These papers submitted to the congress is a publication of the WFEO Committee on Education In Engineering, addressed to engineering educators, educational officers at Universities and leaders responsible for establishing educational policies for engineering in each country. The articles it contains reflect the concern of people and institutions linked to WFEO, to provide ideas and proposals with the object of improving formation of engineering education.

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Mobility of Engineering Professionals — What have we achieved Globally

Dr Peter Greenwood
WFEO Vice President

I’m going to talk about three main things strongly linked to the theme of this conference:

1. The World Federation and its role in engineering education and training and societies needs
2. Life-long-learning or whole-of-career education and training and where we have got to—a sort of score card, and
3. What we need to do from now on

World Federation of Engineering Organizations (WFEO)

The Engineering World

Introduction

WFEO has about 80 national members covering about 16 million engineers. We facilitate our members’ activities and their involvement in WFEO and we represent them at the global level, to agencies such as the UN and UNESCO, WTO, OECD, World Bank etc.

WFEO’s Vision is:

WFEO is the internationally recognized and chosen leader of the engineering profession.
WFEO cooperates with national and other international professional institutions as the lead profession in developing and applying engineering to constructively resolve international and national issues for the benefit of humanity.

**Our Mission is paraphrased in Slide 2.**

Five of the nine activities in our mission are particularly related to mobility of engineering professionals for example:

1. To represent the engineering profession internationally, to assist National agencies …. And address the most critical issues affecting nations of the world.

2. To enhance the practice of engineering.

3. To make engineering information available to countries of the world, facilitating communication of world’s best … to WFEO Members.

4. To foster socio-economic security and sustainable development and poverty alleviation among all countries of the world, through the proper application of technology.

5. To cooperate with Funding Agencies such as development banks

**Standing Committees — our STCs**

WFEO has ten standing committees that are the foundation of WFEO’s technical activity, made possible by the involvement of technical experts from our various members.

The Standing Committee on Education in Engineering (CEIE) has a Working Group on The Mobility of Engineering Professionals.

**The Mobility of Engineering Professionals**

WFEO is very interested in the Mobility of Professional engineers because we see it as part of our mission.

WFEO believes that as far as possible all engineers should have a recognized degree and be recognized by some accepted organization as competent experienced engineers capable of independent practice.

To do this we have cooperation agreements with the International Engineering Alliance, Eur-Ace and FEANI, which is also a member of WFEO. These organizations have
multi-lateral agreements, which are supplemented by bi-lateral agreements between individual nations.

**Our partners are shown in Slide 3**

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**WFEO POLICY ON MOBILITY**

- WFEO believes in generic attributes for graduate and competent engineers ...
- Recognizes the role of the world’s accreditation and mobility organisations ...and
- Pledges to support their activities to maintain ... qualifications and professional standards.
- WFEO will encourage the recognition of graduate attributes and professional competencies for engineers by the United Nations, governments and
- Other international agencies involved in the provision of engineering goods and services.
- WFEO will provide a source of information for all stakeholders in the competent, ethical practice of engineering and
Facilitate exchanges between people and organizations involved in engineering activity.

**There are two key outcomes from the policy:**

1. WFEO will cooperate with international and regional agencies involved in accreditation and assessment by showcasing their activities and facilitating our members’ involvement, and

2. WFEO will publicize the work of our cooperating agencies in our representation role through our contacts with other global organizations.

The policy is based on a position paper and a more recent information paper which can be downloaded from our website.

These documents were prepared by the CEIE Working Group.

We also have a Model Code of Ethics, which was prepared by the STC on Anti-Corruption (CAC).

In our future work we will encourage and facilitate our national members in Africa, the Middle East and Southern South America in their efforts to participate in international or regional accreditation and assessment activities.

**Registration or Certification**

WFEO, among others, thinks that only about 20% of engineering work around the world is done by engineers needing registration or some sort of certification.

The other 80% may not be in a position to benefit from the attributes and competencies of the formal system.

However, there are a number of other reasons why engineers, employers and governments may be interested in engineers having a recognized professional standing. There are 12 reasons in the WFEO paper, mentioned above. Most of the reasons are different to the need to be regulated but are very important to individuals, employers of engineers and the providers of engineering products and services. Slides 6 & 7

List of reasons why engineers want to achieve recognized professional standing, nationally or internationally Slide 6
1. To become registered and capable of doing particular engineering work, which is often covered by legislation.
2. To do any work requiring an engineer in those countries where the title “engineer” is legally protected.
3. To use it in an immigration application.
4. Individual engineers want the personal satisfaction of knowing they have achieved a certain standard.
5. Companies want to measure their engineers in an independent system.
6. Governments know companies have the intellectual capital and people to complete engineering projects.
7. Development and funding agencies can satisfy themselves that the engineering—human resource risk is acceptable.
8. Professional standing includes a commitment to practice ethically and competently.
9. Managers, banks and insurance companies want to reduce engineering risk.
10. Specific skills are identified more clearly than the engineer’s qualification title or main discipline.
11. To work in disaster relief.
12. Work in certain industries like nuclear power engineering that are becoming more regulated.

**WFEO also believes in Lifelong learning and Continuing Professional Development.**

My first point by way of introduction is: Life-long-learning is critical to the success of the engineering sector and we as providers must continue to provide LLL and CPD throughout an engineer’s career.

These points and LLL/CPD are vitally important to the mobility of professional engineers. The best illustration of this I am aware of—and the latest over the years—is shown in Slide 5, courtesy of Hu Hanrahan, Chair of the Washington Accord.

**Engineering Practitioner Career**
An interesting aspect of this slide, adapted from the original, is the place for active and inactive retired engineers.

Retired active engineers are a valuable, but often ignored, part of the work force when engineers are in short supply.

And, we forget inactive retired engineers at our peril. They are still interested in engineering, they still inspire young engineers and can come back to haunt us if we ignore them and make mistakes.

Active and inactive engineers are also valuable to WFEO and other learned societies—the profession—for their participation in governance and technical roles.

**Scorecard**

So how do we as a profession score our performance on the whole—of—life scale for developing good engineers?

**Green Zone Now:**

In the green zone, the performance is pretty good. Stage 1 has graduate attributes and two internationally recognized Accords (EUR-ACE and the Washington Accord) with moves by them to cooperate to remove differences.
Their accreditation processes are not prescriptive, but participation does require a process that is: “substantially equivalent” to those of the other signatories and has been satisfactorily peer reviewed.

Stage 2 is pretty well covered too. We have competencies, and two main internationally recognized agencies (with mutual recognition agreements), using the competencies to assess candidates for engineering registration (FEANI and the IEA). There are moves by the international agencies to cooperate on improvements and mutual recognition. As with international accreditation, the processes are based on “substantial equivalence” and peer review.

There is some assessment overlap related to International Registers, beyond Stage 2. It is also common with international registration to have bi-lateral agreements between jurisdictions to cater for special needs and requirements.

There are a few regional and other initiatives in accreditation and assessment, including universities and regulatory approaches that most likely are “substantially equivalent” but which have yet to be peer assessed.

The international assessment of competency and ability to practice is well established. However, it is the first assessment of engineers after their education and training. It can therefore be considered as the assessment establishing the foundation of an engineer’s career, which might be in regulated or unregulated engineering work. In either case, it gives the engineers themselves a quality mark that they can carry during their careers provided they adhere to the CPD requirements and practice ethically and competently.

Some nations have competencies for specific areas of practice including academia, but they are not yet used widely and there are only a few examples of this.

Industry already has a role in the preparation of attributes and competencies, but there is room for a greater, more strategic and more structured contribution.

**Green Zone Next:**

1. We need to encourage and help engineers working in the 80% unregulated area of engineering work.
2. We need more involvement and cooperation from the missing nations, and
3. We need to up---date the reasons for regulating, examine the work presently not regulated e.g. financial engineering and
4. We need to improve everyone’s understanding of the meaning of regulation.
   It is about:
   a. Public and work place safety and
b. A level playing field in the delivery and receipt of engineering products and services (called Asymmetry of Knowledge). It is not about:
c. Restrictive trade practices or restraint of trade.

5. We need to consider whether, in codes of ethics for professional engineers or elsewhere, we should cover economic and environmental impacts. There may be more. And

6. We need to review the relationship between learned societies, universities and industry. Each part of the engineering sector must be involved in defining the future nature of engineering work, the qualifications and competencies needed and how to deliver training. We’ll be lucky if the answers are right but at least they would give some conception of what might emerge.

7. When we have informed ourselves and reached some sort of consensus, we can make a start on informing governments and the general public. Do these two groups want detail they don’t understand because engineers have lost their trust in what we do and the way that we do it?

**Red Zone now:**

There are two main difficulties in the Red Zone. Firstly, the additional experience required to be on an international register probably only amounts to two years at the beginning of perhaps 40 years of professional practice. So it could be said to be part of Stage 2.

Some diagrams call “Professional Practice” Stage 3. It might even be divided further into Stages 4 and 5, which would cover the need for even greater engineering expertise and finally greater management expertise.

Secondly, the engineering practice stage is recognized mainly by engineers and employers doing the 20% of engineering work thought to require registration.

Only a small proportion of nations participate in the international multi-lateral agreements and the vast majority of engineers are not involved. That would include a significant proportion of the 16 million engineers alone represented WFEO National Members. Many of those engineers have no quality mark and would find it difficult to practice other than where they were assessed.

In addition, beyond the Registration category, the assessment processes do not yet include mid—career engineering or engineering—management competencies.

At this point in an engineer’s career, some are involved in advanced engineering work. They lead small specialist teams or manage projects of significant value.
Other engineers work as engineering middle managers and may also contribute to company management. The major proportion of engineers however will still be involved in mostly technical engineering work.

Higher degrees, advanced training and technically-orientated management degrees are all available to mid-career engineers. However there are no corresponding competencies in the process so it may be that the advanced education and training is more suitable for the “Expert” rather than the “Experienced” category. The “Management” category deals with this by covering the later years of the “Experienced” category and the “Expert” category.

Engineers involved at the highest levels may be involved in the biggest projects or activities in construction, manufacturing or research for example. In management they would be involved at the enterprise level and might require corporate governance training or qualifications.

**Red Zone next**

Supposing that this is where some engineers start to exchange some engineering for some management in their work profile, new training and experience are needed. We need:

1. Recognition of the developing circumstances.
2. Appropriate attributes and competencies. Leading to different quality marks.
3. Appropriate CPD and assistance in maintaining competencies.
4. Industry inputs, more than ever, which should include sharing knowledge and experience with company Human Resource staff, preferably in a formal way.
5. New alliances with like organizations in other disciplines. And
6. To use this knowledge to anticipate changes in the nature of engineering work and the consequential changes in education and training.

**Yellow Zone Now:**

The new, interesting part of this slide is the Yellow Zone for active and inactive retired engineers.

Why retired active are engineers a valuable paid addition to the work force when engineers are in short supply. At the end of their careers, their training and experience could include any aspect and level that I have discussed above.

Apart from doing engineering or engineering management work they are an invaluable source of mentors, again across the whole range of possible recipient engineers, particularly at senior levels. In fact they have been used as temporary replacements for
senior staff, even CEOs, in certain circumstances. Many other examples are available, such as helping to get a start-up project off the ground.

Active and inactive retired engineers help WFEO and other learned societies in governance and technical roles. Some may want to do the same sort of work they did professionally but many are prepared to try new activities, given some modest training. They are also indispensable and mostly unpaid contributors to the work of the accreditation and assessment agencies and the services that those agencies provide to their signatories.

Yellow Zone next:

A lot of what I have said is breaking new ground as far as accreditation, registration and the work of learned societies are concerned. So we need to begin with:

1. Recognition of the situation
2. Consideration of how the engineering workforce and employers are affected and involved with what we might call Stages 3, 4 and 5
3. Flesh out the whole of career approach
4. Consider what education, training and experience might be needed
5. Consider how industry and employers can be involved, particularly training professionals within companies and
6. Offer mentoring and other training to facilitators.

In Conclusion we must:

1. Believe that cooperation is critical in the coming environment.
2. Bring key stakeholders together to share their knowledge and needs.
3. Start with past knowledge, experience and mistakes for what we need in the future.
5. Regulate more appropriately.
6. Inform our “clients”.

WFEO In its belief that good professional engineers are vital to engineering activities and to society in general looks forward to cooperating with like organizations to achieve these outcomes.

No matter how speedily we address these matters, we should have the big picture in from of us. Without the big picture, we may proceed from the little picture in the wrong direction.
WFEO’s website has the Mobility policy and 2 information papers in the CEIE archive.

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www.wfeo.net.org for policy, info paper and update

Thank you Slide 9.
THE "STANDARD" CORE AND GENERIC GRADUATE COMPETENCES FOR ARGENTINE ENGINEERS AND THE MEASUREMENT OF INSTITUTIONAL EFFECTIVENESS

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Abstract

Modern society understands college graduates as competent human beings (with a set of skills), able to practise their professions within the reality that surrounds them. The level of competences accomplished by graduates is an indicator of the quality of academic education at universities. Both universities and society need to know how effective they are in providing their professionals with skills. Consequently, it is imperative to measure institutional effectiveness in training; in other words, the degree of achievement of competences expected by graduates.

The Federal Council of Argentine Engineering Deans (CONFEDI) established a set of core and generic graduate competences for Argentine engineers, according to the appropriate developmental level at the beginning of their career path. This specification of graduates' basic competences also serves to assess and facilitate the process of recognition of academic activities developed in different institutions for exchange programmes and national and international academic mobility between accredited institutions.

