A Major Modification of the Electronic Engineering Curriculum at the Universidad Nacional del Sur

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Abstract- *This paper presents a major modification to the Electronic Eng. curricula performed at the Electrical Eng. Dept., Universidad Nacional del Sur, Argentine. After a brief introduction to some particular aspects of the university system in Argentine, the paper focuses on the diagnostic and main changes considered for the previous curricula. One of the objectives is to reduce and bound the many elective courses that the previous plan offers without loosing the flexibility they give. In particular, this flexibility is very strongly related to the student motivation. Both the student motivation and the loose control of elective courses are aspects that we try to improve.*

Other characteristics of the new curricula are both the specific approval and evaluation rules and the concrete limits on academic time load recommendations respectively. The main purpose of these limits has close relation with shortening actual permanency of the student in the university system to obtain the academic degree.

Besides the changes proposed the evolution and control of them play a fundamental role for the success of the initiative. With this objective in mind, some tools to realize this control were also proposed.

Finally, an additional discussion relating this curricular modification with other experiences worldwide is included in order to compare possible results.

Introduction

Electronic engineering education at the Electrical Engineering Department of the Universidad Nacional del Sur, Argentina, has increasingly faced with the conflicting problems of trying to keep up with the fast advances in technology, increase teaching performance and, at the same time, maintain the five year engineering curricula recommendation [3]. An additional problem to solve is to offer a suitable motivation to students that have an heterogeneous education at beginning of the freshman (or first engineering year level) in order to help them to end their studies.

In order to position the reader, a brief review of the history and characteristics of the Electrical Engineering Department (EED) and the Universidad Nacional del Sur (UNS) is helpful. The UNS was created in 1948, initially as the Instituto Politécnico del Sur, and renamed in 1956 as the UNS. In this year the Electrical Engineering Department was incorporated. Our institution is medium size (9.000 students) if compared to the others universities of the university system of Argentine. The university organization is based on departments (some related departments are the (Civil) Engineering Dept., the Mathematics Dept., the Physics Dept. and the Computer Science Dept.). Our department teaches Electrical and Electronic Engineering to, normally, 400 students.

It is worthy to mention, additionally, that the national university system is free, no fee or tuition is required to the students to complete their studies [6]. Also at this moment there is no admission examination and only supplementary courses for non-homogeneous high school education are taught.

The Electrical Engineering Department was historically engaged toward Power Systems Engineering education. At the sixties, the importance of computer technologies became evident and the Electrical Engineering curriculum divided in two orientations: light current and heavy current. Several years after that, and at the cost of a strong educational delay, the evolution of these two orientations led to two different degrees: Electrical Engineering and Electronic Engineering. The same profile but with, perhaps, different scale in the offer of courses, can be associated to the characterization of the entire university system in Argentine. Particularly, some universities have contemplated a special emphasis in the area of telecommunications, computer sciences or control systems. Thus, our department had imparted education to form an Electronic Engineer with a special bias in automatic control and digital systems.

Fortunately, over the last years several academic and gubernatorial initiatives were taken to freshen up the Electronic Engineering curricula at university level. Among them, one of the most important initiatives was the financiation obtained for the project: Mejoramiento de la Educación en el Departamento de Ingeniería Eléctrica, UNS presented to the Fondo Para el Mejoramiento de la Calidad en la Educación Universitaria from the Education Ministery of Argentine [1] with the support of the World Bank. This financial support is part of a five-year program whose objective is oriented to introduce an appropiate actualization to the degrees of our department. Another institutional effort that has given a guide to follow for the curricular modification was the External Evaluation of the Universidad Nacional del Sur, were some useful recommendations related to the improvement and/or upgrade of academic and practical aspects were performed.

It is worth to mention that External Evaluation was only recently introduced in the university system of Argentine,

and not many universities have accepted it yet. This is a major improvement of the system since it gives to everybody a clear view of the quality of each university.

The main characteristic of the proposed curricular modification can not be related to a unique point [8]. It is possible to define it as a major revision [5] (minor changes were performed in 1988). Among the particular aspects that have been introduced in the new curricula we can mention:

- A new curriculum divided in: basic sciences (physics, mathematics, etc.), a core (basic engineering courses), a body (especific Electronic Engineering courses), orientations (control, communications and computers) and general formation (additional modules).
- Requirements for an efficient evaluation and approval of examinations.
- Specification and control of the maximum academic time load.

