Curricular and Pedagogical Changes in Engineering Courses: Support to Freshmen

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Abstract: This paper is concerned with curricular changes that have been implemented at PUC-Rio during 1999. The initial proposition for these changes has already been presented at the ICEE99. The fundamental principles that guided these changes are revisited. Implemented changes are described, together with preliminary evaluation results, for specific disciplines and overall. The paper starts with an outline of the Engineering Course at PUC-Rio. Objectives and curricular plan are presented through a review of previously published papers (previous ICEE proceedings), by some of the authors. A second part is dedicated to strategies and general pedagogical principles, where the student situation, under the present social context of the University, is revisited. Proposed objectives are presented. Next, the implemented curricular changes are described, including the new curriculum for freshmen and the refurbished disciplines of Calculus, Physics, General Chemistry, Introduction to Engineering and Introduction to Computing Science. The new courses of Technical Writing and Modeling are also presented. A section is devoted to assessment, showing the results obtained so far, for each of the aforementioned disciplines. Difficulties found, including problems with teachers and tutorship, are discussed. The evaluation results are regarded as highly preliminary, due to the short period of time to carry on a proper evaluation. Also, some of the pedagogical strategies are still to be developed and tested.

Keywords: Engineering education, engineering curriculum, pedagogic methodology.

a) Introduction

This article presents first results of the curricular reform implemented at the first four-semester period of the Engineering Course at PUC-Rio, subject of study by da Silveira et al. [1]. This reform, on both sides of curricular structure (organization and distribution of contents, abilities and attitudes to be developed, redefinition of disciplines group) and of didactic methodologies to be implemented, was officially approved by the end of 1998 and implemented – part of it on an experimental basis – in 1999. As a matter of fact, the implementation of the reform is being carried out gradually. Methods have been evaluated and objectives redefined as the project progresses.

The Engineering course at PUC-Rio takes an average of five years, follows the credit regime and is organized in semesters. The cycle of common studies, codenamed "Basic Cycle", corresponds to the period of three to four initial semesters, where basic sciences (Physics, Mathematics, Chemistry and Computing Science) and most of the required humanistic disciplines are undertaken. After opting for one career, students then proceed to the "Professional Cycle", comprising four main groups that include: 1) common engineering disciplines; 2) basic disciplines for the engineering specialization (Civil, Computing, Automation and Control, Mechanical, Materials and Metallurgy, Production and Chemical); 3) disciplines that will define the emphasis within the engineering

specialization (for example, in Electrical Engineering, the student can opt for Electronics, Power, Systems or Telecommunications); 4) freely elected disciplines, including those related to entrepreneurship.

2. Strategies and general pedagogic principles

Before presenting the results, it is worth mentioning the strategies and pedagogic principles that guided the curricular reform. They were established from the situation of the students entering the university and from the objectives of the course, as described by Scavarda do Carmo et al [2].

2.1 The entering student – situation analysis

Below, a brief description is given on the predominant profile of the student as he or she enters the University. There are exceptions, but they certainly constitute a minority.

The unprepared student: The student presents "gaps" in his/her formation; the content of the secondary school has been poorly absorbed; he/she possesses unrestricted belief in the media, in detriment of his/her own critical assessment capability; he/she suffers from the "protected teenager syndrome".

The postmodern student: The need, or application, for everything that is taught is demanded; he/she is oriented for immediate application of the content; unemployment, environment degradation and preservation of cultural diversity are subjects that he/she has in high regard; tribal association is preferred in place of an individual life.

Student under the influence of postmodern society: There are strong boundary conditions affecting this student. They are dictated by a postmodern society that over-appreciates cases of fast enrichment, fame, social success and physical beauty in detriment of experience and responsibility that come with maturity.