This paper presents the set of standard core and generic graduate competences for Argentine engineers and represents the first study in Argentina to measure institutional effectiveness in the training of engineers. The paper attempts to help and motivate other universities to carry out their own assessments and share their experiences.

Keywords: Engineering competences, Engineering skills, organizational effectiveness, organizational effectiveness measurement.
1. **Introduction**

New paradigms, such as knowledge society, globalization, social networks, and the current economy make up a particular scenario that requires new forms of exchange and communication. The world has changed and still changes, and present society demands more from universities: not only training ("knowledge"), but also the acquisition of professional competences (skills) to their graduates (the "know-how"). This is clearly seen in the Bologna Declaration of 1999 and the declaration of "education as a public responsibility" of the Salamanca Convention 2001.

The old paradigm of professional training based on teaching as a mere knowledge transfer scheme that students will know how to articulate and implement effectively has been losing ground in today's reality. In the current vision of society, the college graduate is a competent human being (with a set of skills), able to practice his profession within the surrounding reality.

The International Commission on Education for the Twenty-First Century, convened by UNESCO and directed by Dr. Jacques Delors, through its report (known as the Delors Report) (1) proposes that "education throughout life is based on four pillars: learning to know, learning to do, learning to live together, learning to be", issues that become the base when thinking, designing, implementing and evaluating skills training processes.

In Argentina, "there is consensus that an engineer must not only know; the engineer also must know-how. The know-how does not arise from the mere acquisition of knowledge but it is the result of the commissioning functions of a complex structure of knowledge, skills, abilities, etc., which needs to be explicitly recognized in the learning process and must include pedagogical activities for the engineers' development"(2).

Davini defines competition (skill) as a "long-term process that involves the incorporation of explicit and implicit ways of thinking, valuing and acting in different social environments". Furthermore, he states that professional development includes continuous, interactive and cumulative learning, which combines multiple learning formats (3).

In a competences-based education, the explanation of the skills sought by professionals becomes "the goal", and determines the academic curriculum (class materials, content, activities, modality of teaching), the profile of teachers, the teaching techniques, etc. The need to get "competent beings" in relation to "the goal" results in that the whole process of training should change, above all, it should be conceived and practised as a process of acquisition of skills to students (and, eventually, to graduates). That is, it seems the greatest and inevitable challenge of engineering schools these days in Latin America.

According to Verdejo "To have valid and reliable assessment tools and processes at different times of training, requires that the institution provides structural, organizational, institutional policy and program strategies, consistent with the approach of professional skills."(4)
In this context, each university in the first place, and society in general, wish to know how effective they are in providing engineers with relevant competences. It is therefore necessary to define the competences (skills) expected to be developed in the professional level. Then, the institutional effectiveness in the training of such competences can be measured, i.e., the degree of achievement of these competences by graduates. The present work is a great opportunity for research and development, and is practically essential in the assessment of institutional quality and continuous improvement of the academic units, where graduates (the product itself), who are the ones to provide their feedback, are fundamental in the process.

To measure effectiveness, it is necessary to have a "standard" as a reference. Therefore, the deans of Engineering Schools in Argentina have met with their national association, the Federal Council of Argentine Engineering Deans (hereinafter CONFEDI) and have synthesized and agreed on ten generic core competences desirable for any Argentine engineer. These skills are, in fact, "the goal" to be achieved by the Schools of Engineering in Argentina, in relation to the competences that they must provide to their engineers-to-be.

An interdisciplinary research team, composed of professionals in Engineering and Science Education at FASTA University, carried out an unprecedented research project to determine the degree of achievement of those competences expected in the life of the graduates of FASTA’s Faculty of Engineering. This research (hereinafter "research") consisted of the study of the perception of the graduates of the academic unit (the sample included 48% of graduates) about the level of competences acquired throughout their training.

2. **Competences**

First of all, the present research will start from the notion of "competence" proposed by Perrenoud: A competence enables a person to adequately carry out a set or family of tasks and situations, using the concepts, knowledge, information, procedures, methods, techniques and also other more specific competences (8).

Le Bofert assimilates this competence to "knowledge application": Possessing knowledge or skills does not mean to be competent. We can know about the technical or management accounting rules, and not know how to apply them at an opportune time. We can know the commercial law and draft bad contracts. Experience shows that there are people who have knowledge or skills and cannot apply them adequately and in a timely manner in their work. What is known in a singular context (marked by labor relations, institutional culture, chance, time constraints, resources...) is indicative of the "step (transition)" to achieve the competence, which is realized in action (9).

In this sense, competence is conceived as an act or performance to be achieved by the students (having some basic knowledge) often aided by the teacher; but they finally must learn to act by themselves, according to the specific requirements of their profession and their range of opportunities.
CONFEDI confirms that many of the competences proposed are skills/facets. This definition implies the use of complex and integrated capabilities related to knowledge (theoretical, contextual and procedural) and linked with the knowing-to-do (formalized, empirical and relational), which refers to the professional context (understood as the environment where the professional must act or exercise). The above definition also highlights the expected professional development (understood as, how a technically competent and socially committed professional acts) to which ethics and moral values can be incorporated (2).

In this paper, the term "competence" is considered as synonymous of the term "skill" (in English).

2.1 Engineering Competences

"What means a teaching oriented to engineering competences development?" (2)

To encourage the development of competences, it is required from the onset to be specific about which competences should be considered in all engineering studies.

It involves thinking about engineering training from the axis of the profession, i.e., from the professional exercise, considering what all the engineers should be able to do in different scenarios of their professional and social development in the early years of their professional performance.

Brailovsky (10) states that "competence" is a construct only partially accessible through measurable aspects, such as knowledge, technical skills, attitudes, problem-solving skills, reasoning and communicative abilities, among others. CONFEDI makes some observations regarding skills, which explains the different "proficiency levels" of competences along the academic path. It also raises the question of the necessary comprehensive training that goes beyond the technical training, and which is essential to keep in mind when evaluating.

An important aspect of the definition of generic core competences for recently graduated Argentine engineers is to distinguish Professional Competences from Graduate Competences. Graduate competences are developed through pre-professional practices by students along the path of the curricular academic studies aimed at training them for effective job placement. This implies a certain level of development or degree of mastery of the competences of recently graduated engineers. In contrast, Professional Competences are developed through several years of professional practices and therefore represent a subsequent and higher level of development or degree of domain.

From the point of view of competences development, the educational purpose of the career curriculum should be defined by the Graduate Competences, which are key to effective job placement. Since these competences refer to the recently graduated, they attempt to give a degree of development suitable but not optimal (since that would require work experience),
which is why acquiring an acceptable level is possible, even if not all the capabilities involved are achieved.

2.2 Classification of Engineering graduate competences (recent graduates) (2)
The classifications of competences carried out by experts are varied and are based on several criteria. Thus, there are no univocal categories. For example, the model of Professional Competences posed by Huerta Amezola (11) establishes three levels: Basic, Generic and Specific. Other studies, like the so called Project Mecesup (Program for the Improvement of Quality and Equity in Higher Education) organize the competences into four large axes: General, Crosscurricular, Specific and those of foundational Know-how (12). In this work, only the classification adopted by CONFEDI will be considered.
CONFEDI, when referring to "Generic Competences", alludes to those behaviors that are more universal, in this case, all those actions that have to do with the professional activity of any engineer. "Specific" competences refer to the activity that a particular engineer must acquire, according to their field of study. Based on this criterion CONFEDI distinguishes: GENERIC COMPETENCES: which are those professional competences common to all engineers. SPECIFIC COMPETENCES: which are the professional competences common to the engineers from the same field of study (i.e., Environmental Engineering, Computer Engineering, Industrial Engineering and Electronic Engineering, among others).

2.3 The process to achieve the "standard" core and generic graduate competences for Argentine engineers.
CONFEDI have worked for two years to agree on the set of generic core competences for Argentine engineers. To this end, several meetings and workshops with experts were held and the final document which was agreed upon has become the national "standard". Among the criteria considered for the final drafting of the "standard" core and generic graduate competences for Argentine engineers included: amplitude (conceptually integrating the different perspectives of production, trying to achieve greater inclusion of contributions), clarity (expressions used are as clear as possible in plain language wherever possible), precision, conciseness, depth and coherence.
The "standard" core and generic graduate competences for Argentine engineers were approved by the assembly of CONFEDI in the city of Bahía Blanca, in October 2006.
2.4 The "standard" core and generic graduate competences for Argentine engineers

CONFEDI has made a careful selection of what they consider the fundamental core and generic engineering graduate competences in Argentina. They, as a whole, make up “the standard” to be achieved by the provision of skills in Engineering Schools of Argentina. They are as follows (2):

**Technological Competences**

1. Competence to identify, formulate and solve engineering problems.
2. Competence to conceive, design and develop engineering projects (systems, components, products or processes).
3. Competence to manage, plan, execute and control engineering projects (systems, components, products or processes).
4. Competence to effectively use the tools and techniques of engineering.
5. Competence to contribute to the generation of technological developments and / or technological innovations.

**Social and attitudinal competences**

6. Competence to communicate effectively.
7. Competence to act ethically, with professional responsibility and social commitment, considering the economic, social and environmental business in the local and global context.
8. Competence to learn continuously and autonomously.

Once again, we must clarify that it is assumed that the core and generic graduate competences are not exactly the so-called "Professional Competences". Those skills will be developed in the graduates' professional exercise (as suggested by CONFEDI).

2.5 The specification of core and generic graduate competences for Argentine engineers

CONFEDI concluded a set of ten core and generic graduate competences for Argentine engineers, each one specified or divided into two simple and integrated levels of capabilities. So for a given competence, the model adopted is:

1. Competence XX (Generic / Specific)
   1.a. Associated Integrated Capabilities
   1.a.1. Component Capabilities

A generic example:

1 Competence to ..........

---

1 In this paper the term "competence" is treated as synonymous with "skill", but in Spanish they have different meanings. "Competencia" is the correct term in Spanish.
This competence requires effective articulation of various capabilities, among which may be listed:

1.a. Capability to .......... 
This capability may include, among others:
1.a.1. Being able to .......
1.a.2. Being able to .......

An example:

3. Competence to manage, plan, execute and control engineering projects (systems, components, products or processes)

This competence requires effective coordination of various capabilities, among which may be listed:

3.a. Ability to plan and execute engineering projects

This capability may include, among others:
3.a.1. Be able to identify and obtain or develop the necessary resources for the project.
3.a.2. Be able to plan the different stages in managing the objectives, methodologies and resources involved to meet the project
3.a.3. Be able to program in sufficient detail the times of execution of the works, in accordance with an investment plan
3.a.4. Be able to run the various stages of a project according to the objectives, methodologies and resources involved to meet planned allocating resources and responsible
3.a.5. Be able to manage time, human, physical, financial and technological resources for the fulfillment of the planned
3.a.6. Be able to solve problems that arise during implementation.
3.a.7. Be able to communicate progress and final report of engineering projects.

3.b. Ability to operate and control engineering projects

This capability may involve, inter alia:
3.b.1. Being able to operate, inspect and evaluate the progress of engineering projects to verify compliance with goals and objectives.
3.b.2. Being able to detect deviations in compliance with technical standards, health and safety, quality, etc., And to produce the necessary adjustments.
3.b.3. Being able to identify the need and opportunity to make changes in programming.
3.b.4. Being able to make decisions for changes or failures in engineering projects.
3.B.5. Being able to control the adaptation of changes and emerging alternatives to the original project.
3. **The research**

3.1 **Background research**

Since the transformation of Higher Education in Europe (called the Bologna Process), different projects had been carried out between Europe and Latin America for the analysis and evaluation of university practices that serve as background to this study. Amongst them: the "Tuning" (5), "Project UEALC 6x4" (2004-2007) (6) and the study PROFLEX (2006-2009) (7).

3.2 **General Objective of the research**

The overall objective of the present study was "Measuring Academic Effectiveness from the self-preception of FASTA University Engineering graduates, based on the set of generic core competences for Argentine engineers, as defined by CONFEDI.

From the results of the perception of engineering graduates in relation to the competences acquired during the university education, it can be analyzed how these competences are present in the proposed curriculum and it is possible to design measures to improve institutional effectiveness.

In this context, the institutional effectiveness is related to the proposed curriculum, so considering the survey’s results some aspects of it might be changed. For example, redesigning studies' plans may help in academic improvement and to increase effectiveness in the acquisition of competences. Rethinking plans under this perception, make careers authorities try hard to find a way to fulfill expectations of many involved parties, not only government, but also students, graduates and the employment sector.

To sum up, the question that guided the research was, specifically: What is the perception of graduates of the competences developed during their training at the university and to what extent this contributes to evaluate the academic effectiveness of FASTA University Faculty of Engineering.

4. **Methodology**

The research was conducted through a "self-administered" survey with questions regarding the set of graduate competences proposed by CONFEDI. The survey consists of more than 30 questions, many with multiple choice answers, using Likert scales. The survey is applied and completed only via web.

Among other questions about general aspects, there were several questions regarding the competencies, none of them was faced directly. Several questions were constructed to measure the perception of the graduate about his or her degree of achievement of each competence.