The previous curriculum was not structured around orientations and more noticeably, by the related problems that this generate, does not have any control or rules to organize evaluation procedures efficiently and control of the academic time load to students.

In order to describe the proposed curricular modification (already approved in 1997) at the EED, the paper will be presented in the following sections: in section II the problems to be corrected from the previous curriculum are reviewed. In section III, the new curriculum is presented, including the main characteristics and principal aspects. In section IV, the evolution of the proposed curriculum will be considered and finally, in section V, we include some general comments and considerations for future actions.

Characteristics and problems related to the old curriculum

The previous curricular plan of Electronic Engineering dates from 1988. Like other engineering degrees in Argentine it is based on 5 and 1/2-year study cycle. It was mainly organized on a two and a half years period of basic sciences and math formation (common to Electrical and Electronic Engineering) and three years of specific formation. These last years were structured around elective courses, with particular emphasis in control and digital systems engineering (by the previously cited historical reasons). This last characteristic, many elective courses, although has given an appropriate flexibility for the students to choose more motivating courses, it has made the academic control very difficult to be performed. Indeed, this is one of the main problems that the curricular modification had to reduce since there was not a clear mechanism for the EED to control the electives the students choose.

There are two kinds of problems: external and internal. External problems, which we must detect but can not directly or indirectly be solved, are relative to social factors and non homogeneous quality of basic education. This is a particular characteristic of our academic system. Students with a non-specific education (as for example bachelor in foreign languages, commerce, etc.) do not have the same preparation and motivation to basic sciences and mathematics as those that have a technical formation. However, all them share the same classroom at the same courses. These problems cause early desertion and decreasing matriculation.

Internal detected problems also cause desertion in diverse stages but with different origin. Without intent to be exhaustive, some internal detected problems are listed below:

1. *Inefficient contents of the basic courses.* This inefficiency is mainly related to inappropriate requirements of practical and conceptual formation along these years of study. The fact is that math courses were taught without emphasis on physical applications and considering that electrical and electronics engineering students needs were similar to those of the mathematics students.
2. *Low relationship between the contents of the basic courses and the specific courses of Electronic Eng*. This point is related to the previous one, and has also a close relation with student desertion before the beginning of the specific courses. This is so because the students were not adequately motivated to study mathematics in the behalf of having good basis for Electronic Engineering.
3. *Inefficient evaluation for the courses* (mainly in the first two years of study). The type and form of evaluation required at several courses produced an undesirable delay to succeed the final examinations.
4. *Lack of well-defined orientation.* The flexibility associated to the extensive offer of elective courses without well-defined rules have induced to an imprecise formation.
5. *Professional profile not well defined.* Two profiles become involved in the discussion: technological (conceptually analytical and practical) or scientific (conceptually theoretical or using modeling and synthesis). Obviously, being different alternatives, a compromise solution between them is required, where some other concurrent factors play an important role.
6. *Long staying period before graduation.* Closely related to point 3. The overlapping between preliminary study to final examination and simultaneous class assistance is other cause of difficulty for students. This problem obviously causes desertion and decreasing matriculation.

The discussion motivated by the previous aspects was not easy and, since these factors are closely related a suitable solution to some of them does not conduce to a global solution contemplating all of the remaining problems. Some

key ideas at hand to try a solution to the previous problems are the following:

- Organize the contents of the courses around conceptual groups composed of:
  - Basic sciences (Mathematics, physics).
  - Introduction to Electrical Engineering (core).
  - Body of Electronic Engineering.
  - Orientations: control, computers, communications (new).
  - General formation (additional modules).
- Reassign several topics between the specific courses aiming to improve the efficiency of academic load time. The key idea here is to associate to each course a maximum academic load-time (for all concepts) and an estimation of effective time of study for the student to use. Both the maximum load time and the effective time of study can not overload a maximum pre-established in order to allow the student to have some spare time for other (cultural, sportive) activities.
- Determine well-defined conditions for grading and (mainly) evaluation that are not limited exclusively to the approval of the final examination.
- Eliminate redundant academic contents. The idea here is to modularize the contents of the courses in order to have an appropriate and efficient duration (with a minimum of overlapping contents) reconverting some of the existent electives. In order to modularize and shorten some courses, alternative courses should be created to complete the academic offer. Adequate definitions of the orientations can be useful to this purpose.
- Give a more essential and objective formation. The duality of the professional profile intended: technological and/or scientific, must be solved regarding a compromise with aspects such as: regional job market [7](effective insertion of the graduated), actual duration of the studies, the requirement for a conceptual and practical education, not necessarily extensive.