In addition to the above-mentioned factors, a merely classificatory university admission exam ("vestibular") and a problematic secondary education system, all contribute to an admission exam in which, among the top 1000 candidates, only 200 meet the required standards. There is a strong correlation between the performance of the student in the admission exam and in the first two years of course, a trend that has been observed in other universities [3]. As a result, schools face a high failure rate, leading to low retention [4]. On the other hand, cases where well-prepared students, ready for advanced classes, found themselves unmotivated in classes more suitable for the average student. The following question is posed: How to prepare the scientific-oriented entrepreneur engineer, proposed by PUC-Rio [2], under the above conditions?

2.2 General pedagogic principles

In a previous work [1], the application of a number of principles and strategies was established, as follows:

a) To attend students in a way adequate to their inherent difficulties, for instance, by dividing freshmen into three main categories (advanced, average, and those in need requirement more attention);
b) To break with habits acquired in the secondary school, making the university a distinct environment. This can be achieved by avoiding "talk and chalk" classes, by taking the student away from classroom (technical visits, laboratories, field tests, seminars, etc.), by providing an ombudsman, to allow for dissatisfactions to be readily exposed, by tutoring the student, in a individual and collective basis.
c) To relate theory to practice, by showing the student that day-by-day problems are related to the technology that is being taught in class;
d) To expose the student to new situations that take him/her to develop the required attitudes and abilities (team working, design, professional attitudes in general);
e) To encourage entrepreneurship, as described in detail by Aranha et al. [5];
f) To develop the necessary intuitions, in each discipline, before intensifying the associated concepts;
g) To make classes and evaluation based on the construction and analysis of concepts and to avoid teaching in terms of a "quest for results".
h) To make use of concurrent teaching, as described by da Silveira and Scavarda do Carmo [6], by encouraging the student to look for the theory that will help him/her solve a specific problem;
i) To make extensive, and intensive, use of computers by requiring student work, such as laboratory reports, seminar transparencies, experimental data, graphical results, to name but a few, to be presented in a professional and updated form;
j) To treat students in a merit basis: the better the student grades, the better are the chances for obtaining scholarships, in-campus job positions and grants.

3. Implemented curricular changes

The main curricular changes that have been decided, based on the assertions above, are described next. Some of them have already been tested in the last few years. Others have been improved during their implementation. In fact, the prevailing phase is of great adjustments. So far, no necessity of a significant change of objectives has been detected.

I. Freshmen were divided into three groups (principle *a*): Students best placed in the admission exam are enrolled in a special Calculus class, where they are exposed to a greater demand. Intermediate placed students are enrolled in the normal classes. Students with less than sufficient results in the admission exam, are enrolled in "Introduction to Calculus", specially designed to motivate students and to fill existing gaps [7].

II. The same approach was applied to Physics with the creation of an Introductory Physics course. Emphasis was put in relating the Physics content to the student day-by-day experience (for example, how to measure the speed of light in the microwave oven) and to high-tech applications (for instance, GPS system) [8]. In this case, pedagogic principles *a, b, c, f* and *g* were observed.

III. Being a catholic university, humanistic formation courses were maintained. As one example, in the compulsory course "Man and the Religious Phenomenon", students, through a series of seminars, are encouraged to investigate society, within the religion framework. Pedagogic principles *b, c* and *d* apply.

IV. Freshmen hands-on course "Introduction to Engineering" has become compulsory (pedagogic principles from *b* to *h*). Encouraging results of this 500-student experience has been reported elsewhere [9].

V. To improve the capacity of the student to express him/herself properly, and to increase his/her capacity of arguing, the compulsory course "Introduction to Technical Text" was created.

VI. From the application of pedagogic principles *f, g* and *i*, the intensive use of numerical analysis, graphic computational facilities and algebraic computation (MAPLE ®) was introduced in disciplines Calculus and Linear Algebra.

VII. Introduction to Computing Science: object-oriented languages are now considered, with concepts of recursivity, interactivity and abstraction levels being developed. Disciplines treating structure programming and data structure have become compulsory, in a clear example of the application of pedagogic principle *c*.