The research surveyed graduates from Environmental Engineering and Computer Engineering at FASTA’s Faculty of Engineering, between 2006 and 2010, obtaining a sample of 104 individuals determined by their voluntary response.
The investigation conducted by an interdisciplinary team of researchers (three of them from the area of Science of Education and another three from the Engineering area), allowed permanent triangulation in relation to the concepts and steps followed throughout the theoretical and field work.

The main instrument (survey) was validated in terms of content and as a construct, based on the selection of the ten generic skills developed by CONFEDI, including some of the capabilities unbundled to detect if competition was recognized by the graduate. Some of the capabilities on other competences were used as distractors.

The 80% of the survey items used to measure the extent to which graduates perceive to have obtained the competences, respond to Likert scales. The instrument was validated by Cronbach's alpha coefficient of internal consistency, which reached a value of 0.768.

The survey was anonymous and all the necessary steps to maintain this condition was carefully considered as well as the privacy and security of data and of the results obtained. A random access unique code was generated to each user. The responses were stored by a code unrelated to the user.

A web-based system used for the administration of the survey was programmed in PHP and MySQL database. The invitations and reminders were distributed by email, including a brief description of the project and its objectives, and a web address to access the survey. All data collected in the survey was statistically analyzed with XLSTAT.

5. **Research conclusions**

It should be noted that the indicators obtained for institutional effectiveness in terms of the generic competences acquired by graduates were very satisfactory. The overall results were:

<table>
<thead>
<tr>
<th>Competence</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Competence to identify, formulate and solve engineering problems</td>
<td>52.50%</td>
</tr>
<tr>
<td>Competence to conceive, design and develop engineering projects (systems, components, products or processes)</td>
<td>65.75%</td>
</tr>
<tr>
<td>Competence to manage, plan, execute and control engineering projects (systems, components, products or processes)</td>
<td>62.50%</td>
</tr>
<tr>
<td>Competence to effectively use the tools and techniques of engineering</td>
<td>72.75%</td>
</tr>
<tr>
<td>Competence to contribute to the generation of technological developments and/or technological innovations</td>
<td>58.50%</td>
</tr>
<tr>
<td>Competence to work effectively in teams</td>
<td>84.10%</td>
</tr>
<tr>
<td>Competence to communicate effectively</td>
<td>78%</td>
</tr>
<tr>
<td>Competence to act ethically, with professional responsibility and social commitment, considering the economic, social and...</td>
<td>77.71%</td>
</tr>
<tr>
<td>Competence to learn continuously and autonomously</td>
<td>65.13%</td>
</tr>
<tr>
<td>Competence to act with an entrepreneurial spirit</td>
<td>53.00%</td>
</tr>
</tbody>
</table>
Further to the analysis of the results of individual competences, those results obtained from the competences at large were also investigated. These indicators were also gratifying for our Institution. From the analysis of the Pearson correlation matrix and table of p-values it can be inferred that some competences are strongly related to each other. Competence 6 with competence 7 (0.724); competence 9 with competence 10 (0.709); competence 5 with competence 9 (0.558) and finally competence 2 with competence 7 (0.486).

This paper aims to share the experience with other institutions and university managers to motivate reflection and debate on the subject and replication thereof in other institutions. The experience is a valuable research in itself. Its process, analysis and design methodology are, in short, the real contribution to the university management, in particular, in the field of Engineering.

6. Conclusions

Argentina has a "standard" set of core and generic graduate competences for Argentine engineers, with the consensus of all the engineering colleges of the country. That is an essential aspect when considering and measuring institutional effectiveness throughout such competences.

The perception of the degree of acquisition of skills by graduates is an useful and representative tool to measure institutional effectiveness.

If "forming competent beings" is the actual challenge of engineering schools, it requires changing the current model of training to a competence based one. Therefore, this research represents a significant contribution for the analysis, design and implementation of the process of change.
Acknowledgments

The authors would like to thank the entire research team, in particular Dr. Mónica Prieto, Director of the Interdisciplinary Team. Special thanks also go to FASTA University Observatory, which contributed to the statistical analysis of the survey results, in particular to Prof. Mónica Pascual.

References

[6] 6X4 UEALC Propuestas y acciones universitarias para la transformación de la educación en América Latina (http://www.6x4uealc.org/site2008/pre/03.pdf)
AUTOMATED COURSE ASSESSMENT TOOLS USED AT THE LEBANESE INTERNATIONAL UNIVERSITY

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Abstract

This paper aims at presenting the automation of the course assessment in the multi-campus common exams Lebanese International University by introducing two dynamic Excel based tools. The first one is the course section grading tool used by the instructor to evaluate students and generate the scores of the course and program student outcomes as well as an assessment report. The second tool is the statistical tool that collects all class sections data and provides a statistical report including the course outcomes scores and the score of each program outcome. The coordinator uses this report to analyze the results, synthesizes the instructor recommendations, and proposes corrective actions to close the loop of continuous improvement. The results of all courses are to be included in the yearly program assessment report and the self-study report.

Keywords: ABET, multi-campus, spreadsheet, academic assessment, change management.

1. Introduction

The Lebanese International University (LIU), founded in 2000, is the largest and fastest growing private university in Lebanon. Presently, LIU has around 20,000 students enrolled in its five schools: Pharmacy, Engineering, Education, Arts and Sciences, and Business. This figure represents 13% of the overall number of students enrolled in private higher education institutes in Lebanon [1]. LIU’s School of Engineering (SoE) has approximately 3,000 fulltime students enrolled in the following programs: Surveying, Mechanical, Biomedical, Electrical, Electronics, Computer, Communications, and Industrial. With campuses spread across major cities and geographical regions throughout Lebanon, LIU has become the fastest growing university among the country’s 45 private higher education institutions. LIU also has expanded regionally (Arab
countries) and internationally. LIU presence spans Yemen, Senegal, Morocco and Mauritania [2]. Currently, more expansion is planned both locally and internationally.

Over the course of two years, the SoE revised the syllabi of all offered courses in light of the programs learning outcomes. Moreover, clear statements of these outcomes and methods of assessment were developed. Understanding that the success of such process depends on the comprehensive implementation of a learning outcomes approach in higher education [3], the SoE put together a plan to align this effort with ABET (Accreditation Board for Engineering and Technology) guidelines in an attempt to seek accreditation in the future. ABET is recognized as the worldwide leader in assuring quality and stimulating innovation in applied science, computing, engineering, and engineering technology education [4].

As this initiative started to be implemented, it became evident that automated assessment tools were needed in order to sustain, evolve and improve it. Two software tools were developed in-house in a joint effort between SoE instructors and undergraduate senior project students. The first one was the course grading tool which primarily involves a control to create an activity grading sheet for each conducted evaluation activity in each class. It also computes the score achieved by each course outcome (or performance criteria PC) and the course contribution score to the program student outcomes (PSOs). The tool generates an assessment report where the instructor provides his or her assessment and proposes corrective actions. The second tool was the statistical tool that collects all class sections data and provides a statistical report including, among others, the overall average, median, mean, percentile grades, the PC and PSO scores, and an overall assessment report. One of the main objectives was to avoid the pitfall where educators, researchers, and institutions devote time and resources to develop educational innovations, many of which are not adopted widely [5]. This paper will present these tools and their features in details with special focus on the advantages they provide for multi-campus universities administering common course activities.

2. Issues at Stake

Student performance assessment has always been a challenge especially at the university level. It usually involves processes that identify, collect and prepare data to evaluate the attainment of student outcomes and program educational objectives. But assessment alone is not sufficient. It must be complemented by a formal evaluation through processes for interpreting the data and evidence accumulated through the assessment processes [6]. This process would also be instrumental to align with ABET criteria when seeking accreditation. Furthermore, it contributes significantly to quality control and assurance.

A major challenge at LIU is the fact that it is a multi-campus university. Processes usually need to be applied at all campuses according to policy and regulations. The management of such an effort by course coordinators and chairs is pretty intense and involves a high risk of human error. This is especially true when instructors are using a variety of tools or sheets for class management. It must be noted that the introduction of the new tools is still new and has prompted
some resistance to change from faculty. Therefore, additional effort was needed to cope with the change and manage it to ensure smooth introduction, faculty buy-in and adaptation.

### 3. Proposed Solution

The automation of the course assessment is based on two dynamic Excel Tools. The first one is the course section grading tool which is mainly composed of a control to create an activity grading sheet for each conducted evaluation activity. Within this sheet, the instructor can map the elements (questions, presentation components, etc.) to specific PCs which leads to determining how each student and the entire class perform against the PCs. This serves as an interim on-going assessment report in order to identify weaknesses and take remedial actions. By the end of the course, the overall section assessment report is generated. The instructor uses this report to analyze the results and propose corrective actions.

The second tool is the statistical tool that collects all class sections data and provides a statistical report including, among others, the overall average, median, mean, and percentile grades. It also generates an overall course assessment report containing the COs scores and the score of each program outcome. The coordinator uses this report to analyze the results, synthesizes the instructor recommendations, and proposes corrective actions to close the loop of continuous improvement. This tool can be used at any time of the semester to monitor, track and control the course performance.

#### 3.1. The Course Section Grading Tool

The course section grading tool (the grading tool) is a set of spreadsheets that provide templates for instructors to record student and course related data. At the beginning of the semester, the course coordinator feeds in the PC sheet that contains the course general information, the grade distribution according to the syllabus, the course PCs and their mapping to ABET’s program student a-k outcomes (Figure 1). After completion, and with one click on "Done", an instructor information sheet is created. The created file is used by all course sections instructors. Each instructor completes the information sheet with own name, section number and schedule and then hits "Prepare". This will create a set of sheets to control the course attendance, grading, and assessment (Figure 2).

#### 3.1.1 Dashboard

The dashboard is a summary sheet that gives the instructor an overall view of the class student names loaded from a school management system and detailed grades (Figure 3). It provides also the weight distribution as well as hyperlinks to each activity sheet. An activity is any evaluation task assigned to students during the semester.

#### 3.1.2 Attendance

The attendance sheet (Figure 4) is generated automatically using the information in the information sheet. It allows also mass emailing of students using Microsoft Outlook [1].
3.1.3 Grades
The grade sheet (Figure 5) summarizes the student numerical and letter grades. It provides the ability to apply a linear curve and shows summary statistical information.

3.1.4 Activities
An example (Final Exam) of activity sheet is shown in Figure 6. It details the activity elements (questions, report and presentation of a project, etc.) and their weighted mapping to the course PCs. This mapping will be used to assess the students against the PCs and the course against the PSOs.

3.1.4 Statistics
The statistics sheet provides the frequency of each grade for any selected activity and the final grade.

3.1.5 Assessment Report
The assessment report (Figure 7) is filled by the instructor at the end of the semester. It provides the score recorded by each one of the PCs and PSOs. The instructor should assess the effect of the previous corrective actions and provide suggestions for continuous improvement.

3.2. The Statistical Tool
The statistical grading tool is a set of spreadsheets able to load grades and metadata from individual grading tools and show individual and global statistics related to a course. After each assessment, the coordinator of a course receives one grading tool for each section of the course he is coordinating. The statistical tool allows the coordinator to view the completed activities and the elements of each activity by clicking on the “Load Course Activities” button (Figure 8). Once loaded, the coordinator has the possibility to select either an activity or an element of an activity and load the grades of the selected activity/element from each received grading tools by clicking on “Load grades for selected Activity/Element” button (Figure 8). At the end of semester when all assessments are completed, the coordinator has the possibility to load final grades with one click on the load final grades button (Figure 8). Once the grades are loaded into the statistical grading tools, a set of sheets are generated to the coordinator (Figure 9).

3.2.1 StatisticsSheet.
The statistics sheet displays the individual and global statistics of the select activity, element of an activity or the final grade (Figure 10). In this example, we loaded the final grades of the 17 sections of the Electric Circuits-I spread across the eight LIU campuses. The chart to the right shows global statistics, the total number of students (462) and the distribution of the letter grades. Individual statistics are shown to the left. The current version of the statistical tool can support up to 60 sections of the same course. The tool allows the coordinator to perform linear curving scenarios on the raw grading using the “Curve” button.

3.2.2 Scores
The scores sheet shows the mapping between the PCs and the PSOs. It shows also the scores recorded by each one of the PCs and SPOs for each section and as an average.
3.2.3 Final Report

The final report is completed by the coordinator at the end of the semester. It provides him with average scores recorded by each one of the PCs and PSOs for all sections across LIU. The coordinator should assess the effect of the previous corrective actions and writes any suggestions for continuous improvement.

Fig. 1. Snapshot of the performance criteria sheet filled by the course coordinator.

Fig. 2. Sheets available for the instructor to control the course attendance, grading, and assessment.

Fig. 3. Snapshot of the dashboard (Student names are hypothetical).

