ADVANCED SP TOPICS IN AN INNOVATIVE UNDERGRADUATE EE CURRICULUM

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ABSTRACT

The design of an EE curriculum is a uncommon challenge these days. Not only because it is difficult to awaken technological vocations among young students, but also for the complexity of the applied technology courses and their associated high costs. Nevertheless, innovative changes in an EE program senior year in Argentina are developed in this paper, with a focus in Signal Processing specialty.

The approved change in the curriculum meets the accreditation standards for the country and expects to promote the development of R+D groups and PhD programs at the University.

Index Terms— Signal Processing Education. Electrical Engineer Program

1. INTRODUCTION

An educator is someone devoted to give eyes to the blind. If you ever taught unfamiliar topics to young students, you experienced the challenge of catching their curiosity and building significance in their minds.

If the matter of discussion is electrical engineering, the bet doubles. This field of study is rather complex, requiring from the student a large amount of basic preparation. The reason why a teenager decides to follow the engineer calling is sometimes lost among differential equations and Poynting vectors.

If such a student succeeds thru this path under the guidance of enlightened professors, he will be ready for learning application technologies with confidence and some keenness.

At this point of his career he faces another dilemma. What line of work does he prefer? Industry, entrepreneurship or research? Which courses are better suited for that purpose?

An electrical engineer curriculum should be able to answer each question according to country's opportunities; giving tools and abilities to their undergraduates.

A way of satisfying these demands in a country like Argentina is to have a five year EE (Electrical Engineering) program. After graduation their knowledge is "broadband", letting them insert nicely in any kind of business.

As graduate programs are scarce [1], research projects got seldom funds, and industry jobs are not well suited for overrated doctor engineers, there are very few students who pursue a PhD after graduation.

I work at ITBA (Buenos Aires Institute of Technology) located in Argentina's capital city. It was founded in 1959 and since then, thousands of students have received their engineer degree. The major areas are: Electrical, Industrial, Computer Science, Mechanical, Naval, Chemical and Power Engineering. Even though it's a small university of 1700 students, its academic level is accredited by CONEAU [2] with the highest marks.

I started teaching Circuits & Systems and Signal Processing at the electrical engineering department of ITBA many years ago. Since then I always card about the context my courses were taught.

Therefore I was able to adapt the content of signal processing courses to the EE program needs [3] [4].

In other areas, similar syllabus development has been performed.

This movement, along with well equipped labs and strong basic courses in mathematics and physics has contributed significantly to support a robust undergraduate EE program.

But after that, if a student wants to go further, he must choose between a master's degree which is industry application oriented or a doctorate in a subject he is not sure he is interested in.

How can industry invest in research instead of buying cheaper technology goods from abroad? How can I change that?

Well, as a first step, giving eyes to the blind. I'm an educator above all.

Many industry managers are engineer graduates. If we teach them more about research subjects and opportunities before they live campus, they will know in the future that their companies may support university research projects for a good reason.

As an example, if I expected that someday Argentina has start-ups in Signal Processing, I should teach undergraduate students about SP applications before they get their first degree. The same happens with other areas, like telecommunications or bioelectronics.

When I got the EE chair at ITBA, I had the opportunity to sow the seeds, so I began an EE senior year program change.

2. ACTUAL EE CURRICULUM

To evaluate the changes in perspective it is required to describe the real program [5].

In table 1, there is a list of courses that students must take each year. The number of hours required to attend each week is 24, a substantial difference with most American programs.

It is also expected that students spend another 16 hours of study during the week.

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Given this work load, along with lab assignments and other homework, they don't usually take any job during the first four years. But when they are preparing their final project, they are supposed to work at least 3 months in an industry or company, in order to gain some experience outside the university.
The courses with no hours assigned (0) represent those activities carried out in other places than ITBA, but they are mandatory to reach the degree. English language is an example.
When students get to senior year, they have to decide which electives they should attend, but only from each specialization.