VIII. The content of General Chemistry was organized in themes of immediate appeal, such as the oil industry, pollution control and environmental impact evaluation. The methodology, employing pedagogic principles *b, d, e, f* and *h*, included teamwork, discussions and presentations, as well as conventional class and exams. This item is described by Campos et al [10].

IX. A new discipline, Modeling, was introduced. Challenging problems are presented to the students, in order to make them notice the importance of mathematical modeling for the representation, analysis and solution of engineering problems and situations. The pleasurable and group challenging aspects are basic pedagogic tools for these disciplines. Pedagogic principles *b, d, e, f* and *g* apply. An extensive evaluation is planned for the second semester of 2000.

X. An ombudsman, accessible trough e-mail, is available since 1998. An individual tutoring system was introduced in 1999.

XI. Use of Internet: students have full access to Internet. A number of disciplines of the Basic Cycle have interactive web pages. The goal toward a systematic and regular use of computer and Internet is being approached.

4. Initial evaluation

A general evaluation can be presented after one year of the new curriculum. In some cases, the evaluation, as described below, is already quantified.

- Introduction to Calculus: Double-failure and high evasion rates, previously a systematic situation [11], have been reduced. The present discerning system has allowed for a "merging" of students, of different levels, at the third period, without noticeable problems. It can be said that the aim has been achieved, even though didatic material, in preparation, must be improved [7].
- Introduction to Engineering: It has been a success in the process of adapting freshmen to the University, bringing Engineering to them and inspiring new ways of education (such as for students prone to practical work).
- General Chemistry: Failure rate has decreased and students start finding the discipline interesting [10], which is a departure from their usual opinion.
- Introductory Physics: Although still in development, this discipline has received a satisfactory evaluation from the students. Habits and opinions (students and faculty) have been changed, so the aim has been accomplished. A CD-ROM of the discipline has been developed in a project involving an incubated firm.

- Introduction to Technical Text: The discipline was well received by freshmen. Its real effect in the capacity of the student to express him/herself can be only measured by the end of the year 2000 or even 2001.
- Modeling: It is being offered for the second time, on an experimental basis, for a class of 50 students. Text book and the professor manual, still in preparation, will be of vital importance at the time it will be offered for classes totaling large number of students. Teacher attitude is crucial for the methodology of the course.
- Tutoring and Ombudsman: The tutoring system is still in formation. On the other hand, the ombudsman has already served to detect, and solve, a number of problems. Curiously, one problem with individual tutoring is that students are, sometimes, more aware of curriculum changes, and their consequences, than the faculty.
- Finally, it should be mentioned that each change has found negative reactions among faculty. Conversely, professors directly involved with some action that resulted from a particular change have adhered enthusiastically, in general. Therefore, it is believed that a broader dissemination of the ideas and results will result in a greater support to the new curricular program.

5. Concluding remarks

Initial objectives have been attained, as it can be seen from a comparison between the preliminary evaluations above, and the ones presented in the works cited. A more realistic assessment, even including an evaluation of student behavior in the subsequent courses, will only be available at the end of the year 2000.

Still to be done, the implementation of the discipline "Contemporary Science and Technology" and the extension of the new didactic strategies to the higher Calculus and Physics disciplines. Also, the whole engineering curriculum will have to be adjusted to receive the students coming from the "Basic Cycle" under the new curriculum.

An increased use of simultaneous use of sequential and concurrent teaching [6], as already applied in Automation and Control engineering and electrical engineering courses is to be expected. In this sense, open curricular organization is under study, avoiding objectives too much constrained by over specified contents and their excessive partitioning different courses.

Perhaps, the major suggestion of this paper is to better organize the assessment results and to publicize them among students, faculty and high schools, which provide students for the university. This divulgation is essential not only for the university publicity but also to the success of the new curriculum implementation. The resulting *"sprit de corps"*, bonding students and faculty, and generating high expectations will help establish a new attitude, active and entrepreneurial, as a mark of the PUC-Rio student: the formation of the scientific based entrepreneurial engineer.

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