EDUCATION DRIVEN BY PROBLEMS. ONE CASE EXAMPLE INVOLVING ENVIRONMENTAL MANAGEMENT

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Abstract *– Problems are intrinsically cross disciplinary, though the use of education driven by problems may foster habits that are much more connected to the real professional situation then do the typical academic solving mechanism. This paper discusses the advantages of cross-disciplinary education in enhancing horizontal, inter departmental collaboration. Real problems can be discussed also in several levels of comprehension and help university actions from research practices and graduate studies along the Engineering Education chain down to Freshman years and even to outreach actions in the K-12. This paper discusses the advantage of a theme treated in several levels of studies. We report efforts developed in the Centre for Sciences and Technology of the Pontifical Catholic University of Rio de Janeiro in studying the environmental problem of a nearby lake ("Lagoa Project") by using the several problems associated to an important water resource in a urban area.*

Index Terms – Education driven by problems, Engineering Education, Environment, First two years, K-12.

MOTIVATION

The Schools of Engineering, in order to bridge the gap found by students when they leave the pre-university School, designed a very specific program for the first two years (freshman and sophomore years), mostly devoted to basic sciences (Physics and Chemistry), Mathematics and Computer Sciences. The first two years, as expected, are taught in a considerably higher level than the similar courses in the High School, requiring more abstract thinking, more refined reading skills and leaving to the students more freedom for personal schedule control. The traditional methodologies used in the freshman and sophomore years keep the School of Engineering distant from the High School educational processes, but the taught subjects still keep them distant to the realities of the profession of Engineer.

Thus, students actually must leap two distinctive gaps: from High School to the School of Engineering and them from the first two years to the Professional years. The new level of maturity required by the School of Engineering is not followed by a clear justification (in the student point of view) of the expected student behaviour.

In the French system, it is usual that the first two years be covered outside the School of Engineering, in the "Ecoles Preparatoires", whereas in the United States something similar happens in the Community Colleges.

In most American, British, French, Brazilian and Italian Schools, the Basic Sciences are presented as a base for future technical knowledge, in an absolutely abstract and formal environment, aiming scientific theorisation. The first two year disciplines are sequential and built a theoretical body of logic and knowledge, as discussed by Silveira and Scavarda [1]. German Schools developed the practice of the *Practikum*, that covers practical knowledge in the specific field of engineering in which the students are registered, but not necessarily offers activities that resembles the practice of the Engineer.

In many research universities, some practical works are developed under the guidance of researchers, whereas in smaller universities professional engineers present standard problems, following Tyler instructional methodology [2].

Very seldom students are exposed, in the first two years, to situations connected to the real life of the practitioners, with its frequent human and social aspects, those clearly part of a non scientific or technical context.

Students, before enrolling in the School of Engineering, have already a glimpse of the real daily life of the professional, this vision is mostly the result of their observation. The learning process, nevertheless, become apart from the future realities of either the real professional practices or of the imaginary vision of the students and do

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not fit in their expectations, contributing to the large drop-out rate during this period.

The motivation of this paper is the search of a mechanism to mitigate the natural difficulties found by students of Engineering in their freshman years. Many efforts are done to match the first two years to the High School, but seldom the used mechanism show the real life of the practitioner. Actually, it is the exposure to the real life of the practitioner that attracts the students in their first contact with the School of Engineering. The mechanism that shows the real life of the practitioner justifies the natural difficulties posed by the necessary call for maturity.

CURRICULUM AND PEDAGOGIC METHODOLOGIES

Two concepts appear in the base of the disciplines offered in the School of Engineering:

1- The traditional “Serial Disciplines”, that tend to “discipline” the educational process by using information that are taught in sequence, following the conceptual logic of the learning process. From the concept of function to the derivative and them to integral. From the concept of cell, to tissue, them to organism, species and finally to the Evolution Theory. This disciplined way of education is essential to built a conceptual body by “pushing” the student from basic knowledge, to applications and to problem solving multidisciplinary activities. The logic of this mechanism of education starts with concepts and ends up in concrete problems, these typical applications of the strong cultural, scientific and technological body of knowledge previously built.

