Social Sciences in Engineering Education

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INTRODUCTION

The last decades of the twentieth Century have introduced a large number of novelties to all fields of science. This fact has had a direct implication on many societal issues such as the vision we historically had about engineering and engineers. This has also influenced the way decision makers are approaching engineering education. The need for adopting new approaches and new trends are emerging in order to fill the gap between the "final product" of our schools of Engineering and the social expectations we are encountering. This paper focuses on Lebanon as a case study. Lebanese schools of Engineering are well established, internationally recognized, and have a massive number of their graduates employed in both the MENA and the Arab regions. This is why we consider that our conclusions may be relevant to future research.

1 WHAT IS "ENGINEERING" TODAY?

1.1 Origin and development of the term

The term "engineering" comes from the same Latin origin for the word engine. It means designing and constructing. While the usage of the term has witnessed an important development through the last three centuries, it has remained very close to its origin that is, applying the knowledge of pure science, mainly in construction, where, the term construction is not restricted to buildings.

1.2 Actual extension of the usage of the term

In the last few decades, the term engineering has become very generic and has been used to describe organizational work that goes from the conception to the implementation of projects related to different types of knowledge. On one hand, there exist today university majors with Engineering curricula where the classical definition does not apply, Genetic Engineering being an outstanding case. On the

other hand, taking into consideration the specializations formally recognized by professional bodies (like the Order of Engineers in Tripoli - Lebanon), one could find 260 different specializations under 6 categories. While 5 of these categories are well defined, covering all the specializations and sub-specializations of civil, architecture, electrical, mechanical and agricultural engineering, the 6th remains unnamed covering all other specializations. This is to say that the term is semantically under development and needs to be clarified.

1.3 Multiple expectations due to a new semantic field

It is normal for the expectations of the different groups of the society to change with this widening of the use of the term “engineering”. While the origin of the term is still nearly the same, the outputs are no more driven by pure science in its basic definition, but are more and more related to the concept of designing, understanding the structure, and constructing the links within any type of science. Engineering seems to have become an applied science for all sciences.

This new paradigm influences also the outcomes expected from engineers in the work market. The fact that a new semantic field of the term “engineering” is emerging has a direct impact on the expected deliverables. This slow but steady shifting from “applied pure science” to “applied science plus managerial skills” is irreversible and challenges the well-established engineering curricula.

1.4 What is the impact of change on the engineering curricula?

The ABET program outcomes (a-k) [1] are considered in many countries as the main reference for the engineering curriculum design. In addition, decision makers try to adopt and implement an ABET outcome curriculum model ultimately aiming for international recognition. While the items “g” and “j” are concerned with general education (communication skills and contemporary issues), all other criteria focus mainly on “engineering” as an applied science by it.

To illustrate this fact, let us recall the results of the project launched by the “Foundation Coalition”[1]. It states “the project found limited resources for both instruction and assessment of ABET a-k outcomes” ([2] p.1). Efforts were done to enhance engineering education using new learning methodologies and developing high mental skills. But a major change is to be expected from the “Engineer of 2020” initiative of the National academy of Engineering, which mentions in its “Phase 1 Report” nine expectations for engineering graduates that go beyond the a-k ABET outcomes.

2 THE NEW EXPECTATIONS OF THE HUMAN ENVIRONMEMNT

2.1 Expectations of the engineers themselves

In order to obtain the engineers’ feedback on the curriculum they have studied, a questionnaire was designed. The main objective of this questionnaire is to identify the possible gaps/deficiencies in engineering education as perceived by the graduates based on acquired work experience.

A testing of the preliminary version of the questionnaire that is compiled by the authors has been conducted with feedback collected from 25 engineers having BS, MS and PhD degrees. Based on the analysis of this feedback, a final version was adopted. With no particular sampling, the questionnaire was sent through the Faculty of Engineering Office using their alumni database. Some of the faculty members

[1] http://www.foundationcoalition.org

were involved in this preparatory work. An independent team, from the statistics laboratory, analyzed the collected data. The authors went through this analysis and read it critically, comparing it to other articles in similar literature.