Fig. 4. Snapshot of the attendance sheet. It allows instructor to create an Outlook email to all students.
## Activity Sheet

<table>
<thead>
<tr>
<th>Activity Name</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Converted Total Grade</td>
<td>40.00%</td>
</tr>
</tbody>
</table>

### Contribution

<table>
<thead>
<tr>
<th>PC-1</th>
<th>PC-2</th>
<th>PC-3</th>
<th>PC-4</th>
<th>PC-5</th>
<th>PC-6</th>
<th>PC-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>25%</td>
<td>0%</td>
<td>75%</td>
<td>0%</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

### SUM

<table>
<thead>
<tr>
<th>ELEMENT 1</th>
<th>ELEMENT 2</th>
<th>ELEMENT 3</th>
<th>ELEMENT 4</th>
<th>ELEMENT 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### AVERAGE

<table>
<thead>
<tr>
<th>ELEMENT 1</th>
<th>ELEMENT 2</th>
<th>ELEMENT 3</th>
<th>ELEMENT 4</th>
<th>ELEMENT 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.28</td>
<td>4.35</td>
<td>4.23</td>
<td>5.00</td>
<td>5.68</td>
</tr>
</tbody>
</table>

### MAX

<table>
<thead>
<tr>
<th>ELEMENT 1</th>
<th>ELEMENT 2</th>
<th>ELEMENT 3</th>
<th>ELEMENT 4</th>
<th>ELEMENT 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>89.00</td>
<td>20.00</td>
<td>15.00</td>
<td>19.00</td>
<td>20.00</td>
</tr>
</tbody>
</table>

### MIN

<table>
<thead>
<tr>
<th>ELEMENT 1</th>
<th>ELEMENT 2</th>
<th>ELEMENT 3</th>
<th>ELEMENT 4</th>
<th>ELEMENT 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.00</td>
<td>0.00</td>
<td>3.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Weight

<table>
<thead>
<tr>
<th>NB</th>
<th>Student ID</th>
<th>Nb of elements</th>
<th>Full mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>40.00%</td>
<td>5</td>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

### NB | Student ID | Total Grade | ELEMENT 1 | ELEMENT 2 | ELEMENT 3 | ELEMENT 4 | ELEMENT 5 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11130674</td>
<td>50.00</td>
<td>8.00</td>
<td>13.00</td>
<td>6.00</td>
<td>15.00</td>
<td>8.00</td>
</tr>
<tr>
<td>2</td>
<td>11130626</td>
<td>54.00</td>
<td>9.00</td>
<td>6.00</td>
<td>12.00</td>
<td>20.00</td>
<td>7.00</td>
</tr>
</tbody>
</table>

---

**Fig. 5.** Snapshot of the grade sheet.

**Fig. 6.** Snapshot of the activity sheet.
**Fig. 7.** Snapshot of assessment report sheet.

### Course Assessment Report

<table>
<thead>
<tr>
<th>LIU</th>
<th>Course Assessment Report</th>
<th>PSO</th>
<th>a</th>
<th>3/18/2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dep.</strong></td>
<td>Electrical</td>
<td>Dep. Electrical</td>
<td>Fall 2012-2013</td>
<td></td>
</tr>
<tr>
<td><strong>Course name</strong></td>
<td>Electric Circuits I</td>
<td>Electric Circuits I</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Course code</strong></td>
<td>EENG25</td>
<td>EENG25</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Section</strong></td>
<td>A</td>
<td>Credits</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Instructor name</strong></td>
<td>Samih Abdulnabi</td>
<td>Samih Abdulnabi</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coordinator</strong></td>
<td>Adnan Harb</td>
<td>Adnan Harb</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Assessment Techniques

Give your detailed evaluation of the effectiveness of current assessment techniques in helping students achieving the Performance criteria. You only need to comment on those that are ranked poor (1 and 2).

<table>
<thead>
<tr>
<th>Technique</th>
<th>Nb of activities</th>
<th>Weight</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>2</td>
<td>10</td>
<td>4: Usually students copy the assignments</td>
</tr>
<tr>
<td>Test</td>
<td>1</td>
<td>20</td>
<td>4: Good applications for starting Electrical Relations</td>
</tr>
<tr>
<td>Midterm</td>
<td>1</td>
<td>30</td>
<td>2: Bad Calculations</td>
</tr>
<tr>
<td>Final</td>
<td>1</td>
<td>40</td>
<td>2: Weak in integration and derivation</td>
</tr>
</tbody>
</table>

#### Assessment Results to this Program Students Outcomes

<table>
<thead>
<tr>
<th>Semester</th>
<th>Current semester</th>
<th>Previous offering</th>
<th>2nd previous offering</th>
<th>3rd previous offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantitative</td>
<td>70.25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Result of Previous Offering Corrective Action**

Suggest modifications to the subjects or learning activities to improve student performance relative to this performance criteria.

Suggest modifications to the learning assessment tools to better measure student performance.

<table>
<thead>
<tr>
<th>Student ID</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC-01</td>
<td>78</td>
</tr>
<tr>
<td>PC-02</td>
<td>71</td>
</tr>
<tr>
<td>PC-03</td>
<td>73</td>
</tr>
<tr>
<td>PC-04</td>
<td>69</td>
</tr>
<tr>
<td>PC-05</td>
<td>66</td>
</tr>
<tr>
<td>PC-06</td>
<td>65</td>
</tr>
<tr>
<td>PC-07</td>
<td>64</td>
</tr>
</tbody>
</table>
4. Critical Assessment

Despite its value added benefits, the adoption of the implemented tool posed some challenges and risks that require careful assessment. Some issues were related to common difficulties associated with the deployment of any software artifact while others are directly related to the process which the tool is automating.

While the vast majority of all users of the tool are computer literate, some faculty members face challenges when using the spreadsheet version. Moreover, the lack of “wizard-like” steps that guide users into the process, forces a learning curve for the fluent operation of the tool. In addition, and due to the fact that the tool is independent from the University Management System (UMS), faculty members are obliged to duplicate the effort of entering grades. Addressing factors that affect the dissemination environment of software applications has been shown to be crucial for the success of adaptation process [8].
Since the tool governing program is self-contained in the Excel™ file, it poses a deployment issue: whenever a new version is created (due to a bug fix or enhancement), it must be re-distributed to all users. “Version wars” become inevitable causing dysfunctional conflict between faculty members which may lead to unsatisfactory experience for instructors [9].

The last issue poses an additional risk: data inconsistency. Editing of data in the Excel™ sheet requires the exact duplication of the work on UMS. This is an error prone process leading to the increased risk.

In order to create aggregates of the data from a particular course or program, all related Excel™ sheets must be collected, compiled and processed. Since the collection process depends on human response and availability, the aggregate reports timely availability is compromised.

The solution to the issues listed above is not beyond realization. In fact, a simple yet effective solution is under development. The new version will be integrated into the web-based UMS system.

5. Conclusion

University learning assessment is an on-going process that needs to be subject to continuous improvement in order to secure sustainability. ICT (Information and Computer Technology) plays an important role in supporting such a process. This paper described the automation of course assessment in the multi-campus common exams Lebanese International University. The solution was based on simple dynamic Excel tools. Although the tools are simple and Excel based, they provide a good basis to perform course assessments across multi-campuses. Enhancement and evolution of the tools is possible and there are already plans to integrate them with the existing university management system which is web-based and more user-friendly.
References


ETHICS AND ENGINEERS IN THE NEW MODERN ERA: UNIVERSITY PERSPECTIVE

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Abstract

In this modern era, engineers do not live alone on the planet. They have to interact with persons, ordinaries and professionals, to survive and to succeed in their professions as engineers. The interactions are becoming more complex due to the tremendous advances in technology which is becoming an integrated component of their lives. The complexity is further compounded by the values and needs of societies in which engineers are living. Furthermore, persons have different social backgrounds, values, customs etc.... Besides, any professional action, activity or decision could affect and may have consequences and implications on the environment and the society. Thus, these interactions have to be governed by ethics (practiced by all engineers) that should be globalized. The ethical responsibility should be addressed by different parties: universities, industries, engineering associations, governments etc.... In this work, the ethical issue is addressed from the university's perspective. It can be achieved by introducing: i) a course (courses), ii) small modules in most courses and iii) in practical training. However, a platform for communication purposes should be in place and the engineers should acquire the ability of critical thinking, identify the ethical issue in a problem and provide the appropriate analysis to make sound decisions.

Keywords - Ethics, Engineering, University, Industry, Critical Thinking, Communication, curriculum.
1. Introduction

The ethical issues can be faced by a person, and particularly by an engineer, almost daily. It can vary from a typical real life problem to a professional problem. For example, assume that you have a car that you need to sell and the transmission has a big problem. Also, you have been told that the transmission is going to fail within few months. The ethical issue becomes by addressing the following question: do you tell the buyer of the car’s condition? or you pretend that your car works perfectly without any problem? As another example, assume that you are an engineer and you are studying a defibrillator that satisfies the "standard ANSI/AAMI DF2" for recommendation purposes to a medical facility that exists in a developing or under developing world. [1]. The battery is a crucial component of the design. It should be fully charged and should retain its full capacity at a temperature of $0^\circ$ C. Under these conditions, the battery should be able to provide three discharges during a span of three minutes. However, the battery is expensive and its replacement may not be affordable by the facility [1]. The ethical dilemma will be the following: do you recommend the device even though you know the facility may not afford the replacement of the batteries? do you recommend a battery which is not expensive and can be afforded by the facility and does not work according to the standard?

Thus, the values and the ethics that are practiced by an engineer who has graduated from his university during the span of his life and in the working place (companies, industries, and enterprise) are of great importance. They have become a mirror that reflects the values of the engineer, the society, the university and the professional industry in which he is working. If the ethics are taken into consideration in the design and the development of a particular system, in the advancement of technology (or any particular research in any field of engineering) or in bringing to light a given innovation, the outcomes through the reflections of engineers, their activities and their actions can be of great values (i.e. improve the quality of life) or of worst values (i.e. harmful) to people, the local society, the country and to the societies all over the world. Besides, the engineer has to be aware of the environmental context. The environment is for all human beings and not for a particular person. For example, the air that we breathe is not limited to one person or a group of people in a particular country or region. Thus, the pollution that is emitted in one area by industries is easily transferred to another area since there are no borders for air and its movement. Similar conclusions can be attained if it is looked at other issues such as water, sea, deforestation, acid rain and global warming. Also, the above ethical issues may be compounded by the fact that the industries, companies and organizations may have objectives (technical, profitable, economical, etc...) that contradict with the benefits and the welfare of the people who are living in a particular society and their needs [2-3]. Furthermore, the ethical issues have become crucial for accreditation institutions such as the Accreditation Board of Engineering and Technology (ABET). The latter institution requires the universities which are
pursuing the process of recognition and accreditation, to incorporate ethics within their engineering programs. Some ABET criteria indicates that the student enrolled in an engineering program should acquire “an understanding of professional and ethical responsibility” and should have a “broad education necessary to understand the impact of engineering solutions in a global and societal context” [4].

2. Approach

The ethical issues should be pursued by different entities such as the universities, engineering associations (federation of engineers,...), industries, governmental agencies etc... In this paper, the ethics is addressed from the university’s perspective. Actually, the student should be exposed to ethics (at least moral ethics) at an earlier stage i.e. preliminary schools and homes.

The university should look at the issue of ethical responsibility of the engineer as an integrated component of its engineering curricula. The ethics should not be observed as an independent and isolated component in its program and consequently, are irrelevant throughout his engineering profession. It should be emphasized as a valuable outcome in the fulfillment of requirements to obtain its degree. Besides the accreditation and the implications of engineering works on the environment and the society, the university is driven by the great concerns about the behavior of engineers with respect to ethics during their years of study as well as in their working places. That is, this responsibility should address, if any, the academic dishonesty and integrity (such as plagiarism of the term paper, copying answers during an exam from other students who are sitting in his proximity, etc....) that have been observed in various educational institutions as well as the concerns in professional institutions without any remorse or giving credits to the appropriate persons.

The objective of such endeavor is to make a student aware about ethics and consequently to become sensitive about these issues when he is performing his job or is taking decisions, especially professional decisions. Subsequently, the knowledge about ethical issues and responsibility has to be increased through studying and analyzing more ethical cases as well as becoming aware of the ethical codes of his profession. In other words, the university should equip the student with the information, the knowledge and skills so that he will be in a position to make a sound (best possible) decision in solving the engineering problem under consideration within the context of the society and the environment.

The ethical issues and ethical responsibility can be addressed by various universities through different approaches: i) develop one (few) course (s) within the engineering curricula, ii) embed a small component of ethics within each course (or most courses) and in iii) practical training.

2.1 Develop an ethical course
The development of such course (or courses) can be (are) easily accomplished. However, the faculty should not lose the broader picture and the final objective i.e. relate the ethics with the engineering curriculum that is developed at the university. He should be aware and consequently, make the student in his turn aware of the fact that the given ethical course (courses) is (are) not just a required component towards the fulfillment of the student's degree. That is, a course in which he registers for one semester and completely is forgotten as soon as he receives his grades. In other words, each ethical course should not be treated as an independent component from any course in which he is enrolled or activity that he performs during his BS, MS and/or PhD programs and even from any activity during the span of his life. Therefore, the faculty should stress the ethical issues in its broader sense and urges the student to practice such responsibility during the remaining courses at the university.

2.2 Develop ethical modules

In this approach, the ethics are integrated in various courses throughout the engineering curriculum. They can be offered in few sessions during the span of the semester and each respective lesson could have a duration of about half to one hour. Also, they can be introduced in small dose that will require some amount of time within a particular session or/and are integrated in problems and exercises i.e. "Micro-insertion" [5]. That is, the conventional problem will be modified in order to reflect the ethical aspect which the engineer should be aware and would face in his professional carrier. The instructor should highlight the ethics which are related to the topics of the course. Then, he should provide examples (simple and complex) that will stress and highlight the practice of ethics with respect to the respective material. Consequently, this approach reiterates the principal idea that ethics are a valuable component throughout the student's engineering education as well as in his profession. Consequently, the student should live with ethics every day and should practice it.

