINEERING IN BRAZIL

The definitions and updating of the academic patterns an Engineering School should adopt are hard tasks to perform in this new world. As the "Educational System," the Engineering field is submitted to a wide range of both external and internal factors that exercise strong influences on its upbringing apparatus.

The profession itself has deeply changed in the latest decades due to the changes in the industrial structure, to the incorporation of new technologies in products, to a high degree of scientific content in industrial processes, and to the increasing complexity of products. An engineer of present times deals not only with designing, but is usually involved with management and Research & Development activities. He or she has to add worries about environmental and social issues to his or her daily routines, and a great amount of knowledge on the economic side of the enterprise activity is demanded.

The drastic reduction of "time to market" for most new products has set about a deep change in the design activities within companies: team work, computing support, marketing considerations are necessary components of an engineer's design task. The fast rhythm of scientific advances and the constant introduction of technological innovations in production claim for a strong scientific background in the engineering schools' curricula. These are some of the factors that call for pedagogical projects which are able to provide the Engineering Schools with the formative routes adequate to fit the professional environment.

Engineering courses have a unique position in more developed contemporary societies' educational systems. Even in those, such as the Brazilian society, that has experienced a late capitalist modernization process, the formation of engineers has always been considered a strategic tool for economic growth, mainly in the industrial sector.

The creation of engineering schools has turned out to become a *sine qua non* condition to make the capitalist economy expansion possible, since they provide the generation of the necessary technical cadres, especially for the industrial sector. By merging ideologies and spreading newly technological and organizational alternatives, engineers dispute with doctors, lawyers, and, later on, with economists in the up-building of the modern Brazilian State bureaucratic elites. These professionals' academic formation itself has permanently been interpenetrated by the different forms of understanding the Brazilian reality and of identifying which turning points were to be overcome so that Brazilian society would appear as a modern nation; besides, of course, the definition of the possible roles engineers were to play in the national sphere.

The engineering courses have been born under the monarchy in the XVIII century and reaffirmed in the republic period that has started at the end of the XIX century. The first engineering school in the country was created in 1792 and was inspired in the French engineering schools. In 1874 after receiving the names of Royal Military Academy (1792), Military School (1839) and Central Schools (1858), was founded the Polytechnic School, result of the transformation of the ancient Central School. This new denomination had been adopted in Europe at that time to designate all civil graduate schools related to engineering.

Along the XX century, though, they would leave behind the condition of being restricted areas, accessed only by the regional oligarchies' newer generations and bourgeoisie sectors, and would open up opportunities to a larger presence of middle class layers' young students influenced by the capitalist development process. This process was pulled by

industrialization and the consequent urbanization that would follow, and was more concentrated and intense in the south and southeast regions of the country.

The latest decades were marked by meaningful alterations in many areas of professional formation; given the changes stemmed from the globalization process. The neo-liberal economical model adopted by the later government of Brazil conveyed to important changes in the engineering market, and certain specialities like industrial engineering and electronics consolidated their position reached in the eighties, displacing those traditional ones, like civil and mechanical engineering.

On the other hand, in the same period, the demand for engineers has decreased, but the number of engineering private schools has increased, augmenting the number of opportunities available for graduating in engineering. In the late nineties Brazil had 160.000 students enrolled in engineering degrees, half of them studying in private schools. Despite the recession that the country has experimented for the latest years, the number of candidates to be an engineer is increasing in Brazil, but it must be remarked that some changes occurred in the social profile of the candidates to an engineering career.

The engineering workforce (engineers and technologists) appears to be increasing globally, despite some declines in Europe and in the US. Demographic studies suggest that the next generation engineering workforce will be largely Asian in its cultural origin [3] while the contribution of Central and South America remains to be determined over the long run. China, Taiwan, Korea and other Asian countries have made a strategic commitment in increasing the engineering workforce, in order to lead the manufacturing sector globally and the forecasts reflect this.

STUDENT MOBILITY

The mobility of engineering students is not a novelty for the Polytechnic School. Reports of the XIX century written by ancient students and directors describe the "voyage grant"[4], a grant given to young graduated engineers to go abroad and complement their studies in developed countries, in order to get in contact with technological innovations and scientific discoveries. Students eligible to this grant where the ones that had had higher grades in all courses during the school period. At that time France was the main destination of the students and they used to work in public works, railways, bridges, tunnels, etc. The reports of these engineers are still available in the Library of Polytechnic School.