The questionnaire was sent to about 700 engineers, holding a BS, MS or PhD in Engineering. PhD holders earned their degree in foreign universities mainly in Europe and North America. BS and MS holders earned their degrees mainly from different engineering schools in Lebanon. But it is to note, that due to the Ministry of Education and Higher Education directives, all these schools have a high degree of similarity in their curricula. Accordingly, we did not consider the university granting the degree as a survey parameter.

268 answers were received. 86 % of them are graduates from Lebanese institutions and the majority is working in the MENA and Arab regions. The table below shows the result to the question: *In your practice, have you felt the need for additional training?*

Table 1. Needs' perception

Category	Number of answers	Never	Sometimes	Often
BS	34	3	19	12
MS	220	26	142	52
PhD	14	5	7	2
Total	268	12.7%	62.7 %	24.6 %

The figures in Table 1 show that 88.2% of the MS holders, who are the regularly registered engineers, feel a high need for additions to the curriculum. The PhD holders are the ones who feel less this need (5 out of 14), mainly because they are involved in academic work and are not usually exposed to the same working environment. On the other hand, 91.2% of the BS holders feel the urgency of such additions.

2.2 Expectations of the managers

In an article published in the European Journal of Engineering Education, E. Ramadi et al [3] tried to answer questions related to the satisfaction of the MENA region managers with the engineering graduates, in terms of skills, gaps between expectations and satisfaction, and preparedness for employment. For the purpose of the study, 36 skills were listed. The study concluded that: "gaps were reported in all 36 skills ([3] p. 17), and "that recent graduates may not have been sufficiently prepared for employment immediately upon their graduation" ([3] p. 13).

Comparable conclusions were reached in similar studies done in India [4] and Australia [5]. The three studies recommend a revision of the curricula of the Engineering schools giving more attention to skills that are not usually considered an integral part of the Engineering education.

2.3 Expectations of the social milieu

As mentioned earlier, the scientific community developed the new semantic field of the term "engineering", but other factors influenced the way it is actually received by the social milieu at large. Nowadays, higher education institutions are graduating technicians and technologists who are mostly driven by the applied aspect of science, while the social milieu expectation for engineers is mostly driven by design issues, problem solving related to what is expected by a specific environment, and by managerial skills. These three issues constitute common background to the different

types of engineering (not only as applied field of pure science); hence the need arises for developing courses that will enhance the performance of the engineers in the society. R.L. Meier et al, reached comparable conclusions in 2000 [6].

In twenty unstructured interviews with community actors (mainly head of municipalities, social workers, and parents), in responding to how they perceived the engineers as social actors, they unanimously agreed on these new expectations, stressing the fact that the technical component and the applied science vision is no more the unique aspect of the societal demand.

3 WHAT IS LACKING?

3.1 The engineers' feedback

In order to describe better the engineers' needs, we asked them to prioritize their choices on a scale from 1 to 10. The tables below summarize the percentages of their first and second choices of the 234 engineers who have answered "often" or "sometimes" on the Need question.

Table 2. Distribution of the first choice

Category	BS	MS	PhD	Total percentage
Business & Management	18	112	2	56.4
General Knowledge	0	12	0	5.1
Psychology	1	2	2	2.1
Philosophy	1	3	0	1.7
Sociology	1	1	0	0.9
Arabic Language	0	7	0	3.0
Foreign Languages	1	8	0	3.8
Communication	7	17	2	11.1
Finance & Economy	1	12	2	6.4
Others	0	12	0	5.2
Total	30	186	8	224