2.3 Practical Training

The Ethical issue must be also integrated as an essential component in the training of an engineering student. Actually, the practical training has become a key component of any engineering program towards its fulfillment [6]. That is, a degree will be granted if the training within a company or an industry is accomplished successfully. However, it is not enough to expose the student to the workplace from the professional point of view i.e. apply and practice the acquired knowledge, skills, tools and information in his field of study. He should also practice ethics, including professional ethics, in the workplace. Consequently, he should learn and acquire the ethics that are practiced by engineers in the industry in which he is fulfilling his practical training. This practice should become a second nature to the trainee. In this context,
industries and companies should be involved with the engineering students and their roles should be positive and highly required in preparing them for the new era and a bright future in their respective fields. The ethical issue is another reason for which both, the university and the industries, should work jointly effectively and efficiently for the benefit of the students. Similar to the acquired technical tools and knowledge, ethics should be practiced and not be kept as a moral theory that the student has to learn in a course or courses and are forgotten.

2.4. Discussions

The engineering student should be able to comprehend and understand through the materials and through his contact with the professors and staffs of the engineering’s faculty (and with the whole university to a certain context) the ethical responsibility at large and the responsibility that comes with his profession. This responsibility should emphasize the appreciation and the respect of other people works, especially the work of his colleagues in the profession. This aspect includes several issues of great importance such as plagiarism, copyrights and patents even though it is a minor. There are no white lies in the profession of engineering. It could be costly in terms of human life. The engineer has to give the proper dues to the person around him even in the simplest interaction and yet a valuable one.

It should be pointed out that the university should address in its program the preparation of an engineering student to acquire the ability to identify the ethical issues that are associated with the task that he is performing or the problem that he is solving (for example with the design of a particular system that is requested by a company). In other words, he should be able to understand the problem at hand and to recognize the impact of the outcomes of the proposed engineering solution on people, the environment, the society, the economy, etc… In this context, the student should present recommendations with his reasoning and the justifications that have led him to the particular ethical solution. This is very crucial in order to be able to make the best and the most appropriate solution. Always he should take into consideration "the good of the public" [7]. Thus, he should be aware of the current state of technology and of the technology that is being developed and its impacts (positive and negative) on the society and the environment as well as on the future development and direction of the engineering profession.

Besides, the courses or the modules that are introduced should not be restricted to moral concept or theory. Even though, few lessons could be included along with the code of ethics respective to the corresponding field and profession, the presented lectures, the discussions and the information should be more concentrated on the analysis and the study of realistic cases. In this manner, the abstract concept can be related to real ethical problems that will be faced by engineers in their professions [9 - 10].

Furthermore, it will be worth to develop seminars during the span of the semester (for one credit- a seminar per week) in which professional engineers who are working in companies and
industries are invited to present a lecture for one session. The lectures will be about a moral problem that was encountered, the analysis that is performed and the decision that is made. This should be followed by a discussion between the students and the lecturer to gain more insights about the ethical issues under consideration. Also, professors and lecturers from educational institutions who are experts in the indicated area can be invited for the same purpose.

3. Communication

In this context and to gain the most, a platform for communication purposes among the students, between students and the professors, and between the university and the industries should be put in place [8]. This is very crucial in the process of teaching ethics because the platform will allow students to express well their ideas and opinions about an ethical issue orally as well as in writing. Thus, the student should not feel at all that he will be penalized for the open discussions i.e. express freely his opinions and suggestions. Subsequently, this open environment will allow the professor as well as the participants to discuss the various ideas and suggestions in order to make the appropriate decision in a given ethical situation. The communication can be achieved by dedicating sessions to discuss particular issues/case studies as a group or/and by submitting a written report followed by a presentation. However, it might be that some students do not express very openly their ideas and thoughts aggressively and effectively (i.e. they might be shy or little bit afraid to go to the limit). Thus, a dedicated internet site should be established and the discussions can proceed. The latter scheme can be a valuable tool to extend the discussions beyond the class and it might lead the students to actively participate in the on-going discussions without any reservation in expressing themselves. Furthermore, since the information can be stored during the offered semester, it will be available to the student and the professor to view how their discussions have been evolved during the span of the semester and to learn the appropriate lessons.

4. Critical thinking

The success of such endeavor requires the student to be able to think. In other words, the developed engineering programs at the university should provide the platform in which the student is encouraged to be active in the discussions in the class and on the internet and allow them to be an integrated component in the presentation of the course. He should not be passive students i.e. consume information and accept whatever his professors present without any discussions. That is, he should be guided and leaded to provide the information i.e. the ability of critical thinking. Having been equipped with such capability, he will be able to collect and analyze the information efficiently and effectively when he is faced with a problem, and will be able to grasp very quickly the theory (or theories) and insights of any complex problem and its
impact on the people around him, his environment, his society, his country, his region and the world to a certain extent. Furthermore, this capability will allow him to acquire the ability to differentiate between facts that are based on sound theories, beliefs and opinions when he listens to his colleagues speaking in a seminar, workshop, conference or reading an article that is presented in a conference or a journal.

5. Conclusion

The ethical issue should be addressed by several parties: universities, industries, engineering associations, governments, secondary schools, elementary schools, homes, etc... The issue is complex and it is not easy to tackle. However, it should be addressed by all parties in order to reach a successful end. In this paper, the issue is addressed from the university point of view. The ethical responsibility can be achieved by developing dedicated courses or by inserting in almost each course a small component. However, it should be emphasized that the ethics should not be perceived as an independent component toward the fulfillment of a student's degree. The ethics should become a second nature to the student and a "motto" that guides him in his activities. Also, a close cooperation should be forged with the industries in order to provide the student with professional ethics during his practical training. Besides, the success of such endeavor requires the creation of a platform of communication between the involved parties, the preparation of the students to acquire the ability of critical thinking and the ability of continuous learning in order to be current about the state of technology, tools and information.
References


HAVE THE LEARNING OBJECTIVES IN HIGHER EDUCATION IN EGYPT BEEN ACHIEVED?

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Abstract

Recently, the governmental Universities in Egypt were introduced to the Quality Assurance Concept. They were asked and given incentives to apply for the local accreditation for the whole faculty and not just programs. The National Accreditation and Quality Organization requires that each course must have a file. This file should clearly indicate the ILOs (Intended learning Objectives) for the course and how they are to be measured. This paper discusses and answers the following questions and phrases:

- What are the learning outcomes in the engineering higher education in Egypt?
- How could the learning outcomes be measured?
- The current evaluation system in Egypt
- Results of a national experiment for measuring intended architectural Learning outcomes
- The AHELO results
- Main Challenges
- Main Lessons
- Results
- Conclusions and recommendations

Keywords: Higher education – intended architectural Learning outcomes – AHELO- evaluation system in Egypt- NARS
1-Introduction:

Recently, the governmental Universities in Egypt were introduced to the Quality Assurance Concept. They were asked and given incentives to apply for the local accreditation for the whole faculty and not just programs. The National Accreditation and Quality Organization requires that each course must have a file. This file should clearly indicate the ILOs (Intended learning objectives) for the course and how they are to be measured. Last year, the Organization of Economic Cooperation and Development (OECD) conducted a visibility study on a universal exam—the AHELO. They tried the AHELO exam on final year students in some faculties of engineering (Civil Dept. only). AHELO is the Assessment of Higher Education Learning Objectives. Nineteen countries around the world took part in this exam. Two from North America, two from central and Latin America, six from Europe, one from Africa (Egypt), two from the Arab world (Kuwait and the Arab Emirates), and four from Asia. A Ph.D. Study in Cairo University was conducted on the quality of the educational program for architecture engineers. The results of the AHELO exam and Ph.D. Study are revealing and could be a very good basis for answering the question which is the title of this paper.

2-What are the learning outcomes in the engineering higher education in Egypt?

In section (1) of the NARS[1] (National Academic Reference standards) for Engineers there are eleven attributes. The NARS also defined groups of qualifications, attributes, and capabilities expected from the Egyptian engineering programs. They were divided into two main groups: general expectations and specific expectations for each discipline (Architecture, civil… etc). The general expectations were divided into four categories:

A. Knowledge and Understanding (12 items)
B. Intellectual skills (12 items)
C. Practical and professional skills (12 items)
D. General and Transferable skills (9 items)

The specific expectations for architecture engineers (as an example) were divided into three categories only:

A. Knowledge and Understanding (11 items)
B. Intellectual skills (9 items)
C. Practical and Professional skills (8 items)

With a total of $11 + 61 = 72$ items

These seventy two items are too much. We suggest that they can be reduced to about 24 items at most taking into consideration the following attributes:
2-1 Knowledge and Understanding:
In the age of personal note books, PC's and global accessibility to the internet what is the knowledge a freshly graduated engineer should acquire? Could he/she be allowed to look in the internet for it or should he/she memorize it. It is becoming obvious that we should teach students how to search for the knowledge efficiently and quickly and give them only the very basic knowledge in college.

2-2 Intellectual Skills:
The engineer should be able to think. Not only logical and mathematical thinking but also critical and creative thinking. He/she should be able to analyze any data and process it. Simulation / modeling is very useful in the age of easy and available software. Problem solving is obviously needed as well as the ability to use mathematics and mechanics in different applications. The question is should the engineer be skilled in working with his/hers hands? Should the engineer be practical and not theoretical in his approach to the use of rules and laws to solve problems? Theoretical skills are not enough as engineering is a very practical profession.

2-3 Practical and professional skills:
Imagination is very important to Architects. Soft skills and communication abilities are important to all engineers. Is the engineer the person who communicates by drawing his ideas and not writing them? Drawing ability is very important but what about reports and the ability to express himself in writing?

3- How could the learning outcomes be measured?
This is a very important question to the faculty in engineering institutions. Are exams enough to measure these outcomes? Clearly reports, essays, experiments, presentations … etc. Should be used also. But are all the staff keen to measure the learning objectives they stated in the beginning of the course? Are all the outcomes in the NARS exist in the offered engineering programs? Are these outcomes measured throughout the courses of the programs? and how?

More important is the question: are our students prepared to be taught these skills and competences or are they more used to the method of teaching and learning used in secondary schools. In Egypt teachers are oriented to teaching the students to get very high grades because of the scarcity of places in higher education and they are not oriented to teach them how to think. They train them how to solve the mathematical exam and get full marks regardless if they understand the concepts or not.

If the results of the AHELO exam are not compatible with the students grades in the faculty of Engineering, what will be our conclusions? There are several possibilities:
A. The faculty members are not interested in measuring the achievement of the ILO’S.
B. The faculty members are interested but they are not trained to use the right tools.
C. The students coming from higher education have very bad learning habits and the faculty cannot change them radically. He / she will – then - have to go along with these habits.

D. The huge number of students in the lecture theater (more than 300 students in some Engineering departments) is a big obstacle for the faculty to achieve good results with the ILO’S.

If students with excellent grades in their faculties have low rating in the AHELO exam and students with only 50% grade get the highest rating, would this shred doubts about the grading system in the faculties of Engineering in Egypt?

4- **The current evaluation system in Egypt**

The grading system in Egypt (because of the huge number of students among other things) relies heavily on written exams. There are exercises, essays, reports, and even oral exams but all of these are carried out without concentrating on measuring the achievement of certain objectives. If the methodology of assessment used in the AHELO exam could be adopted by the faculty, the trust in the results or grading system can be greatly improved. I do not think that this methodology is yet available for the staff to use, and it should be made available.

A national grading system could be adopted where question banks are prepared nationally and used in different educational institutions. This could be of particular importance in Egypt as governmental supervision on quality of education in private institutions is missing. Having national grading system will mean that the same stick is used to measure the graduates of all engineering institutions: public or private. Even if there are some differences in the curriculum between different institutions it is still possible to have the same measuring stick.

5- **Results of a national experiment for measuring intended architectural Learning outcomes:**

A research was conducted in Cairo University to measure the intended learning outcomes which are needed by construction engineers graduated from architectural departments using indirect measurement methodology. In the research, a random homogeneous sample (450 exits) was chosen and distributed among 12 architectural programs from different colleges in Egypt to perform **questionnaire (a)**, and about (850 students) to perform **questionnaire (b)** in different levels of the program. In this research the opinion of the market place was not measured, only that of the students.

**The used methodology for measuring the Learning outcomes:**

To perform an indirect measurement for the intended learning outcomes for this research the following activities were used:

- Using questionnaires:
  - Questionnaire (a) asking the exits about indicators of I.L.Os (intended learning outcomes), their activities during the years of the program depending on themselves and depending on the program activities plans.
b. Questionnaire (b) trying to define most of the obstacles facing the students to fulfill the I.L.Os and the best practices in the courses.

- Perform several meetings with individuals and groups:
  - The exits.
  - Students in different levels of the program
  - Staff,
  - Instructors and co-instructors
  - The headers of the selected academic programs

- Checking and analysing different official documents:
  - Rules and regulations organizing the program
  - The topics and contents of the courses (as possible)
  - Assignments and quizzes
  - Final Exams of the majority of the courses (for the last 5 years)
  - Final results for the levels for the last 5 years
  - Documents for the program found in the quality assurance unit and its results if found.

