REFLECTIONS ON ENHANCING THE QUALITY OF ENGINEERING EDUCATION

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Abstract *¾ We are observing a trend where there is a reducing interest for the engineering profession and an increasing penetration of "learning providers" in the education market. A sweeping reform in the content and method of engineering education is long due. Actively participating in engineering education international conferences has encouraged the author to review his approach towards teaching. We hope that a "collaborative reflective work" on these changes will help in creating a more effective learning environment.*

Index Terms ¾ collaboration, integration, innovation, life-long-learning.

INTRODUCTION

This works attempt to summarize the experiences gained while the author introduced changes in the approach to teaching engineering inspired by the contributions made by the participants in several international education conferences. Changes were started when in 1995 it became clear that a) "*industrial companies were challenged by the rapid pace of technological innovations in consumer product market*" and b) due to the short life cycle of technological products, industrial development was only possible by the "*acquisition, fusion and diffusion of new technologies generated from basic research*". Since investment on research and development is today more important than investment on capital, it is now necessary that new strategies be implemented. Some of the new strategies implemented by industries are:

- Fusion of different technologies,
- Establishment of the research centers,
- Public financing of research,
- Promotion of technology transfer,
- Adoption of new educational policies.

As a consequence of these new strategies, industrial development now require that schools, a) change curricula so to include more technology than science, b) give more stress to continuing education, c) promote joint research projects with industry. Kaynak and Sabanovic argue that only if cooperation between university and industry is properly implemented, universities may be able to meet the expectations arising by rapid technological changes. Although today research in some areas -such as control, communication and biomedicine- require a high degree of specialization, a more general approach could help to bridge gaps and generate new development [1].

BACKGROUND

As the author became aware of the issues on engineering education described in the previous section while participating in a conference on university/industry/goverment collaboration. There he argued that NGOs such as foundations, associations chambers and unions, should be involved in the enhancement of the quality of education [2]. His first contribution in this direction was in 1998 during the UICEE conference in Cracow with a paper giving the results obtained by implementing hand-on design to mechanical engineering fresmen students [3]. As students started asking questions about the reasons for having to take the courses thy were assigned, the author developed new ideas about the integration of courses forming part of the undergraduate engineering curriculum.

Interest for engineering education grew further when it was clear that a four year undergraduate program was not enough to cope with the needs of industry: "life-long-learning" was then the only feasable alternative. As a consequence the students had to be made aware of the fact that the education process will actually never end [4]. In order to develop a "life-long-learning" program, establishing a partnership relation with industry stood high in the agenda of the author. The first formal contact for collaboration was established in 1999 with some promising results which were reported in an international conference [5].

Although it was not possible to get further support of other industries, the author meanwhile assigned his 48 freshmen students specific topics that where generated by the cross tabulation of *sensory, nervous, tissue (hard), respiratory, cardiovascular, gastro-intestinal and tissue (soft)* topics with *measurement, diagnosis, design, manufacturing, treatment, simulation and monitoring* topics [6]. Students had to present progress reports every week on their work after selecting the variables, deciding the equations, fixing the memories addresses and registers to be used and actually writing/tracing the program [7].

Some of the ideas that were developed during the dialogue with participants in the international conferences -reported in the previous paragraphs- were implemented in the actual teaching. Results are summarized in following section. The support of peers and superiors in now pledged.

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RECOMMENDATIONS

In this section we present some recommendations that are the result of reflections on the concerns about the future of engineering posed in many educational and industrial quarters. These recommendations are based on the experience gained in the past five years. Table I presents the reasons and possible solutions to the discontent that can be observed in the three partners of engineering education. Historical data provided by employers such as the example given in Figure 1 can encourage candidates to join the career which they consider having many hardships.

The design approach as the one given in Figure 2 shows clearly that there is room for a variety of subjects that can be covered in an undergraduate program. Educators discontent arises from the conflict due to the "time competition" for educational and research assignments they are expected to fulfill. We argue that by conceptually mapping the research work with the topics given in Figure 3 and covered in the curriculum, reconciliation and full integration between the two activities is possible. In Table II an extract from the work of the late Prof.Kriton Curi is given as an example.