Table 3. Distribution of the second choice

Category	BS	MS	PhD	Total percentage
Business & Management	4	31	3	16.2
General Knowledge	5	21	1	11.5
Psychology	1	4	0	2.1
Philosophy	2	4	1	3.0
Sociology	3	6	0	3.8
Arabic Language	0	7	1	3.4
Foreign Languages	1	16	0	7.3
Communication	2	51	2	23.5
Finance & Economy	11	46	1	24.8
Others	2	5	0	3.0
Total	31	191	9	231

For the sake of analysis, the following table shows the comparison between the percentages of the categories that score the most and the least:

Table 4. Percentages comparison

Rank	Business & Management	Finance & Economy	Communication	General Knowledge	Foreign Language	Philosophy
1	56.4	6.4	11.1	5.1	3.8	1.7
2	16.2	24.8	23.5	11.5	7.3	3.0
3	6.4	25.6	23.9	11.5	14.5	3.4
4	3.8	11.1	19.2	19.7	11.1	3.8
5	5.6	11.1	5.1	18.4	17.9	3.0
6	1.7	7.7	2.1	15.4	13.7	12.4
7	1.3	3.8	4.7	8.1	11.1	15.4
8	2.1	4.7	3.4	3.0	10.7	24.8
9	3.0	4.3	3.4	4.3	8.1	26.1
10	3.4	0.4	3.4	3.0	1.7	6.4
Total	99.9	99.9	99.8	100	99.9	100

These tables show clearly that the engineers' needs in the field are shifting from the applied pure sciences, as stated in the classical definition of engineering, to a more business-oriented paradigm. The strength of an engineer is no more based on his technical abilities but also on other skills that are either not covered or is very poorly covered in the schools' curricula. Even if tables 2 and 3 show a high preference towards business and financial issues, table 4 illustrates the fact that communication and general knowledge are still two important aspects to be taken into consideration while proposing new learning outcomes to the curriculum.

3.2 The managers' feedback

E. Ramadi et al ([3] p.17) in their recommendations mentioned two main issues to be enhanced in the engineering schools curricula, namely time management, and communication, with emphasis on the importance of language as an essential tool for presenting and defending ideas. While considering that the 36 skills of the study have to be enhanced in the engineering schools, it seems that the priority given by the engineers themselves does not coincide totally with the managers' feedback.

This is totally understandable because the managers try to stress skills that they consider as priority for their operations, the engineers try to pinpoint skills that will help their advancement in their career. Nevertheless these two complementary points of view lead to the same conclusion: Revising the engineering schools curricula is becoming a must and simultaneously ensuring the proper assessment of the implementation process.

3.3 The social science dimension

The social milieu expectation issue presented above in section (2.3) has its own requirements in terms of curriculum content. It is clear from the E. Ramadi et al article [3] and from the tables 2 to 4, that engineers and managers are not emphasizing its urgency. While philosophy, psychology, and sociology are essential to any community engagement, the degree to which the engineers are not yet aware of the implications of this new societal paradigm is shown by the table below:

Table 5. Philosophy, Psychology and Sociology percentages

Rank	Philosophy	Psychology	Sociology
1	1.7	2.1	0.9
2	3.0	2.1	3.8
3	3.4	5.1	3.4
4	3.8	12.4	5.6
5	3.0	15.8	8.1
6	12.4	13.2	17.5
7	15.4	15.4	22.6
8	24.8	11.5	23.9
9	26.1	12.0	10.7
10	6.4	10.3	3.4
Total	100	99.9	99.9

Engineers are asked to work in different human environments, each of them having its specificity. They are called upon by managers to have better communication skills. At the same time, apart from the General Knowledge (table 4), the importance of acquiring essential knowledge in social sciences is not stressed. In fact some Engineering programs like the University of Queensland, or Tufts, or Pittsburgh, or Macquarie introduced philosophy courses even in the undergraduate program of Engineering. But in order to structure any revision of the curricula, we should specify the reasons and the means of such changes.