Samples of questionnaire (a) results are shown in Fig(1) – tofig (5) These results show that:

i. Exits opinion about the effectiveness training for thinking methodologies and skills is between 47-66% except managing critical problems in various stages of working projects that they carry out in the faculties of engineering which is only 26%.

ii. The constraints in working drawing projects that they should have been trained to face covered: local culture, climate, social environment, cost, and building regulations. Their opinion is that the training was not enough (42-53%) especially the cost constraint as who thought it was enough were only 20%

iii. When the students were asked if they took architecture objectives into consideration in their projects their approval ranged from 17-39%.

iv. When they were asked if they have sufficient technical skills (Fig (4)), their opinion varied significantly. Preparing the sketches and drawings scored high rates (71-86%) while preparing the levels grid, assessment of alternative construction systems and techniques, and defining the suitability of construction systems scored as low as (12.4-21.4%).

v. The exit students have very low opinion (4-20%) about the performance of the program plans and activities in the architecture departments (fig (5)).

From these samples and the rest of the research results, the researcher concluded that:

i. Generally, a significant gap between the desired I.L.O.S and the achieved outcomes was found according to the opinion of the exits working as field engineers.

ii. The research has identified the obstacles that prevent achieving the I.L.O.s in each program as well as the common obstacles in the different programs. Some of these obstacles are:

   - Architecture Programs are basically theoretical with little emphasize on practical issues.
- Activities such as visits to sites and exhibitions, seminars, debates are weak and are not in general carried out.
- Emphasize is on memorizing not discussing or critical thinking.
- There is no clear general philosophy for the program or its connection to Egyptian culture and society needs.

iii. The research found out that most of the Egyptian architectural programs need to transform their educational systems which is mainly based on knowledge to a new system based on competencies and skills. Performing well strategic and action plans based on the analysis of the constraints, local, and global needs of the academic program can greatly enhance these systems.

iv. Finally, the research recommended that is time for using a different measuring methodology for measuring the achievement of the program I.L.O.s (direct measurement methodology) after using a well-designed curriculum map for each course as well as the whole program is needed.

This research depended only on students and exit opinions and it should be extended to include workplace opinions as well as staff opinions: Nevertheless, the results indicate a significant gap between what is desired and what is actually been achieved in the area of learning outcomes.

6- The AHELO results:

Before discussing the AHELO results in Egypt, attention should be given to the purpose and philosophy of the AHELO exam. The purpose is to assess what students in final year of higher education know and can do upon graduation. AHELO aims to be direct evaluation of student performance at the global level and valid across diverse cultures, languages, and different types of institutions. It is intended as international comparative assessment designed to provide higher education institutions with feedback on the learning outcomes of their students which they can use to foster improvement in student learning outcomes. The AHELO exam concentrated on looking at outcomes in:

i. Generic skills common to all students (such as critical thinking, analytical reasoning, problem solving, and written communication).

ii. Discipline-specific skills in economics and Engineering.

The exam (feasibility study) will show: Percentage of achievement of outcomes for different skills. Together with the grading in the faculty of Engineering for the same group of students, the AHELO results can not only judge the achievement of the ILOs but also judge how good the rating system in the faculty is. Faculty administration as well as staff should make use of the results to enhance the teaching and learning methodologies as well as the evaluation system. The feasibility study report showed the main challenges, achievements, and lessons as follows:

7- Main Challenges

i. The rapid and radical changes that involved the whole Egyptian community.
ii. The repeated changes in the leadership of higher education institutions and management boards that altered the implementation schedule for the projects activities.

iii. The large Egyptian universities (80000-250000 undergraduate students) and their incomplete electronic databases.

8-Mail Achievements

i. High response rates for students (total number 4212) and faculty (total number 877), representing 18.3% (students) and 18.2% (faculty) of total AHELO participation.

ii. Increased awareness of the academic societies regarding the importance of linking the intended outcomes of programmers with the labour market.

iii. Success of the first concurrent online testing in the participating universities.

9-Main Lessons

i. National governmental commitment and support are cornerstones for assuring success of such large scale research studies.

ii. Recruitment of students for participation in future studies entails innovative strategies.

iii. Test simulations using released test instruments should be considered, for training purposes, as well as for exploring pitfalls and how they can possibly be avoided.

10-Results

10-1 Participating institutions and response rates achieved:

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Strand</th>
<th>Generic</th>
<th>Economics</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students (International targeted students participation = 1500/strand)</td>
<td>1 434 (95.5%)</td>
<td>1 130 (75%)</td>
<td>1 648 (110%)</td>
<td></td>
</tr>
<tr>
<td>Staff member (faculty) (International targeted faculty participation = 350/strand)</td>
<td>319 (91.1%)</td>
<td>231 (66.0%)</td>
<td>327 (93.4%)</td>
<td></td>
</tr>
</tbody>
</table>

10-2 Students
The input by Egypt to the AHELO constitutes 18.3% of the total participating students.
10-3 Impact at national / institutional / faculty level

Egypt considers participation in the AHELO project an investment from which the profits would be expressed in the form of valuable data, its analysis and its benchmarking with other countries. AHELO expect requests from the various stakeholders (government, the Ministry of Higher Education, the supreme council of Universities, policymakers, institutions, faculty, students, accreditation agencies, sponsors and professional organizations/syndicates) to use the obtained evidence – based data (AHELO results) for the following purposes:

- Reviewing graduates' skills:
- Modification of curricula and teaching methods to promote self-learning and development of students' generic skills:
- Adjustment of the intended learning outcomes to fit the requirements of the labor markets, both nationally and internationally:
- Focus on the assessment of learning outcomes in addition to the inputs and processes:
- Evaluation of the systems for quality assurance in higher education, aiming at closing the chain of inputs, processes and outputs.

10-4 Summary scores

Table 1 presents summary score statistics for all institutions and for Alexandria University. The following statistics and abbreviations are used: count (#), mean (×), median (M), standard deviation (SD) and 95% confidence interval around means (95% CI).

As the 500 cutoff level at the generic skills score has not been achieved (only 487 is achieved), then this score shows than the level of generic skill is generally not acceptable. Table (2) shows the AHELO scores for Egyptian students according to broad field education. It shows that more than 50% of those who scored more than 600 are from the science field and only 9.7% are from engineering, manufacturing and construction. Health and welfare add 12.9% to those who scored more than 600. Table (2) shows also that only 2.5% got more than 600, 15% got less than 400, and the majority of 82% got between 400-600 with an average of 487. This not acceptable and show that the generic skills are weak and should be greatly improved.

The authors could not obtain any more of the AHELO results but these results are enough to show that the generic skills are below the cutoff level (writing skills are well below that). This means that a lot of work should be oriented to improving these skills. When the results of engineering skills will be published they will be below the desired levels as the market is always complaining about the lack of these skill in the graduates.[4]

Conclusions and recommendations

1. Both the research done in Cairo University and the AHELO results indicate that most of the desired I.L.O,s have not been achieved to any satisfactory level. There is still a
long way between completing the paperwork for the course file (including desired I.L.O.s and achieving results and outcomes that satisfy the market place).

2. The methodology of measuring the desired I.L.O.s is far from being rational. It is recommend that the scientific departments in the faculties of engineering take this matter seriously and prepare seminars and invite educational professionals in order to establish a rational mechanism to measure the achievement of the I.L.O.s. (Direct measurements of the I.L.O.s indicators).

3. To facilitate this, it is recommend to adopt about nearly 24 out of the 72 skills and competencies of the NARS based on the guidelines given in this paper.

4. A national grading system could be adopted in Egypt, where question banks are prepared nationally and used in different educational institutes. This grading system should concentrate on measuring the important skills for the market (upper bloom taxonomy pyramid level, not the knowledge and understanding levels only).

5. Finally, it should be stressed that the graduates of the faculties of engineering in Egypt in recent years lack a lot of the skills needed in the market place. Filling the paperwork that includes I.L.O.s in the course file only will not result in reaching the desired outcomes and hence the satisfaction of the market place. Only hard work based on rational mechanisms and direct measurements will enhance the skills of the graduates and achieve the desired I.L.O.s.

References


### Table 1: Scores for all institutions and for this institution

<table>
<thead>
<tr>
<th></th>
<th>#</th>
<th>X</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>This institution</td>
<td>121</td>
<td>487</td>
<td>487</td>
<td>75</td>
</tr>
<tr>
<td>All institutions</td>
<td>10657</td>
<td>500</td>
<td>495</td>
<td>100</td>
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</table>

### Table 2: Distribution of Egyptian students according field education and AHELO Score

<table>
<thead>
<tr>
<th>Field of education</th>
<th>Broad Field of Education</th>
<th>AHELO Scores</th>
<th>More than 600</th>
<th>400-600</th>
<th>Less than 400</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>percent</td>
<td>Weighted%</td>
<td>Frequency</td>
<td>percent</td>
</tr>
<tr>
<td>Education</td>
<td>83</td>
<td>6.9</td>
<td>81.4</td>
<td>19</td>
<td>9.2</td>
</tr>
<tr>
<td>Humanities and Arts</td>
<td>2</td>
<td>6.5</td>
<td>1.4</td>
<td>119</td>
<td>9.8</td>
</tr>
<tr>
<td>Social Sciences Business And law</td>
<td>1</td>
<td>3.2</td>
<td>1.4</td>
<td>65</td>
<td>5.4</td>
</tr>
<tr>
<td>Science</td>
<td>17</td>
<td>45.8</td>
<td>2.9</td>
<td>513</td>
<td>42.4</td>
</tr>
<tr>
<td>Engineering manufactur and constructio n</td>
<td>3</td>
<td>9.7</td>
<td>1.4</td>
<td>197</td>
<td>16.3</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1</td>
<td>3.2</td>
<td>1.1</td>
<td>80</td>
<td>6.6</td>
</tr>
<tr>
<td>Health and welfare</td>
<td>4</td>
<td>12.9</td>
<td>5.3</td>
<td>63</td>
<td>5.2</td>
</tr>
<tr>
<td>Services</td>
<td>1</td>
<td>3.2</td>
<td>1.3</td>
<td>85</td>
<td>4.8</td>
</tr>
</tbody>
</table>
Fig (1) – Pregraduates opinions if training on "Thinking methodologies and skills" was sufficient

Fig (2) – Pregraduates opinions if training on "working drawing projects taking various constraints into account" was sufficient?

Fig (3) – Pregraduates opinions if they took architecture objectives into consideration in their projects
Desired technical skills

Fig (4) – Pregraduates opinions that they had sufficient technical skills of the shown items

Fig (5) – Pregraduates Opinions about existing programs in Architecture departments
ENGINEERING EDUCATION AND THE BOLOGNA PROCESS

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Abstract

A retrospective view on the introduction and implementation of the Bologna process in engineering education in Europe is given. The advantages and disadvantages of the Bologna process are discussed, with a particular referral to the Montenegrin experience. Several recommendations for possible improvements of engineering education within the Bologna process are suggested.

Keywords: accreditation, Bologna process, cycles of education, curricula, degrees, diversity, engineering, E-education, inflation of knowledge, life-long learning, quality assurance, outcomes, student mobility.

1. Introduction

Engineering education has a long tradition in Europe. A few rather different types of university engineering education could be recognized. The “German type” education was implemented in most European countries. The traditional German education system provided two distinct engineering programs having several features in common. One was offered by the technical universities and had a more theoretical orientation, while the other, taught at the Fachhochschulen, had a more applied profile. The former required typically five years of studying, enabling for research and in-depth development activities; the latter was a shorter cycle of typically four years and was meant to train production-type engineers. They were both implemented as one cycle programs. Students were supposed to get some insight into basic industrial manufacturing and develop engineering skills, as well as the appreciation for the work of others upon which they would rely on. Following the thesis work, which typically took one semester, the students would receive the Diplom-Ingenieur (Dipl.-Ing.) degree.

The engineering education in France was not much different but was more theoretical. In UK engineering education was organized mostly on the basis of three-year courses leading to the
degree of *bachelor of science* or *bachelor of engineering*. Some four-year course programs have also been organized leading to M. Eng. which is equivalent to master degree. On the other hand, in some European countries, and at some point of time, the engineering education was organized in concentric cycles: two years of course work for the degree of *engineer*, with the continuation of another two or three years for the *Dipl. Ing.* degree (*diploma of engineering*). This practice was later abandoned.

The length of the actual study for the university degree in engineering departments was in practice much longer then the prescribed 4 or 5 years. Students were allowed to retake the exam many times, after failing the course first time, until they pass. Often, students would finish all required course work, but would remain students for much longer, even several years, to pass all exams for audited courses and complete their degree. Consequently, many argued that such a system was inefficient and expensive to run.

The master program lasted most commonly two years and was a prerequisite for the doctoral program. In Germany the *Dipl.-Ing.* was the prerequisite for the doctoral degree (*Doktor-Ingenieur, Dr.-Ing.*). The scientific work for the doctoral thesis was usually performed at the university within three to five years, and was conducted as part of research projects. In engineering sciences, the higher-degree candidates often worked on their theses as the paid departmental teaching or research assistants. In the former USSR, the graduate study was organized for the *candidate of science* (*kandidat nauk*) degree. This was recognized by other countries as an equivalent to master degree, but nowadays it is more commonly recognized as an equivalent to Ph.D. degree.

### 2. Introduction of the Bologna Process in Engineering Education

The engineering education in Europe has been greatly affected by the implementation of the Bologna Process, a major reform in the European higher education [1-6]. This process is based on agreements between European countries aimed to achieve comparable standards and quality of higher education within Europe as it integrates, and to meet the growing needs for creative global competitiveness and quality assurance of engineering and other professions. The Bologna declaration was signed by the education ministers from 29 European countries in 1999. In an increasingly globalized world, the Bologna Process currently involves 47 (EU and non-EU) countries. As such, it is a global process of higher education in Europe, introduced with the expectation to facilitate higher exchange and mobility of students and academics among institutions from different countries, promote internationalization, enable less constrained employment after graduation within a broader region, continent, or the entire world, and thus contribute to overall economic growth. The Bologna Process is based on two main cycles, undergraduate and graduate. The prerequisite for the second cycle is successful completion of the
first three-year cycle. The first cycle degree represents a preparation for the labor market, while the second is a graduate cycle leading to master and/or doctorate degree.