2- The non orthodox “Concurrent Methodologies”, where problems and projects are the starting point of the “discipline”, where an integrated effort is developed to built competencies of technical, scientific, managerial and cultural origin. These methodologies could be traced to Dewey [3] and Kilkpatrick [4] and were discussed in Silveira and Scavarda [1]. The necessity of those specific competencies as a basis to the practice of professional Engineering were previously discussed by Lespinard [5]. These methodologies start with a problem that should be faced by a group of students. Useful problems must respond to external realities (for instance, real problems of the market) and to realities that are easily absorbed at the real level of maturity that characterises students, including those of the freshman year.

Concurrent methodologies deal with problems students have already accepted as important and useful (many times identifying them), which ask for necessary solutions and are anchored in team work. In this cases, problems lead the sequence of the learning process, these always mixing different basic subjects. Concurrent methodologies invert the usual process of serial disciplines, since in this cases knowledge must be found and built from one problem. The search for Scientific knowledge is, many times, also the result of necessity.

Concurrent methodologies underline human and social interactions, as well as managerial competencies, while serial methodologies underline the formation of solid scientific and technical culture.

The problem addressed to the Schools of Engineering is how to integrate the two methodologies in their curriculum. The motivation aspect that characterises the concurrent methodologies is necessary to help students to follow the somewhat dry sequences of serial disciplines, that, on the other hand, built the necessary body of knowledge and even language needed by concurrent disciplines that deal with more abstract problems. The two methodologies should be blended in a complete philosophy of learning procedures.

PROPOSITION

We propose the practice of concurrent Methodologies since the first semester of Engineering Education. Project disciplines could foster the concurrent methodologies, bringing real life projects to the everyday life of students. The simplicity of first semester projects could help to bridge the gap between the high School and the School of Engineering, while the resemblance to the real life of a practitioner could help to bridge the gap between the first two years and the professional years.

The mixed process generated by a suitable blend of the two methodologies could mitigate the difficulties of the student in the beginning of the School of Engineering.

Concurrent methodologies are much more time consuming to the professors and involve a network of internal facilities of the School of Engineering (laboratories, consulting with colleagues, infrastructure of Teacher Assistants that need careful organisation) and of external facilities (like industries, government or even professional associations). One challenge is to convince either the university administration and professors to pursue such disciplines. Another challenge is to find appropriate problems that could satisfy the necessary integrating aspects of a suitable subject .

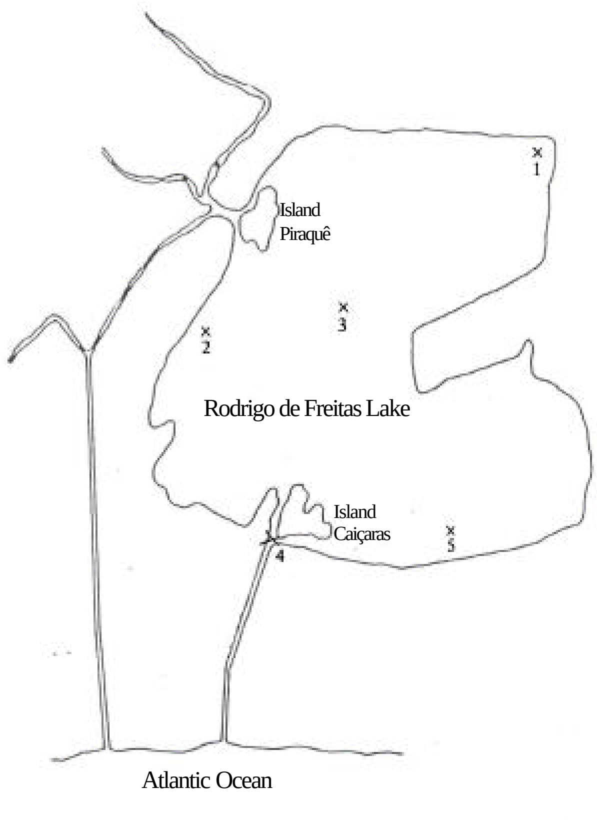
Concurrent methodologies have been used in hands-on disciplines where technical problems of the industries are presented [5]. The just-in-time technique, so useful to reduce stocks of members of a supply chain, may also be used to provide students with pieces of information on Physics, Chemistry and even Mathematics. These techniques, well presented in [5], are very powerful mechanisms to motivate students to face the serial disciplines that built the conceptual bodies of Physics, Chemistry and Mathematics.