4 HOW TO MEET ALL THESE EXPECTATIONS?

4.1 The competencies approach

In order to respond to these expectations, what does the revision of the engineering curricula entails? Keeping in mind that a curriculum is not the sum of its courses and it is not equivalent to its content, we may probably have to envisage a fundamental change. As mentioned above, the work market does not require engineers to be merely technicians or technologists. To be creative, responsive to the emerging needs, and able to perform in constantly varying conditions require a totally new set of competencies in social sciences that will complement the classical learning outcomes, and emphasize the importance of multidisciplinary and high mental skills.

Redesigning the curricula while keeping in mind what learning outcomes will be needed to acquire the expected competencies is perhaps the new educational approach to adopt. The a-k ABET's students outcomes fail to address sufficiently these new needs as they are driven by a pure science approach inherited over the centuries. Even with the expansion nowadays of the communication technologies, a call for a drastic change to include social sciences as an indispensable component of an engineering curriculum is urgently required.

4.2 The social sciences component

The mobility in the global work markets today, the different settings in which engineers perform, and the different types of objectives engineers pursue are enough reasons to consider introducing social sciences into the curriculum. But the pedagogical question remains as to the objectives and the learning outcomes that engineering schools will adopt. The importance relies on linking the engineer's competencies to the social sciences, as part of his/her ability to analyze social

situation, to propose adequate solutions, and to communicate the proper implementations.

Social sciences will not be new subject matters in the content list. They have to be considered as part of the core courses that any engineer will have to master. The difficult issue remains in how to give this indispensable part of the curriculum its value?

4.3 The cognitive dimension

The answer to this crucial question is in the cognitive dimension of the approach. Once more the new learning methods will help a lot in finding the techniques that will be best adapted to the needs. When the social sciences and the different proposed changes become part of any problem-based (or project-based) learning then the engineers will be employable "immediately upon their graduation" ([3], p. 13). Linking social sciences, communication, business and management to the new learning strategies is a must if we need to respond the described needs.

To implement such strategic trend, engineering programs will have to revisit the competencies' list students will master upon graduation. New competencies with adequate assessment, within a multidisciplinary approach to engineering education, will then have to be included.

5 WHAT IS THE ROLE OF THE INTERNATIONAL ENGINEERING COMMUNITY

5.1 The standardization issue

The identified needs to be implemented in the engineering curricula may differ from one country to another. The importance of the Lebanese case lays on its typology. It can be considered as unique in the Arab countries due to its diversity; to it's opening to different higher education systems, and to its international relations. Lebanon is a small country with a historically significant higher education tradition, and the graduates of its schools of engineering seem to be very much appreciated in the world market. Initiating the above mentioned changes in a country like Lebanon is not easy: i) The decision makers will be faced by the standardization of the engineering curriculum to meet mainly the requirements for international recognition and/or accreditation, ii) The pursuing of graduate studies abroad will be hindered, and iii) The global market is still driven by the well-established classical criterion.

While the envisioned changes are highly needed from the Lebanese perspective, to launch a new approach that takes into consideration this new paradigm is almost impossible.

5.2 The accreditation open perspective

In order to get out of this dilemma, we have to look at the standardization – accreditation requirements as a win-win situation. On one hand the international agencies will have to revisit their criteria and their outcomes on the basis of such experiences; and on the other hand, countries like Lebanon have to develop their own strategy on the basis of the internationally recognized patterns by linking them to elements based on their needs and cultures.

If the issue of Social Sciences is stressed here, it is because of the urgency of the needs. In fact, literature published in Europe and America shows that this perspective is global, but some schools of engineering and accreditation agencies are not quick to adopt such new orientation.

5.3 The international efficiency dialog

It is important to give international dialogs on Engineering Education the means to become efficient and fruitful. We consider that we have to move from the era of ideas' exchange to establishing pilot projects in order give the future promotions of engineers the possibility to be as strong social actors as they are good scientists.

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