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Proposal for Full Integration of Electrical Engineering Undergraduate Programs

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Abstract

Electrical engineering requiring an ability to integrate knowledge from various disciplines - informatics, economics, technology and science- continues to be one of the most popular branches in engineering. Currently several engineering schools are introducing the "project centred learning" method to their educational system in order to “integrate” their curriculum. This approach was suggested by ASEE in a special report prepared in 1962. A survey into the curricula of local universities offering undergraduate programs in electrical engineering will show the difficulties encountered in implementing such an integrated approach, the conventional vision of curriculum development being strongly rooted in the mindset of the administration. One university currently involved in launching an integrated program -similar to the one started in the Drexel University- is hoping to meet the demands of industry in the next century.

I. Introduction

The report on "Characteristics of Excellence in Engineering Technology Education" prepared by the American Society for Engineering Education and published in the year 1962 pinpoints the issues that were considered at the time to be crucial in enhancing the quality of education. Among the issues covered in the report -grouped under the headings: faculty, students, curriculum and courses- the nature of the courses to be offered, is extensively evaluated. In this particular section, a warning is made on how "all too often students view their curriculum as a *sequence of compartmentalized courses* and fail to see how the material covered in the various courses is interretaled". This statement goes very well with the metaphore of "not been able to *see the forest* when one is lost *amist the trees*". Althought the report continues on giving some recommendations to improve this adverse situation, the author as an academician and practicioner of the engineering profession -for more than three decades now- has been always puzzled by the fact that "an integrative approach” for the engineering education is still very low in the agenda of many distinguished institutions [1]

In search for a practical solution to the problem of integration in the engineering education, the author reviewed the papers published by the former Dean of Engineering in the Engineering Faculty of Bogazici University (the former American Robert College) in Turkey. These publications suggest -among many other recommendations- the means to integrate education using a ***"project centred learning"*** approach in education. Paradoxically these recommendations have not been implemeted as yet. To our knowledge only Drexel University can be shown as a showcase, where integration is high in the agenda of the administrations' strategic plans. Based on the above mentioned recommendations, the author tries to present here the experience gained while implemented in his courses an "integrative approach" to engineering education.

II. Needs For Education Reform in Engineering

Changes in education are needed to cope with the pressure emerging from the new technological, economical and social developments. Educational methods applying the traditional disciplinary boundaries are not adequate anymore to solve the industrial expectations of today [2]. Although universities -in order to cope with these changes- have created research centers that work with more interdisciplinary approaches, the discipline oriented departmental system of education has survived. Pressure from existing budget regulations, established professional chambers, perceptions and expectations from the community *prevents* overturning "the pseudo barriers" that exist between departments.

As the economical conditions in the world change, the graduates find themselves coping with altogether foreign problems. Since future developments are unpredictable, continuous learning -a lifelong process- is the solution to the adaptability which is needed when new situations arise. While promoting the teaching the art of applying scientific tools to problems that require the use of natural resources for the convenience of men, an education system should develop the ability of *self learning* in the suggested "common fields of activities". Unfortunately the fact that textbooks are written along disciplinary lines, the need to brake the disciplinary barriers is blocked. The gradual removal of barriers can be accomplished by gearing all the available resources to a reduced number of basic headings [3].

Trying to make changes in education to cope with current developments by simply revising "here and there" old methods of teaching is dangerous. Professionals who are required to have the ability of communicating with others, are expected to find economical, practical, durable, innovative, aesthetic, safe, clean solutions to human needs. Students must have experience in applying the basic principles to real problems, whatever this problems may be in the next decades. This requirement is at odds with the traditional education system which is based on formal lecturing. *Radical changes* are thus necessary: the assignment of projects can provide the proper environment for the students to develop the abilities to solve real problems [4].

In a more recent work Yerlici -interested in the philosophy of engineering education- suggests the need of introducing in the learning process, the concept of innovative thinking by implementing *honor programs*. The evaluation system in this programs should include a) real life projects selected by the students that will help assuring the continuity of study and b) comprehensive examinations on the combination of several topics covered during the education process. Students enrolled in this programs should be encouraged to make use of computer centers, laboratories and libraries and evaluated by a special committee headed by a tutor [5].