Obviously, the list above can not be exhaustive. However, the general guidelines presented were helpful to define the New Curricular Plan that will be presented in the following section. Since the improvement and upgrade of this plan must be continuously performed, some tools that seem to be useful to this purpose will be introduced in section IV.

The reformulated Curriculum

The main objectives contemplated were those presented extensively in [1] and they follow the recommendation performed in [2]. Additional considerations about Electronic Engineering at several universities of Argentine, as for example the exhaustive recompilation performed in [3], were also contemplated. A brief discussion and comparison of the Electronic Engineering degree in Argentine with that obtained in other countries will be presented in the next section.

One of the recommendations to be regarded [3] is that any curricular plan must be active for 10 years, i.e., in spite that new curricula is implemented the old plan must be maintained at least for 10 years for old students. With this limitation in mind, we define the academic plan as a reunion of the fundamental concepts of Electronic Engineering using a chronological, gradual and conceptual criteria. The concepts organized in that form can be grouped under a determined name. We intent to define the name of a group of concepts (that form a course) in order to satisfy the compromise between generic names for one side (with the advantage of easy change of contents but the difficulty of control of the actual contents) or specific names for the other side (with the advantage to indicate more clearly the specific academic offer but the difficulty to alter their contents with future curricular modifications).

It is important to note that the change from elective to required courses is related to the alternative of specific or generic names for such courses. Indeed, the alternative of specific names at hand can be useful to increase the graduated and continuing education offer at the EED. The form and opportunity for these courses to be useful as graduate courses is being related to the joint work of curricular modification and graduated programs of the EED.

When selecting and defining the orientations: control, communication and computer, other important areas of Electronic Engineering, as for example microelectronics and mechatronics, were not included. The mechatronics orientation is scheduled for 1998 and is under development. Microelectronics should contemplate such objectives as the formation in the analysis and design of analog, digital or hybrid components and devices, with different scale of integration and their applications. This orientation could be considered in the future at the light of the actual requirements of the job regional market.

The professional scope: To be complete, the major modification contemplates a set of specific rules to be covered as Incumbencies [4]. They enunciate, in gross lineaments, the profile of activities that our graduated are supposed to do. The incumbencies related to this major curricular plan modification are not changed significantly if compared with those related to the old plan. The main reason to maintain the previous incumbencies is that their scope and objective remain similar. Also, a noticeably alteration of the incumbencies is against to the standardization of engineering education pursued in [3].

The new curricula: In the sequel the new plan for Electronic Engineering is presented. First, the detailed program is presented, describing schematically the group of courses and additional modules. Next, an overview of the specific courses is included, in first place for the basic years

and finally for the orientations with their electives and additional modules.

The detailed program of the Electronic Engineering curriculum is shown in Table 1. In order to contemplate the total academic load time per week the following considerations were realized. With a recommended academic load time of 360 hours per period [3] we can consider:

- *24 classroom hours per week* (lectures, tutorials and labs) for all concepts (including additional modules).
- *21 hrs. of study per week* in order to complete 9 hrs. of study per day.

It is noted that the student must select the electives she/he wants to have from a list of available ones for each orientation. The selection must be approved by the academic council of the EED.

The courses of the new curricula can be arranged in the following groups:

- *Mathematics*: Introduction to mathematics, Elements of algebra and geometry, Calculus I and II, Functions of complex variable, Probability and random variables.
- *Physics*: Physics I, Electromagnetism, Physics of the solid, Fundamentals of thermodynamics.
- *Electronic engineering fundamentals.*
  - *Core*: Computer principles I, Electrotechnic, Logic circuits design, Electrical measurement lab I.
  - *Body*: Semiconductor devices, Circuits and systems analysis, Introduction to digital computers, Fundamentals of automatic control, Analysis and design of analog circuits I and II, Electromechanical conversion of energy, Electrical measurement lab II, Digital signal processing, Final Project.
- *Orientations*.
  - Control: Actuators and measurement systems, Digital control systems, Power electronics, Advanced control systems, and electives (4).
  - Computers: Principles of Operating systems, Analysis and design of digital circuits, Applied computer engineering, Digital computer and interfaces, and electives (4).
  - Communications: Fundamentals of communication systems, Introduction to digital communication, Services and systems of telecommunications, Propagation and radiation, and electives (4).
- General formation (additional modules): Inside de university, Introduction to Electrical Eng., Introduction to industrial organization, Elements of industrial safety, Legal engineering, elective modules (3).