Undergraduate students exchange programs in Polytechnic School have started in 1999 funded by CAPES, the agency from the Ministry of Education in charge of supporting Brazilian students abroad. The generic program called "sandwich graduation" has evolved to more specific programs in which partner universities submit proposals of projects to enhance engineering education in an international basis.

Normally, CAPES gives a grant to a student spend a semester in a partner university in the US, France or Germany. These countries have signed bi-lateral agreements of exchanging students and faculty with financial support guarantee by the government of each side. In this modality the student has a pre-approved plan of studies before departing and the credits obtained are validated in the sister university.

The Polytechnic School has cooperation agreements with the following universities:

- École Polytechnique de Paris
- École Centrale de Paris
- École Centrale de Lille
- École Centrale de Lyon
- École Centrale de Nantes
- North Carolina State University
- North Carolina Agricultural & Technical State University
- University of Virginia
- Ohio State University
- Technische Fachhochschule Berlin
- Universidade do Porto

There are some projects underway with North Carolina State University, North Carolina Agricultural & Technical University, Ohio State University and University of Virginia. For instance, the project with the two universities in the Carolinas entitled "The development of engineering projects by bi-national teams" is related to enhance teamwork skills among students developing academic engineering projects geographically apart. The project with Ohio State University and University of Virginia entitled "The formation of production engineers to manage high risk and complex systems" has schedule activities related to the cognitive issues involved in managing complex systems.

There are almost 15 Brazilian engineering students studying abroad, while the Polytechnic School of UFRJ has received 12 foreign students for this academic year. The School's expectation is that these figures will increase rapidly in both ways.

Companies will be involved in these projects offering internships abroad, what will open another way of getting international exposure during the undergraduate course.

Besides this, there are the double diploma programs with Intergroupe École Centrale and with École Polytechnique in France. It is a special program that requires two years (four semesters) of study in Brazil before going to France. The students stay in France for two years and came back to Brazil for more two years to finish his course. In France the student will receive a generic engineering formation in which, besides the engineering courses, the student will study human relations, biology, psychology, etc.

New universities are making partnership with the Polytechnic School and its goal is to involve 10% of the students in programs such as this.

IMPROVEMENTS IN THE ENGINEERING CURRICULUM

The need to offer adequate responses to new social demands is a constant challenge for Engineering Schools. Direct initiatives of University toward social needs, in what relates to the engineering area, a closer cooperation with secondary schools and special support for neighboring low income population are some of the necessary action to be performed. Among the various examples that could be mentioned there are the new top technological fields to be fed with high qualified professional, the new production areas in which the country is developing, and the areas on which growing social worries concentrate.

In Brazil, a first example of these fields is computer science, an area which has quickly spread and now interpenetrates almost all productive and commercial activities, besides a steady individual use – Brazil is certainly one of the top 10 countries in the number of internet access nowadays. The use of computers has created a complex net of related activities, ranging from numerous specialized stores and software firms to a large group of technicians and systems' support personnel. Brazilian industry, after the period of crisis that stemmed from the opening of the internal market, in the late 80's, has recovered, to some extent, its production capacity. Brazil has also many research centers on both hardware and software with high skilled personnel graduated from the Polytechnic School.

A second example is the field of industrial automation and control systems, a field which is present in different sectors of the industry and is constantly spreading. Top sectors of production, such as the car industry and other capital intensive sectors that have a strong participation in the country's GDP demand more and more applications of these technologies. Private companies and public university and research centers support many research and development programs on the area.

The environmental sphere has been attracting more and more attention and worries from society, involving the legal system and the production field. Non polluting social responsible enterprises tend to be more socially accepted, and consumers' protection laws and institutions became stronger. Brazil has large portions of its territory covered by jungles, rivers and other natural treasures which get more and more attention from regional and national Governments, as well as from companies NGOs and society as a whole.

Among the production sectors which have been presenting a pattern of constant growth in the latest years is the oil sector. Brazil is now almost self-sufficient in terms of oil consumption, mainly due to the increase of offshore production observed in the latest 10 years. New fields have been discovered recently, and all related areas, such as shipbuilding and oil production and processing equipment is quickly spreading. There's a high influx of foreign capital to the field.