The implementation of the Bologna Process is to a large extent reflection of the modern globalization [7-11]. University campuses are populated by students of diverse ethnical and cultural background, particularly in graduate schools. The faculty is increasingly diversified, as well. New international universities are being created, with large funding invested to attract the best faculty and students and compete in academic excellence with leading universities and technology institutes worldwide. Engineering education is greatly affected by the development of electronic data bases, open-access journals, and online citation indexes, such as the Web of Science, Scopus, and Google Scholar. Their availability within the countries participating in the Bologna Process significantly improves the effectiveness and quality of both education and research in these countries.

2.1. Accreditation Process

To ensure that engineering education programs produce graduates with a good engineering foundation and professional competences, they are subject to an accreditation process. The European Standards and Guidelines represent a set of standards, procedures and guidelines on quality assurance (QA), adopted by the ministers for higher education in the European Higher Education Area. This includes internal and external quality assurance. The internal quality assurance involves monitoring and periodic review of programs, critical self-assessment report with the assessment of curricula, students and teachers. This serves as an input for the external quality assurance evaluation by the independent peer group or the external QA agency. The accreditation agency makes a decision whether the program is accredited, conditionally accredited, or rejected. The EUR-ACE is the accreditation system that provides a set of standards for high quality engineering degree programs. The European Network for Accreditation of Engineering Education (ENAEE) is the network which authorizes accreditation and quality assurance agencies to award the EUR-ACE label to accredited engineering degree program [12, 13]. Students who graduate from accredited programs have better opportunities for employment, licensure and certification, graduate education and global mobility.

In the USA, the accreditation of post-secondary education programs (excluding doctoral programs) in applied science, computing, engineering, and engineering technology is done by a non-governmental organization ABET (Accreditation Board for Engineering and Technology), recognized by the Council for Higher Education Accreditation (CHEA). The latter is also a non-governmental organization which maintains an international directory of quality assurance and accreditation bodies in 175 countries, which have been authorized to operate by their governments as either governmental or private agencies. ABET accreditation is voluntary - the request for accreditation of a program is made by the institution seeking accreditation for that program. ABET specifies minimum curricula for various engineering programs. Accredited
programs must request reevaluation every six years to retain accreditation. Further description of the process of ABET accreditation can be found on the organization’s website (www.abet.org).

3. Advantages and Disadvantages of the Bologna Process

The first cycle, or the undergraduate engineering cycle of the Bologna Process lasts three years. It is characterized by more focused and shortened curricula, with more intensive faculty engagement in the education process. This new significantly shorter program resulted in larger number of graduates and faster graduation rates. The so-designed European higher education system became more attractive to non-European students, who are coming in increasing numbers to study at European universities (European Higher Education Area – EHEA). Furthermore, the system helps European integration, contributes to its economic and cultural growth, and thus overall prosperity. The Bologna process continues to be merged with political processes in Europe, although some education reforms, presented as part of the contemporary Bologna Process, were underway even before the Bologna declaration.

The implementation of the Bologna Process has revealed numerous weaknesses. Notable among them is a diminished quality and quantity of engineering knowledge gained by students during their BS program (inflation of knowledge). This was recognized by industry and resulted in increasingly more difficult employment, as the graduates were not sufficiently prepared to successfully join the workforce. Shortening the 4 or 5 years of courses to only three years was not an easy task, and unfortunately in this process the quantity and quality of knowledge required for the work in industry was lost. Additional year of specialization offers some remedy. The M.Sc. program is most often designed as the preparation for the Ph.D. program, rather than being an enrichment of engineering knowledge towards the immediate industry needs. The loss of the old and well-conceived degree of the Diplom-Ingenieur has thus been a troubling issue for the industry from the beginning of the process of higher education reform [14]. At some universities in USA, UK, and Australia, the Professional Master of Engineering degree is comparable in its qualities with the Diplom-Ingenieur degree.

One of the major objectives of the Bologna Process was to enhance mobility among students and faculty throughout Europe, but this did not happen as expected. Within the ERASMUS program, which started in 1987, over 2.2 million students spent a term in a different country of Europe until mid-2010. More than 4,000 higher education programs from 33 countries now participate in this program. However, a study of the Higher Education Information Center shows that engineering students show the smallest interest for the study abroad, with only 16% of them studying abroad during 2009 [15]. More efficient processes are under consideration to
achieve the high-mobility goals set at the beginning of the Bologna Process and to approach in quality the Anglo-Saxon system of education. Hearings in European Parliament have taken place in that direction (personal communication with D.P. responsible for higher education in the European Parliament).

The critics of the Bologna Process assert that the process does not offer the quality of the old Anglo-Saxon system of education, and that, to some extent, the Bologna Process transforms universities into “diploma factories”. This is partly attributed to the fact that the Bologna Process originated from the political decisions and activities, without sufficient initial involvement of the institutions of higher education. The Bologna Process has led to student demonstrations during the Vienna conference of the European higher education ministers in 2010. Students questioned the acceptance of the bachelor in the industry, especially in small and medium-sized companies. They stated that the bachelor degree does not prepare well for the working world, that it demands too much learning matter per time, that it does not foster mobility, and that there are too few offerings for soft skill trainings [15].

4. Bologna Process and Engineering Education in Montenegro

Before introduction of the Bologna Process, the organization of engineering education in Montenegro was similar to German system: nine semesters of required lectures, each semester consisting of 15 weeks, plus one month for exams. The tenth semester was used for writing the engineering diploma thesis. The graduates would receive a Dipl. Ing. degree in the particular field of engineering, such as electrical, mechanical, civil, or metallurgical engineering. The actual duration of studying was on average significantly longer than five years. The Master of Science program consisted of one or two years of lecture work plus an unspecified time for writing and defending the M.Sc. thesis, which usually required one to two years. A doctorate degree did not involve taking any required lectures, but only the work on the doctorate thesis, which could take two, three, or more years.

The implementation of the Bologna Process in Montenegro began in 2007. Upon the adoption of the Process, the system of engineering education in Montenegro was radically changed. It is now offered in three cycles: 3+2+3 years. The study for the Bachelor of engineering degree lasts six semesters (each semester consisting of 15 weeks, plus one week for exams). The degree of a specialist is obtained after completion of an additional year (two semesters). The study for the Master of Engineering Science degree lasts two years, after completion of the three-year Bachelor degree. This includes one year of required lectures plus the work on the master thesis. Master degree is in many ways equivalent to former diploma of engineering, but in many cases it provides a more theoretical background needed for the doctoral study. Specialist study attracts fewer students, but it provides lower level of professionalism than
the old diploma of engineering. Consequently, the industry is still reluctant to employ students with such specialist degree. The doctorate program includes only the work on the doctorate thesis, which usually lasts three years after completion of the Master degree. It should be pointed out that in Montenegro, as in many other former socialistic countries which are in the process of transition, much of the industry has vanished. As a consequence, there is no much support from the industry to universities and their engineering education. For example, the contacts of students with real engineering through internships in industry have dramatically decreased or have been lost completely. The coordination or balance between the industry demands and the current supply of higher education remains to be a challenge. Further about the higher education in Montenegro can be found in [16] and [17].

4.1. Accreditation of Higher Education in Montenegro

Higher education accreditation in Montenegro is conducted by the Council for higher education, formed by the Montenegrin Government. The Council consists of 13 members, each elected for the period of six years. Six members are chosen from distinguished scientists or artists, nominated by universities, five members are recognized experts from industry or other institutions outside universities, and two are representatives from student organizations. The Council nominates the committees for the evaluation and accreditation of higher education institutions and their programs, which can include foreign experts. If the institution is awarded the certificate of initial accreditation, it must apply and receive the work license from the Ministry of Education. The institutions are subjected to reaccreditation after a period of at most five years, which is based on evaluation and quality assessment of their programs. This is conducted according to the accreditation rules adopted by the Council, which are made in the spirit of the Bologna declaration, respecting specific characteristics of the Montenegrin higher education system. If a private institution of higher education was accredited by a foreign accreditation agency, it must submit the accreditation document to the Council for higher education for its revision and approval. Each institution must continuously conduct its self-assessment and quality control of its programs and submit them to the Council at the time of reaccreditation. Students are included in the process of self-evaluation. In addition, the University of Montenegro has created a Center for studies and control quality. Every engineering department must have a representative in the council or a committee for the quality assurance. The Montenegrin Government has passed the Law and installed the Council for national qualifications framework, in accordance with the European Qualification Framework (EQF) as an instrument which will enable broader comparative analysis of qualifications, quality assurance, and credit transfer among different countries. Although the Higher Education Act of Montenegro [18] specifies the standards and the process of accreditation of higher education programs and institutions, the obstacle in its realization is the lack of trained and experienced experts for quality assurance. Additional information on the accreditation process within the system of higher education in Montenegro can be found in [19].
5. Recommendations for Improvements of Engineering Education

There are many challenges facing the implementation of basic premises of the Bologna process, such as comparable or equivalent engineering curricula in historically and culturally diverse European countries. Several steps could be undertaken to improve the quality of engineering education. While the official lengths of various engineering programs are standardized, the actual contents of the courses and programs, as well as the criteria for their completion and established learning outcomes, may differ substantially. Similar or equivalent systems of quality assurance and program accreditation should be installed, preserving tradition and autonomy of universities. Specification of learning outcomes and their verification are essential for successful implementation of the Bologna Process. The comparability and equivalency of programs, with created proper interfaces, will result in easier mutual recognition of European programs. Such unification or harmonization of higher education should proceed without sacrificing the diversity, which is challenging by mere definitions of involved concepts. The success here may also prove to be instrumental for the enhancement of student mobility. Equal opportunities and accessibility of higher education must be imperative, regardless of the race, gender, social and economic background.

In addition to the M.Sc. program as a preparation for the Ph.D. study, a Master of Engineering program should be installed, providing a more in-depth engineering knowledge, emphasizing applications and skill-oriented capabilities, and directly linked to modern industry needs. Such programs have already been developed and are expanding in the engineering education in USA. The Bologna Process should incorporate additional measures to adopt other aspects of the American higher education system and establish closer relation to it [20]. For example, it would be desirable for students to give them the opportunity to study for a double-major, e.g., engineering major with a minor in mathematics, physics, biology, economics, or other field. Continuous feedback from students and alumni is a valuable source of information for the improvement of higher education. Finding adequate means to stay in contact with alumni (e.g., via email communications) is challenging but rewarding. Regarding engineering faculty, in addition to their creative research, they should be stimulated to work on the development and incorporation of innovative teaching and learning skills and methodologies.

The quality assurance of engineering programs and institutions must be done with more uniformity throughout European higher education area, promoting the efforts for innovation and developments of new programs within the Bologna Process, but respecting the specific characteristics of education systems in different countries. Minimum curricula for various engineering programs should be specified, paying care to both the education inputs (quality of curricula) and the education outputs (quality of gained knowledge). Engineering programs must prepare students for rapid technological changes, making them able to continuously improve
their skills in multi-disciplinary areas throughout their professional careers. The incorporation of various forms of life-long learning, for example through university extension programs, would provide the means for working professionals to keep track of modern engineering developments and remain competitive in this era of fast changing and developing technologies. This can be achieved through evening or weekend classes, or through on-line interactive courses (E-learning). Engineering education must also ensure that students in their professional work deal knowledgeably and ethically with modern technological challenges and their impact on society and on global issues.
References

DEVELOPING A GLOBALIZED AND SUSTAINABLE MINDSET IN 21ST CENTURY ENGINEERING STUDENTS

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Abstract

The globalization of education is undeniable in the U.S., where every year students from all over the world come to American Universities to pursue their Engineering and Technology degrees. However, the traditional engineering education model has invariably remained focused on purely engineering related topics, providing students with limited global and social content and lacks in the development of their view of globalization and sustainable practices. Engineering projects may extend to domestic and global environments usually requiring the acquisition of raw materials and the disturbance of local sites to complete their projects. Thus, engineers lacking a holistic view of the world may pose a threat to local or distant environments. Therefore, it is imperative to expose these students to the social, economic and environmental repercussions their choices may have for those living near and far. This paper proposes that to create engineers capable of dealing with global issues, their education should also comprise the understanding of economic, social, environmental and sustainable topics currently not included in their academic curriculum.

Keywords: Engineering, education, competitiveness, sustainability, curriculum, academia, industry, globalization.
1. Introduction

Engineering education is extremely relevant for the competitiveness and economic development of any country. According to the U.S. government data, the manufacturing sector is accountable for around 20 percent of the gross domestic product (GDP) of the country [1]. In education the U.S. has experienced a continuous increase in diverse Engineering Bachelor’s Degrees awarded throughout the years. At the beginning of the 20th Century, around 4,900 degrees were awarded in Engineering; by the year 2000 around 245,916 students received a degree in Engineering. During 2008-2009 engineering schools in the U.S. received almost 172,000 students from India, China and South Korea. These three nations were overrepresented in the area of Engineering, followed by Saudi Arabia, Nepal, Japan, Turkey, Mexico, Canada and Taiwan. Chinese and Indian students accounted for almost half (47 percent) of all foreign Science and Engineering students in December 2009. The amount of foreign graduate students still outnumbers the amount of foreign undergraduates. Chinese students prefer business and engineering education while Indian students remain mostly in engineering related areas[2].American students on the contrary paint a different picture. They hesitate in their choice of academic major and usually abandon the engineering path. From those students who initially state Engineering as their main major, 40 percent end up switching to other academic subjects or fail to complete a degree [2]. Today in some universities foreign students outnumber Americans in engineering fields.