The minimum global contents required for the courses of the new curricula are specified with the following information:

- Objectives of the course.
- List of concepts to be emphasized during the lecture.
- The academic load time (lectures and labs, contemplating a maximum of 24 hours per week) and the estimated study time per week (together with the previous time can not be higher than 45 hours per week).
- A profile of the bibliography (normally a reference textbook).

The additional modules: Among the innovative aspects introduced by the new curricular plan, the additional modules of general formation play an important role. The objective of the additional modules is to complement the education of the student in specific practical aspects and/or general education. They are defined with low academic load time.

The functions of the additional modules are closely related to the level of study. The additional modules contemplated in the first year (Inside the university and Introduction to EE) are oriented to give the student two different perspectives: one related to internal aspects of the university (such as bookstore use, courses inscription, etc.) and the other to show a preview of the concepts to be taught in the following years, and their relation with basic mathematics and physics. This knowledge is helpful to reduce desertion in the first year and to lead the student more straightforward to the orientation.

In the following years practical additional modules (Measurement lab I and II) are included. The additional modules of the final years have fundamentally a professional orientation (Introduction to industrial organization, Elements of industrial safety, Legal engineering). Elective additional modules are contemplated to include humanistic education and foreign languages.

Evaluation requirements: these requirements define specific tools to perform an effective control of the level and efficiency of the courses and modules. Also these requirements are useful to track the overall contents of the new plan. The main requirements considered are: General conditions for evaluation, Rules for student evaluation (Curricular Act) and the Curricular Evaluation. A brief discussion of each evaluation requirement is presented in the remaining of this section.

General conditions for evaluation:

A course is characterized by a time period (approximately four month) that has two kinds of qualifications, one for lab assistance and problems solving and the other for the satisfaction of all the requisites of the course (shorter courses have proportional weights). Each course has correlativities, i.e., the student should satisfy a minimum

requirement of qualifications by year in order to progress in his studies. The qualifications are gradualized every year such that the time of study and preparation for examination is smaller in the firsts years than in the lasts. The selected minimum requirements to continue are as follows: if a student finishes year z with x or more approved courses over a total of y possible until this year, then he is allowed to continue during the $z+1$ year with the courses assigned for that year (see Table 2). However, the idea of essential correlativity is maintained for certain courses, i.e., a minimum requirement of correlativity between closely related courses is imposed (as for example between Calculus I and Calculus II, etc.).

Year (z)	Approved Courses (x)	Total Possible (y)
2nd	3	6
3rd	9	12
4th	15	18
5th	22	24

Table 1: Minimum requirements for promotion

Rules for student evaluation

The rules to proceed to the student evaluation were organized in a set of procedures called principles and reglamentation aspects. The principles consider in general that the evaluation of a course or module is performed on the student work throughout all related academic activities (classes, practical home works, labs, projects, reports, etc.) and the qualification can be obtained as a result of different kinds of examination distributed during the course. The recommendation is not to use a unique form of final qualification. Some volunteer examinations are possible with the purpose to allow the student a good accompanying of the courses. The implementation aspects recommend that the evaluation methods must be globally standardized. The results of the evaluation of the students are synthesized in a document called Curricular Act. The qualifications are defined in bands (approved excellent, approved, regular, rejected). In the first two bands the students pass all the requirements of the course. If not within this bands a final examination is in order. The existence of this final evaluation does not replace the previous procedure of evaluation.

Curricular Evaluation

The Curricular evaluation is the annual procedure to analyze the performance of the students, courses or modules and their weight. The main purpose of this tool is to provide academic and statistical evaluation. As a result of this work a suitable snap shot of the behavior of the curricular plan will be obtained and their result will be applied to correct or eliminate problems.