The Polytechnic School of Rio de Janeiro Federal University has been making efforts to follow and respond to these social demands. After having analyzed offer and demand aspects of these professional market segments, the School decided to start up the process of creating new Engineering Courses corresponding to the fore above mentioned areas, according to the guidelines for the development of Higher Education some year ago, which offer incentives and material support for the creation of new graduation courses related to new social needs.

The creation of the courses has inaugurated a new phase in the University. From the very beginning, the courses were designed in a matrix basis, with the direct cooperation between different Institutes of UFRJ. So, the definition of the curricula has taken into account the views of different departments, which would guarantee a pattern of multi disciplinary in their structure. Professionals working on the field, outside the University, have also been consulted.

The administrative structure of the Courses was built in a new way. There are now academic counsels composed by representatives from the Institutes involved and from the Polytechnic School. The team work has also involved the direct participation of the Engineering Graduate School called COPPE, which would be, for the first time in its history, directly responsible for the (shared) guidance of a graduation course.

The curricula contain scientific disciplines and practical activities, and a close pattern of cooperation with the main public and private enterprises of the respective sectors is also present, as in the case of PETROBRAS, the main Brazilian oil company. A closer follow-up of students' performance, by academic advisors, is another component of the new structure.

Direct actions made by Polytechnic School enclose the offer of "engineering packages" to nearby cities. The packages deal with the analysis of local needs and end up with complete projects of electricity distribution, water and sewage systems and the infrastructure works in general. Students work in these projects under faculty supervision.

A closer connection with the secondary school system (high school) is being built by a program of visits for secondary school students and lectures given by our faculty members in the schools. For the low income neighboring population, a preparation course for the entrance examinations is offered in a yearly basis, in cooperation with social movement entities. The Polytechnic School offers material support and most of the teachers chosen for that course is selected among our students.

Some changes in the entrance procedures are also being made. Until 1994, entrance exams were applied to all candidates to the Engineering field. Students would then take regular scientific subjects – such as Physics and Calculus – as well as general formation disciplines. Only after the fourth semester, should students choose the specific field to follow, and would then be classified accordingly to their preferences and their general average. A reform was then made, and from that year on, students' choice is to be made on the entrance period of exams.

A study of the results obtained along the latest 10 years has clearly shown that, although some of the previously existing problems, such as a relatively high barrier between the "basic" and the "professional" cycles and the long "lines" that would be formed by students trying to add up points to be better placed in the dispute for the most desired courses have been overcome. The degree of dissatisfaction, due to the very precautions decision to be made by candidates to entrance exams, has meaningfully increased, as well as drop out rates. A mentality of forced early "professionalization" has also been detected, which has brought many losses to the courses' quality since it would lower the students' interest for scientific disciplines.

The Polytechnic School is now preparing to come back to the original system. Some changes will be made, as the shortening of the "basic" cycle and the formation of an intermediate step by merging of close areas – such as Mechanical and Naval Engineering – preceding students' final choice is another measure to be taken.

CONCLUSIONS AND FINAL REMARKS

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The Polytechnic School of UFRJ is deeply involved in augment the activity of exchanging students. Each country and culture have different perspectives on how to solve problems, emphasize different solution tools and approaches and also have different design constraints, so students become aware of these important multicultural issues.

There are some difficulties to surpass in order to increase the number and the quality of exchanges, one of them being the accreditation process that is different in each country. Some improvements must be done within the American continent in order to have an engineering diploma valid to Americas.

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REFERENCES

[1] Bucciarelli L., *Designing Engineers* , Cambridge, The MIT Press,1994.

[2] Naveiro R., "The role of computer support for integrated product design", *Proceedings of the XI International Conference on Engineering Design* , Tampere, 1997, A.Riitahuhta, p. 465-468.

[3] Kulacki F.& Krueger R., "Trends in Engineering Education: An International Perspective", *Proceedings of the International Conference on Engineering Education* , Rio de Janeiro, 1999.

[4] Turazzi M., "La diffusion de la literature photographique française entre les ingenieurs bresiliens au XIX e siecle", La Revue, Revue du Musée dês Art set Métiers, Paris, 2004. (to be published)

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