As a final measure of reform, Yerlici -clarifying his *vision for the future*- proposes that higher education should a) improve the ability to question and seek for answers, b) sharpen the vision of details, c) refine the mind for greater sophistication at interpreting data and encourage independent thinking by allowing students observe masters do their research work. Although specialization and research can help students develop this ability, excessive costs are incurred when research is used as a tool for teaching. While providing the basic knowledge good teachers should stimulate the minds of their students in the direction of “critical thinking” and “creativity”. Research activities, vital for raising funds and building public image that will attract better students, should not hinder the efficiency of teaching activities [6].

III. First Experience Gained in Integration

While investigating the possibilities integrating the engineering education curriculum as suggested in the previous section, the author was for the first time in his career asked to give a course in Automatic Control. An adequate textbook was searched that could to be used during the semester from an excellent collection of automatic control books, available in the campus library. One was found to be a good compromise between the very sophisticated and the very simple ones. Following the outline of the selected book proved to be very frustrating, so a different strategy was adopted that would encourage students to use books, proceedings, journals and other documents available on campus. To assure a steady flow of information, students were requested to make a weekly reports on their findings and the instructor presented the summaries of these reports in class followed by weekly short quizzes (see Table 1.).

During the first weeks of the course students were allowed to choose freely the topics using the excellent examples provided by Dorf [7] as a starting point to their work. Eventually the instructor provided titles for specific assignments to avoid duplication. The study of “*mobile robots*” -including perception by sensors, cognition by intelligence and behaviour by actuators- was strongly encouraged since it provided a very complete coverage of the automatic control field. Considering the high intellectual level of articles in the journals, the instructor suggested the students to study the *introduction* of each article -to describe the aim of the work, avoiding the mathematical modelling- and the *conclusion* to see the possibilities for future work. Backtracking cited bibliography in each article proved to be an interesting academic effort. Since contributions were graded immediately, an atmosphere of competition -and in some cases of group work- soon developed [8]

The implementation of the new educational strategy described in the previous paragraph encouraged the author to prepare papers on the subject of automatic control. The first experience was the research on the co-ordinated operation of two robots operating in security providing mission, based on work about multiagent intelligence [9]. Students were informed about these developments and encouraged to cooperate. A conference on Intelligent Manufacturing Systems provided the opportunity to present another paper on mobile robots [10]. Consequently students were asked to survey preselected articles in the IEEE Journal of Robotics and Automation which provided the whole class with very motivating information. This first experience shows that instructors a) should be aware of the principle -as argued by Kelly [11]- that human beings have a natural drive to act like a *scientists* and b) must become models to students on how to do research work. We wish to report here that one university currently involved in launching an integrated program -similar to the one started in the Drexel University- is hoping to meet the demands of industry in the next century.

Table 1. Outline Proposal for a Automatic Control Course

Week	**Area**	**Lecture**	**Laboratory**	**Project**
1	Introduction	Outline	Documentation	Library
2	Modelling	Components	Basic	Drilling
3		Parameters		Milling
4		Simplification		Processing
5	Stability	Time-response	Application	Radar
6		Frequency-response		Crane
7		(cont)		Robot
8	Compensation	Phase-lead	Input/output	Car
9		Phase-lag		Ship
10		Design		Aeroplane
11	Fieldtrip	Mechatronics	Airflight-simulator	Powerhouse
12	Conclusion	Classical	Digital	Modern

IV. Further Work on Integration

While experimenting on ways to make an engineering course more attractive to the students, the author embarked in the risky journey of integrating the whole electrical engineering curriculum using this time another of Dorf's monumental work [12]. An *integrative approach* to learning requires that all human knowledge from the atom to the universe be encompassed under one single umbrella [13]. With the advent of the new science of Mechatronics this search has become even more challenging [14]. The fact that a Biomedical Engineering Institute has been in full operation since two decades now, suggested -as described in Figure 1- the idea of using this emerging field as an example for full integration.