As described in Table III, each year of the undergraduate program should have a specific focus in which the candidates should be expected to concentrate. Figure 4 shows how parametric design can give some flavor of engineering practice by making simple calculations. During the sophomore year, education should be focused on the laws derived from scientific findings implemented in cases such as Figure 5. Synthetic approach to design by the integration of data should then be the focus of the junior year (see Figure 6). In Figure 7 and 8 we give a recent example of how the senior year could be devoted to product development. Some selected topics for design are covered in Table IV.

Employers have an important role to play in the enhancement of the quality of engineering education. Some suggestions for their participation as they become members of the academic boards, are given in Table V. As suggested in Table VI, sound policies can make the collaboration between all the educational parties a reality. We hope that proper dialogue can make the course outline proposed in Table VII an enduring possibility. By establishing a formal and informal network between the parties, peers and superiors new ideas can be put forward an implemented with time.

CONCLUSION

We wish to conclude by refering to Dr. Hernaut concerns about the engineering education [14]. As in his case industry representatives should take a leading role in the enhancement of engineering education. Our economical survival is closely related to the new knowledge that can be generated through the contributions of "innovative ideas" by the young generations [15].

ACKNOWLEDGMENT

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TABLE I
STUDY OF PARTNERS DISCONTENT

Partner	Discontented	Solution
Employer	Knowledge gap	Historical data
Candidate	Career hardships	Design approach
Educator	Interest conflict	Conceptual map

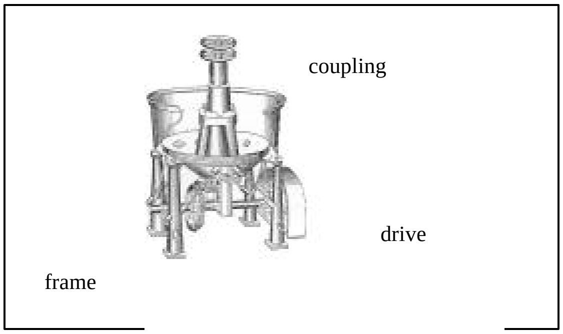

Fig 1. DEVICE FROM THE 19TH CENTURY
(from Knight [8])

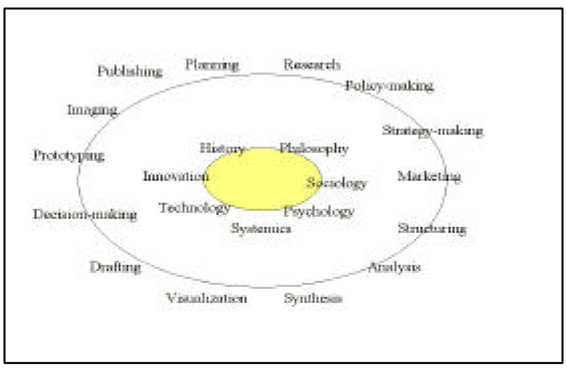

Fig. 2. ENGINEERING KNOWLEDGE BASE
(after ITT ID)

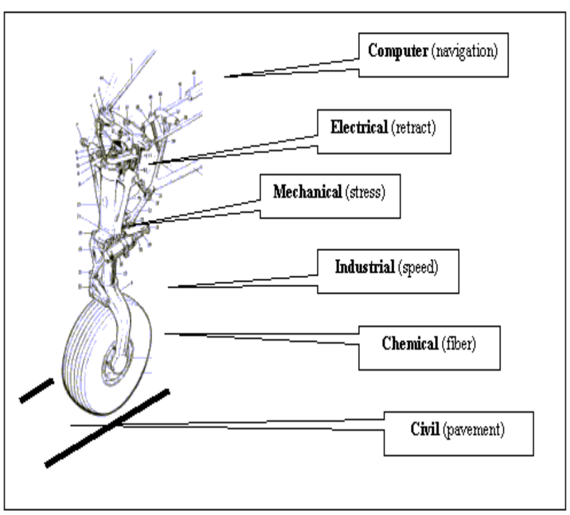

Fig 3. INTEGRATION OF CURRICULUM
(after Tulumluer [9])

TABLE II
ENVIRONMENT ENGINEERING PUBLICATIONS

Year	Area	Design	Location
74-1	Water	Filtration	
74-2	Water	Assimilation Model	River
74-3	Water	Pollution	River
74-4	Solide	Collection	Hospital
74-5	Water	Solid-Liquid Separator	
74-6	Water	Sewage Disposal	City
74-7	Water	Filtration Mechanism	
74-8	Water	Declining Flow Rate Filter	