1st year (Freshman)			
First Semester		***Second Semester***	
Introduction to Computers	*6*	*C Programming*	*6*
Analytical Geometry	*3*	*Mathematics II (Calculus)*	*6*
Mathematics I (Calculus)	*6*	*Discrete Mathematics*	*3*
Lineal Algebra	*6*	*Physics I*	*6*
Social Science I	*3*	*Learning Methodologies*	*3*
TOTAL HOURS	*24*	***TOTAL HOURS***	*24*

2nd year (Sophomore)			
First Semester		***Second Semester***	
Chemistry	*6*	*Probability and Statistics*	*6*
Data Structures and Algorithms	*6*	*Electronic Materials Technology*	*6*
Mathematics III (Diff. Equations)	*6*	*Mathematics IV (Complex Variable)*	*6*
Physics II	*6*	*Physics III*	*6*
TOTAL HOURS	***24***	***TOTAL HOURS***	***24***

3rd year (Junior I)			
First Semester		***Second Semester***	
Electrotechnics	*6*	*Circuit Theory*	*6*
Physics IV	*9*	*Analog Electronic I*	*6*
Mathematics V (Signal & Systems)	*9*	*Electronic Instruments Laboratory*	*6*
English I	*0*	*Digital Electronic*	*6*
TOTAL HOURS	***24***	***TOTAL HOURS***	***24***

4th year (Junior II)			
First Semester		***Second Semester***	
Industrial Organization	*6*	*Information Theory*	*6*
Random Processes	*6*	*Control Systems*	*6*
Signal Processing fundamentals	*6*	*Microprocessors Laboratory*	*6*
Analog Electronics II	*6*	*Electromagnetism*	*6*
TOTAL HOURS	*24*	***TOTAL HOURS***	*24*

5th year (Senior)			
First Semester		***Second Semester***	
Power Electronics	*6*	*Economy*	*3*
Computer Architectures	*6*	*Law for Engineers*	*3*
Final Project Design I	*3*	*Final Project Design II*	*3*
Elective (T or C)	*6*	***Electives (T or C)***	*12*
Social Sciences II	*3*	*Social Sciences III*	*3*
English II	*0*	*Job Practice*	*0*
TOTAL HOURS	*24*	***TOTAL HOURS***	*24*

Electives (Senior)			
First Semester		***Second Semester***	
Digital Communications (T)	*6*	*Networks (T)*	*6*
Sensors and Actuators (C)	*6*	*Antennas & Propagation (T)*	*6*
		Automatic Control (C)	*6*
		Industrial automation (C)	*6*

Table 1. **ITBA Electrical Engineering Curriculum – 2001-2007**

The actual EE curriculum offers only two choices: Telecommunications (T) or Control (C).
As can be seen from the tables, if a student is interested in signal processing, he cannot choose any elective to get deeper into the subject. He just attends Mathematics V (Signal & Systems) and Signal Processing Fundamentals like all his mates. His only chance to continue with SP is to choose a design related to the area in his final project.
Although a program of 240 total week hours seems challenging, it is regular practice in Argentina, and has been proven to be successful not only with local people but also with exchange students from Europe. It is also a plus that graduates may follow

further studies in North America or Europe without any academic problem.

3. INNOVATIVE SYLLABUS CHANGES

In order to develop master and PhD degree programs of relevance, I began assigning projects and budget to the existing R+D groups. Their names and areas are:

- GEDA (Microcontrollers, FPGA and DSPs)
- CAERCEM (Radio Communications, Antennas and EMC)
- CIDEM (Microelectronic devices)
- LEI (Power electronics and control)

Given that most of these groups have been working for some years in different jobs, the new tasks were considered as an opportunity of professional growth.

Once the groups gained confidence in the subjects they were dealing with, I prepared the curriculum change rooted in their development. It must be noticed that I introduced the changes at an undergraduate (senior) level for the reasons explained at the introduction, but with the purpose of developing in the future robust PhD programs supported by R+D project teams.

Table 2 displays the electives courses for the new senior year specializations. The new areas have more week hours than the former ones, giving a total of 27 for the first semester, and 24 for the second semester. SP area courses have a reference mark which points to the text book associated to it.