The growing interest on non technical subjects found in high school students is a world wide tendency that has been connected to the reducing interest show by many bright students in enrolling in Schools of Engineering. This fact suggests that the themes used for hands-on disciplines must encompass human, cultural and social aspects. On the other hand, present real problems also involve more and more non precise and fuzzy questions that blends with technical and scientific problems during the realisation of real projects. The selection of real and attractive problems at the level of maturity of freshman students as themes for disciplines with concurrent methodologies becomes a real challenge.

We chose the well accept environmental problem, with its human, social and economic aspects, as a hands-on theme in our discipline that uses concurrent methodologies.

THE "PROJETO LAGOA" AND ITS FIRST RESULTS

The Rodrigo de Freitas Lake is located in the core of Rio de Janeiro, not far from the campus of the Pontifical Catholic University of Rio de Janeiro. This is a densely populated area, with high tourist interest, that suffered a recent fast process of urbanisation that threatened both its environment and natural beauty, jeopardising the quality of life of local inhabitants.



Map of "Lagoa Rodrigo de Freitas" where we can see the 5 points chosen to collect data.

We proposed that freshman students study the environmental problem of the lake, within its rich urban realities. This problem involves analyses of the water, the air and the sediments of the lake. This was the starting of the *Projeto Lagoa*. Several groups started with a historical survey of some of previous (many disastrous) implemented "solutions", some dated back to the 19th century. Students made their own measurements of the air, water and sediments, comparing with historical series of data.

Students became aware of the difficulties found by past engineers in implementing technical solutions, mostly due to factors like cost, political (lack of) will and even absence of full comprehension of the problem by the local population.

The *Projeto Lagoa* was implemented within a discipline called "Introduction to Engineering", that is obligatory for freshman students.

In this first experiment with *Projeto Lagoa*, a complex network of research laboratories, government (city and State) agencies and even recreation clubs were organized, all eager to help students to collect samples and data. The students decided which analysis were important, which were feasible, how to connect new information with historical series of data for comparison and finally how to prepare consistent reports that could propose real solutions. The final report and public presentation of results were part of the evaluation mechanism of the discipline.

This pilot project generated two spin-off results:

1- The extension of the *Projeto Lagoa* to the outreach program with the K-12. The necessity to present the local population with reliable data, prompted the group (professors and students) to implement this subject in the already existing outreach program.
2- The extension of the interest of research groups in the nearby Lake, within the general scope of "Water Resources in Urban Areas".

These two spin-off results permit that the complex network of laboratories and institutions reinforce the *Projeto Lagoa* and also permit that similar projects in other regions, even abroad, connect to this project facilitating the international contacts between Schools of Engineering. [6]

CONCLUSIONS

It is very difficult to draw final conclusions from a single pilot project. Nevertheless, the drop-out rate among students involved in this project was null, and the final report of these students were much above the general expectation. Several students of this group are engaged in serious studies of problems connected to the environment, and some are helping to keep the network of institutions ready for groups already engaged in similar studies in 2002.

It is important to stress that the work load of teaching such type of disciplines is extremely high, and the very positive initial results were of great importance to keep the group of professors offering the discipline.

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