In a recent seminar one of our former students Tutumluer [15]-when reporting the research work on pavements in airport runaways now under consideration in the University of Illinois- encouraged the university community to brake the disciplinary barriers. Such a research includes besides the evident work on pavement material from the civil engineering point of view, the study of rubber properties in the tires, the landing system control and strength of materials respectively in the chemical, electrical and mechanical engineering fields (see Figure 2.). This seminar showed the importance of incorporating research work findings in the main stream of the educational activities.

A survey into the classical electrical engineering -which in many cases incorporating also computer engineering- programs show the existance of a similar curriculum patterns. A freshman year covering basic sciences, a sophomore year for introductory courses, a junior year of specialised courses in the main areas -namely computer, control, communication and conversion-

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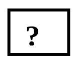
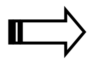
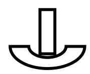
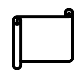
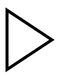
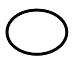
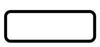
	Symbol							
Sensory		db	Defness		Hearing-aid			
Nervous		EGG				laser		
Tissue (Hard)		MRI						weekly
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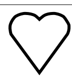
Cardiovascular		#/sec	hypertension			pharmacology	pulsing	
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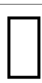
Tissue (Soft)					silicon			

Figure 1. Integration of Biomedical Engineering Disciplines with Examples of Different Body Anatomic Sections