(from Reference [10])

TABLE III
FOCUS ON UNDERGRADUATE EDUCATION

Year	Approach	Remark	Fig.
Freshmen	Descriptive	Parametric design	4
Sophomore	Analytic	Engineering laws	5
Junior	Synthetic	Data integration	6
Senior	Innovative	Product development	7

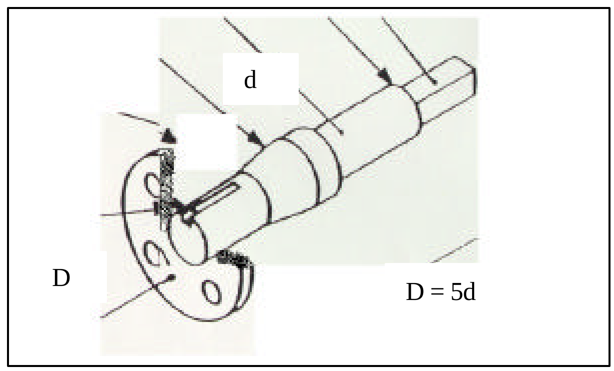

Fig. 4. PARAMETRIC DESIGN
(from Dogus University, Istanbul (Turkey).)

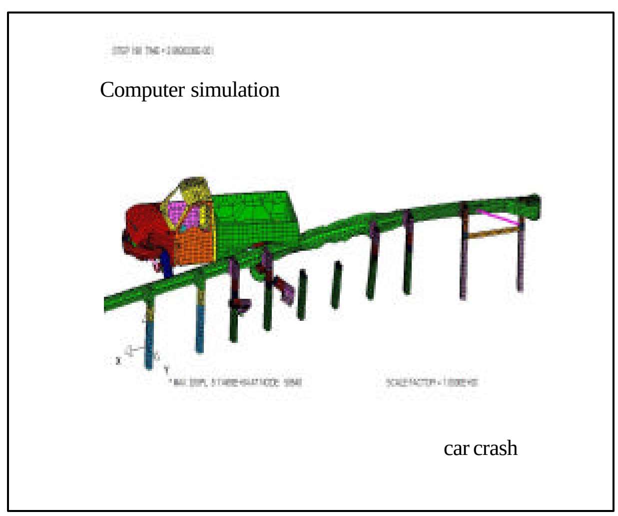

Fig 5. ANALYSIS OF A PROBLEM
(courtesy of S.A.Kilic)

Fig. 6. STUDENTS IN A SITE
(from Dogus University, Istanbul (Turkey).)

Fig. 7. STUDENTS DEVELOPING ITEMS
(from Dogus University Istanbul (Turkey))

Fig. 8. STUDENTS DEVELOPING ITEMS (II)
(from Dogus University Istanbul (Turkey))

TABLE IV
OBJECTIVES OF VARIOUS DEPARTMENTS

Field	**Example**	**Emphasis**
Mechanical	Conveyor	Component design
Electrical	Robot	System control
Chemical	Reactor	Unit operation
Industrial	Plant	Optimization and simulation
Civil	Bridge	Stability and vibration

TABLE V
CONTRIBUTION OF EMPLOYERS

Type	**Remark**	**Ref.**
Portfolio assessment	Contractual learning	[11]
Working environment	Team teaching	[12]
Progressive design	CAD implementing	[13]

TABLE VI
MODEL FOR PARTNER COLLABORATION

Government		**Engineering**	
	Objectives		Design
	Incentives		Operation
Education		**Industry**	
	Motivation		Resources
	Learning		Directives

TABLE VII
AUTOMATIC CONTROL OUTLINE PROPOSAL

#	**Topic**	**Lecture**	**Project**
1	Introduction	Outline (Library)	
2	Modelling	Components	Drilling
3		Parameters	Milling
4		Simplification	Processing
5	Stability	Time-response	Radar
6		Frequency-response	Crane
7			Robot
8	Compensation	Phase-lead	Car
9		Phase-lag	Ship
10		Design	Aeroplane
11	Fieldtrip	Mechatronics	Powerhouse
12	Conclusion	Classical	Modern