Electives (Senior)*: Telecommunications*			
First Semester		***Second Semester***	
Digital Communications (T)	*6*	Antennas & Propagation (T)	*6*
Microwaves (T)	*6*	Networks (T)	*6*

Electives (Senior)*: Mechatronics & Control*			
First Semester		***Second Semester***	
Sensors and Actuators (C)	*6*	Applied Mechatronichs (C)	*3*
Machine Technology (C)	*6*	Automatic Control (C)	*6*
		Industrial automation (C)	*6*

Electives (Senior)*: Signal Processing*			
First Semester		***Second Semester***	
Digital Communications (T)	*6*	(SP) [10]	*6*
Adaptive Filtering (SP) [7]	*6*	Image Processing (SP) [9]	*3*
Neural Networks (SP) [6]	*3*	Speech Processing (SP) [8]	*3*

Electives (Senior)*: Industrial & Power Electronics*			
First Semester		***Second Semester***	
Sensors and Actuators (C)	*6*	Power Electronic Applications (IE)	*3*
Electric Machines (PE)	*6*	Automatic Control (C)	*6*
		Industrial automation (C)	*6*

Electives (Senior) *Bioelectronics*			
First Semester		***Second Semester***	
Biology for Engineers (B)	*6*	Image Processing (SP)	*3*
Microtrasducers (B)	*6*	Bioelectronic devices (B)	*3*
Neural Networks (SP)	*3*	Electromedic equipments (B)	*6*

Table 2. **ITBA EE Senior year Electives Courses – 2008-2010**

Innovations to the curriculum produce interesting consequences that may be summarized as follows:

- R+D project involvement
- Opportunity to explore new areas, unknown to undergraduates
- Reinforcement of accreditation objectives [2]
- Increase of EE vocations, when they glimpse new applications before the end of their undergraduate studies
- Competitiveness among other Engineer careers or other university offers

Although each area has special characteristics and difficulties to overcome, this paper pretends empathizing SP aspects.

In particular the SP specialization has these benefits:

- Introduces students in more advance SP subjects, like Adaptive Filtering, Neural Networks, Speech processing, Image Processing and DSP labs.
- To be eligible to participate in an R+D GEDA project that interacts with industry.
- Give them a chance of designing a final project in the SP field
- To continue studying here or abroad with excellent credentials
- To help us build our SP PhD program.

Those readers interested in course's contents may send me an email and I'll gladly answer their requests.

4. LABORATORY PROJECTS

Motivation comes from action. There is no doubt about it. The new program has courses devoted to labs. Telecommunications has a lab in the course of Microwaves, Mechatronics develop moving systems in the Applied Mechatronic lab. Power Electronic has a course devoted to lab work, Bioelectronic is actually designing its lab. In this context, SP field is not an exception.

DSP/FPGA Laboratory course is intended to develop experiments in the following topics:

- Implementation of digital filters on a DSK platform [11]
- Real-time FFT using DSP/BIOS
- Adaptive channel equalizer
- MATLAB and Fixed-Point C implementation of a Voice Activity Detector
- 2-D Image filtering
- Implementation of digital filters on a FPGA platform [12]

GEDA group has a long experience designing and implementing projects similar to the ones outlined. Former students are also eager to be part of the R+D team to help with the course design.

5. EXPECTED OUTCOME

A survey among current junior students showed remarkable interest in the approach. They were aware that new opportunities as well as innovative challenges were put in their way. None of them showed concern about neither the complexity of the topics they should overcome nor the increase of 3 week hours. These are results that make me fill confident about the program.

Among the prospects I expect an increase of graduates willing to develop certain acquired skills in different paths, such as:

- Entrepreneurs who start new technology business, with highly qualified engineer demands
- Future industry managers who invest in research and development in universities
- Following a PhD overseas, but willing to return and develop research teams in the country.

After graduation students will also serve as contacts of a network which will be able to establish strong links with industry, other universities and research centers.

6. CONCLUSIONS

With the inclusion of certain well defined courses, the EE program described above will profit from motivating benefits.

The R+D groups, already active, will have the chance to develop their respective areas, preparing the new courses, undertaking projects with the students' involvement and acquiring new technologies related to their field of interest. At the same time, this enhancement will contribute to the department goals regarding engineering accreditation, where R+D projects are a must.

From the high school perspective, more eligible applied electronic topics, in touch with the latest advances in technology are important to increase the number of students.

For the faculty, the new course designs generate a different job than the monotony of their well-known lectures. This motivation along with the need of a comprehensive update of information related to the area creates an environment of development.

Students are enthusiastic about the new specialties. They are grateful for the new options offered, but also for the opportunity to explore subjects they would reach otherwise. They find attractive the idea of applying graduate research topics, such as speech processing or neural networks to their final project.

Moreover, the purpose of the curriculum change is to awaken the new generation of Argentinean engineers that R+D is the key to develop the country, a key that is in their hands.

7. REFERENCES

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