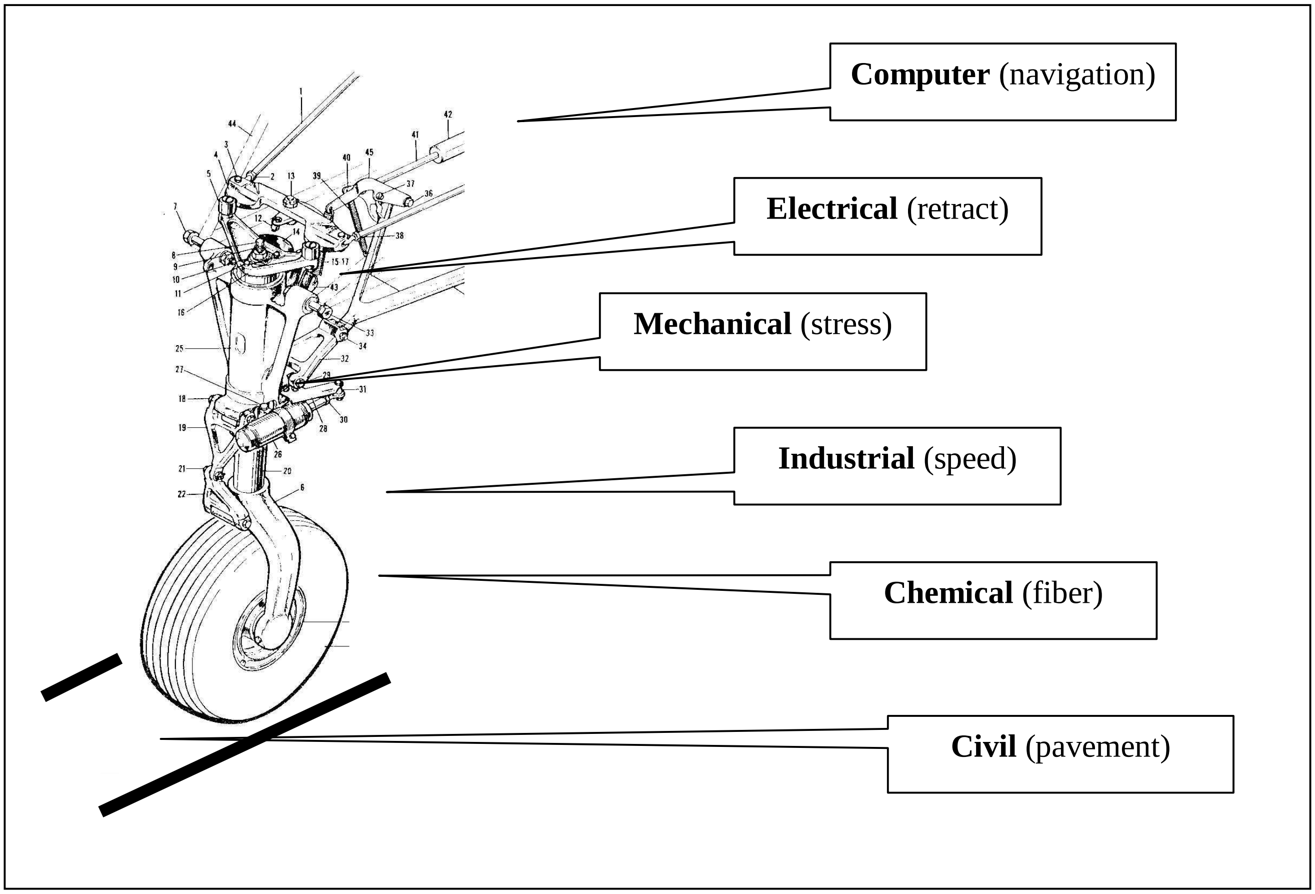


Figure 2. Integration of Engineering Undergraduate Curriculum Example (landing system)

and the last undergraduate year devoted to project related issues. All courses are unfortunalely geared to find the same solution to well defined problems using *pre-determined formulas.* We feel that a curriculum which only considers design work -so essential in the engineer practical life- in the very last year, cannot provide the students with the necessary skills they will need in the real world. To replace this old fashioned system a novel approach to curriculum development is here suggested.

We strongly feel that the IEEE publications -covering a large variety of subjects- can offer very valuable sources of information to undergraduate level students. Even if one single subject is selected as a project to be developed during the undergraduate years- i.e. airplane landing device- all the main topics in electrical engineering can be fully covered. Success in such an approach depends on the ability to show the logical, electrical and magnetic *circuits* of one single *device* in the context of the main system (the *airplane landing* device being an example of an *air transportation* system). This approach will encourage a learning process aiming at securing the students's commitment for a *long-life education.* Person-to-person contact -which can be greatly enhanced during extra curriculum activities- is a prerequisite in a "project centered fully integrated" undergraduate program (see Figure 3.)

		Circuit		**Device**		**System**			
				Computer	*memory*				
		Logic	*gate*	Conversion	*generator*				
		Electric	*amplifier*	Communicat.	*antenna*				
		Magnetic	*wave*	Control	*digital*				
		Electrical				Transport	*sea*		
ATOM	*helium*					Energy	*nuclear*	**UNIVERSE**	*galaxy*
		Mechanical				Processing	*textile*		
		Fastener	*spring*	Fluid	*piston*				
		Coupler	*clutch*	Solid	*brake*				
		Driver	*gear*	Thermal	*heater*				

Figure 3. Integration of Electrical and Mechanical Engineering Disciplines in a Mechatronics Framework

It is important that engineering students realise that the undergraduate program is an integral part of the "big educational picture". Students embarking for a undergraduate program should have an understanding of engineering materials, process, systems and economics before they start high level education [14]. Some students -having succeded in learning the engineering design skills- will hopefully venture in the graduate programs. The aim of a) the *master* (mainly focusing in research and development and experimentation of emerging practices) and b) the *doctorate* level education (concentrating in modelling and verification of new theories) should be clear at the start of the career.

V. Conclusion

The experience gained by the author while attempting to find the means of *integrating the engineering curriculum* to meet the demands of the community in the next century [16] is summarised in this paper. We strongly urge that instructors make sure they motivate students to cope with the requirements of a profession that is recognising no boundaries between various disciplines [17]. A close look at the *Subject Headings of the Library of Congress* (under the classification of TK for electrical engineering) will provide a broader view of the available literature. Hoping that the experience shared here will prompt others to follow the same footsteps and remove the drawbacks that originate from implementing a novel educational model in one course only.

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