Comparisons and additional considerations

An aspect not discussed yet, but that seems to be essential to the work performed around the curricular modification is to compare the proposal with similar academic offer in different countries.

The American university system has introduced many initiatives to achieve a standard curriculum, but generally the Accreditation Board for Engineering and Technology (ABET) performs global recommendations about minimal contents to be contemplated. In a similar grain that in Canada (with the Canadian Engineering Accreditation Board, CEAB), engineering studies in Electrical and Computer Sciences are organized in four years. In our country the Comisión Nacional de Evaluación y Acreditación Universitaria (CONEAU) is beginning this work, but current results (excepts those of [3]) are not disponible.

European universities are working toward a common academic offer of engineering education [9] but since the diversity is very noticeable, standardization does not seem simple. In spite of that, those European countries as France and Spain have a five-year study organization with a similar flavor to our academic system. This is a evident difference with the four year structure of the American universities. Also, other Latin American countries (for example Brazil) have a similar organization of five years on the undergraduate studies as ours universities.

In can be stated that a considerable difference exist between the Electrical and Electronic Engineering education in our country if compared with other systems related to the graduated engineering education. Traditionally the graduated studies in Argentine were reserved for biological (including medical) sciences and humanistic education, leaving for engineering only not well structured continuing education courses. At this moment there are several initiatives to solve the relative delay in engineering education organization, and many universities are working to organize and support graduated studies and activities [1]. An example is our successful graduate degree in Control Systems [2].

Conclusions

A major modification of the Electronic Engineering curriculum in the context of Argentine education is presented. The main changes introduced are oriented to improve conceptual contents of the curricula and to reduce student permanency at the university without obtaining the academic degree.

Specifically, the key to successful modification of the Electronic Engineering curricular plan as proposed is closely related to the tools introduced. They will be useful to innovate and upgrade continuously the rules,

recommendation and obviously the specific courses discussed previously.

Among the proposed tools, the following ones are relevant

- Control of academic load time.
- Analysis and definition of new electives (courses or modules).
- Control of proposed orientation plans.
- Statistics of the Curricular Acts.
- Upgrade the rules and recommendations related to the students evaluation.
- Close relationship with graduated programs.

Last but not least, the key for the success of the proposed curricular modification is a close following of the performance of the students and the global behavior of the new curricular plan. For that, a special academic commission, composed of professors, students and teaching assistants, is in charge of monitoring all facts related to this new curricula.

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Year	1st period	T[1]	P[1]	S[1]	2nd period	T	P	S
1	Introduction to mathematics	5	3	4	Elem. of algebra and geometry	5	3	4
	Calculus I	5	3	8	Calculus II	5	3	8
	Principles of computers I	3	3	10	Physics I	4	3	9
	Inside the UNS [5]	1	0	0	Introduction to EE [5]	1	0	0
2	Functions of complex var.	5	3	7	Electrotechnic	4	4	6
	Probability and random var.	4	3	5	Logic circuits design	3	3	6
	Electromagnetism	4	3	9	Physic of the solid | Fund. Termod.	5	2	7
	Elective additional module				Measurements lab I [5]	2	1	1
3	Circuits and Systems analysis	4	3	7	Fund. of control	5	3	7
	Introduction to digital computers	4	3	6	Anal. and design of analog circuits I	5	3	7
	Semiconductor devices	4	3	7	Electromagnetic conv. energy	4	2	7
	Measurement lab II [5]	2	1	1	Elective additional module			
4	Anal. and design of analog circuits II	4	4	8	Orientation II [(2)]			
	Digital signal Processing	4	3	7	Orientation IV [2]			
	Orientation I [2]				Elective [3]			
	Introduction Industrial Org. [5]	2	0	2	Elem. of Industrial Safety [5]	2	0	1
5	Orientation III [2]				Elective [3]			
	Elective [3]				Elective [3]			
	Final project [4]	2	6	10	Final project [4]	1	7	12
	Legal Engineering [5]	2	0	1	Elective additional module			

1 Hours per week, T: Tutorial (lecture), P: Practice (lab), S: Study.
2 Required courses for each orientation: Control, Computers and Communication.
The academic load time is associated to each course.
3 Elective courses associated to each orientation.
4 Final project lasts two periods.
5 Additional module.

Table 2: Analytical Program of Electronic Engineering.