1.1. Current Decline in Engineering Education

One of the many reasons for the change between majors for American students could be related to the negative perception of the engineering and manufacturing industry in the U.S. The media exercises great influence on the selection of majors and students are receptive to the negativism with which engineering and manufacturing is currently portrayed. As Miller states, parents and students are seeking viable educational programs that are capable of placing graduates in high paying positions with projected long-term growth [3]. Thus, manufacturing is portrayed, as an area of study with almost no future, since increasing production of goods is being offshored to low cost countries. The fact that the U.S. has never been more efficient and that U.S. output has undeniable increased is barely mentioned.

Another possible reason for students leaving engineering as a preferred area of study is the level of mathematical skills required in the engineering curriculum. Pisa studies conducted in 2009 revealed that American students are average and below average in mathematics and science respectively when compared with other OECD countries. Calculus, physics and chemistry seem to be the most difficult areas to deal with in
engineering for American students. Wadhwa [4] mentions that students and parents alike are worried about the outsourcing of jobs while Kennedy states the routine, repetitive aspects of engineering have become commoditized and are being priced as a commodity, not as a profession.

In the end, engineering graduates accept job positions outside the engineering profession, mostly in business and management areas, offering them not only better opportunities but very competitive salaries [4]. It is noteworthy mentioning that today around 30 percent of U.S. workers with science and engineering degrees are age 50 and older[5]. Duderstadt explains that with just 5 percent of the world’s population, the U.S. employs almost one third of the world’s scientists and engineers, and accounts for more than 40 percent of its R&D spending and publish 35 percent of its scientific articles[6]. Despite this fact, reports show that 600,000 manufacturing jobs go unfilled because industry cannot find workers with the needed qualifications and skills sets[7].

2. Required Skills of Future Engineering Students

In his Roadmap to the Future of Engineering Practice Research and Education, Duderstadt explains that “the changing workforce and technology needs of a global knowledge economy are dramatically changing the nature of engineering practice, demanding far broader skills than simple the mastery of scientific technological disciplines” [6]. His stance is also confirmed by recent surveys conducted in the engineering field that according to M. Jones et.al. confirms that skills in Lean Processes, Six Sigma and CAD/CAM are desirable for technical majors. The Association of Technology, Management and Applied Engineering (ATMAE) a recognized accrediting body in applied engineering, confirms the presence of a gap between skills needed and courses offered[8]. Those skills are not necessarily of a technical character but “soft skills”. Duderstadt mentions skills in entrepreneurship value creation, leadership, innovation and global engineering practice. According to Ayokanmbi engineering students must acquire a “global perspective”, what he calls multicultural intelligence skills that will enable them to communicate and appreciate other cultures around the globe. Ayokanmbi cites Patricia Galloway’s statement that “understanding of globalization is key to an engineer’s success in today’s global society”[9]. The purpose of this paper is to emphasize not only the area of globalization as a requirement in engineering education, but also the addition of economic, social, legal and political, environmental and sustainable topics in the engineering academic curriculum.
2.1 Globalization’s Importance in Engineering

Although the term globalization is somewhat tainted with a negative tone, the free movement of goods, capital and labor have enormous potential for growth and development for those in favor of it. Multinational corporations (MNCs) thrive where local market conditions are favorable, and where knowledgeable workers are available. The reach of MNCs has changed in character and evolved from being a set of discrete subsidiaries under a common canopy to a well-integrated and dynamic set of synchronized global operations. These operations cover the whole spectrum of value creation from global procurement, management, and process design, R&D and even after sales[6]. The U.S. exports of manufactured goods are expected to top $1.3 trillion in 2012, as Moutray states, an all-time high. This increase could not be possible without the increasing significance of our business counterparts in foreign markets. [10]. The leading U.S. export products are all related to technical improvements in the areas of transportation equipment, computers and electronics, chemicals, and non-electrical machinery. The key word for this phenomenal achievement is “trade”. Trade in general, and global trade in particular, are areas studied in business education and oftentimes not covered (or insufficiently covered) in engineering education. Thus, engineering students remain unaware of the country’s major trading partners, the different free trade zones around the world, outsourcing, off-shoring, supply chains and their advantages for value creation, technology commercialization, and mutual economic development to name a few. Engineering education must add value to society by transforming engineering deliverables into marketable products and services.

2.2 Understanding Social And Ethical Issues In Engineering

Globalization shortens distance and time leading to a diverse array of engineering projects extending beyond national borders. This entails working with individuals of diverse nationalities and cultures in places that might not look, or work, like ours. Engineering students currently have less than optimal opportunities to practice, understand, even less appreciate, basic cultural differences. The opportunities presented within the American educational environment (i.e. the representation of so many different nationalities in the classroom) are not sufficiently exploited. Thus, prejudices and assumptions lead to cultural imposition, mostly by the most dominant culture in the classroom. Kennedy states that engineering students need to be adaptable to the knowledge base that exists in other parts of the world, who also understand that our culture is not the “only one around”[11].

Understanding social issues within global markets are reflected in the various aspects of the product concept, product design, material selection and also in the respect for social
norms encountered at the worksite. The unquestionable leadership of the U.S. in technology related areas has led to the misconception that what works here must work around the world as well. Engineering students are poorly prepared for the task of working in multicultural teams, and even less prepared for working in foreign environments. Ayokanmbi (2011) calls it “Global Competency” and he advocates for opportunities to study, work and conduct research abroad. He also suggests that learning a new language is paramount in developing a deep understanding of another culture and a way of reaching across cultural boundaries [9].

According to the National Association of State Universities and Land Grant Colleges Committee for International Education[12] students should possess the following skills:

a) Diverse and knowledgeable world view  
b) Comprehend international dimensions in their area of study  
c) Communicate effectively in another language  
d) Exhibit cross cultural sensitivity and adaptability  
e) Carry global competencies throughout life

International business has for long been conducted in the “unofficial” language of business: English. This has diminished the interest for American students to understand the importance of learning a foreign language. However, today engineering projects are conducted on a global basis, and the proficiency (or at least basic knowledge) of a second language would make them more productive and competitive in the global arena. Duderstadt notes, “an increasing number of companies already are searching for engineers with foreign-language abilities and industry experience in global management and team-oriented skills”. This is an area in which the majority of our American engineering students remain at a disadvantage and uncompetitive compared to foreign students in the same field.

Ethics as a topic is frequently found in the business curriculum, but not so in the area of engineering. Ethics, beyond the understanding of moral principles that govern a person’s or group behavior is closely related to the proper understanding of nuances in the verbal and non-verbal communication. Johnson states that the social responsibilities of American engineers as defined in the present system of engineering are ambiguous and weak[13]. Thus, it should be a priority in engineering education to form students with a solid foundation regarding the impact of their work in society. At present students are not sufficiently (if at all) exposed to the ethical and moral ramifications of the technical solutions they may propose to a given problem. It should be well understood among engineering students that the goal of engineering is not just delivering the best technical solution, but delivering a solution that is best for all, humans and nature included.
2.3 Environmental Sustainability

The U.S. with only 5 percent of the world’s population controls 25 percent of its wealth and is responsible for almost 30 percent of its pollution [6]. The U.S. decision not to ratify the Kyoto agreement in 2001 could be interpreted as a disregard to environmental issues, but the U.S. is very much concerned with the wellbeing of the planet. The baby-boomers of 1946 -1964 created a society of wealth in the U.S., and any concern about the impact of their consumption on natural resources was inexistent. Today, we live in a time that condemns waste and the use and misuse of natural resources is constantly under scrutiny. In academia, sustainability issues are considered of extremely relevance for the preservation of our own life on Earth. Terms like global warming, greenhouse gases, CO₂, and alternative clean energy are frequently used, but their reach, impact, and cost are not understood. It is undisputable that human activity, in particular the burning of fossil fuels, cement fabrication, clearing land for agriculture and urbanization has increased the inflow of CO₂ to the atmosphere (IPCC).

Technology-based fixes concentrate on further reducing the already low emissions of developed countries, rather than reducing the increasing pollution of developing countries. For many students then, environmental concerns are frequently related to the area of clean energy, leaving concerns about soil, biodiversity, water consumption, human displacement and deforestation entirely unattended. However, these concerns are not included in engineering education and students do not learn the necessity to address the global problems that arise regarding pollution, regardless of its place of origin. Projects in engineering are mostly of technical content and do not include environmental decision-making issues or explain satisfactorily the interplay of eco-systems and their impact on human and wildlife.

2.4 LeanMinds InEngineering

People usually see Lean as a business tool, a technical fix, and a manufacturing thing. However, Lean is a philosophy, a way of thinking and a strategy for working efficiently and reducing waste. [14]. The philosophy of Lean can be applied to any industry as well as any area of academic studies. Many authors confirm the simplicity of this management philosophy, but they also express the incredible resistance to apply Lean concepts. Engineering students in the area of manufacturing cover to some extent Lean concepts but for the majority of other engineering areas, Lean remains an unexplored manufacturing tool.
Byrne laments that “Lean Manufacturing” as a term, has been detrimental for the acceptance of the Lean philosophysince many see it as a manufacturing tool and not as a management tool. However, Lean has an enormous wealth of knowledge to offer the engineering student. Lean stands for continuous improvement, problem solving skills, teamwork, creativity, innovation and respect for the individual. These are some of characteristics that the 21st Century engineer will need serve society in a global world. The simplicity of its main concept, reducing waste (all types of waste), is a great concept to start forming the mind of a sustainable 21st century engineer.

3. Conclusion

Duderstadt’s report highlights a concern stating that “we are attempting to educate 21th Century engineers with a 20th Century curriculum, taught in 19th Century institutions. Those involved in academia will certainly find his remarks well founded. We advocate for global sustainable minds, but the engineering curriculum is still of strict technical character and as Duderstadt explains in his report, there is not much difference in today’s engineering curriculum when compared with the one used a century ago. In order to create a competent workforce for the 21st century, academia must provide education above and beyond areas that might not be considered engineering related.

Engineering education could attract more students if the current curriculum offered a broader perspective to the profession than a restricted technical character it has today. Engineering professionals should not interpret the inception of “soft skills” as a reduction of value to the engineering academic program, but as a necessary improvement to it. To compete on a global basis, we need to open our minds to the skills needed in this century, and not hold on to a past that will never come back. If technology has so dramatically advanced, why not so the engineering education?

Engineering students are already at a great disadvantage compared to their foreign counterparts. All the nationalities represented at American institutions of higher education clearly demonstrate that foreign students are much more curious, flexible and adaptable to explore new environments than their American counterparts. These foreign students come with already a skill that American students lack: they speak a foreign language (and many times more than one).

American students lack of interest in learning or experiencing another culture, their fear of the unknown, and their reluctance to leave their comfort zone is making them, day by day, less attractive to global markets.
Therefore, it is imperative to give engineering students the tools they need to succeed in a global and challenging world. Their potential should not be restricted to only technical competencies, but extended to cover socio-economic, environmental, and ethical skills. It is only then, the engineering student will become the truly global and sustainable individual that our society in general, and industry in particular, is in need of.


TOWARDS A CONVERGED AND GLOBAL SET OF COMPETENCIES FOR GRADUATES OF ENGINEERING PROGRAMS IN A GLOBALIZATION-GOVERNED WORLD

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Abstract

This paper deals with the notion of having a converged set of abilities of graduates from engineering programs for a diverse yet globalized world. It attempts to provide answers to questions like: What are the needed hard and soft skills (abilities, attributes and competencies) expected of graduating engineers? What transformation do engineering education programs have to experience to accommodate advancements in technology and globalization? What is the role and scope of each of the constituencies of engineering education for a globalized world? What role does globalization play in the generation of modern and industry-ready engineers? What kind of educational reform is needed for engineering programs and institutions? What are the challenges of globalization in educating the engineers of tomorrow? What impact does globalization have on Quality Assurance systems and Accreditation processes? The paper concludes with a set of recommendations to the different constituents for the generation of responsive and globally-ready engineering graduates.

Keywords: attributes of engineering graduates, global competencies, convergence, globalization, engineering education.
1. Introduction

Engineering is a profession that is concerned with the application of mathematics and science and whose objective is to provide solutions to complex problems for the benefit of mankind. With a knowledge-based economy in a globalization-governed world, engineering practice and Higher Education Institutions bear the responsibility of producing graduates who wear multiple hats and are equipped with a long list of hard (technical) and soft (professional) skills. In the past, an engineer was assigned a cubicle in an engineering firm and given the task to design a system or a component with the goal of meeting a particular need. The tools were simple gadgets and the expectations were limited in scope and bound by completing the assigned task. Nowadays, an engineer is a skilled applicator of science equipped with fundamental technical knowledge, versed with technological tools, and ready to take on problems never seen before in a world that is open and competitive. The integration of technology into our everyday lives and its presence in every little corner of the world has made the world a small place indeed and has allowed globalization to govern interactions across economies of the world.

This paper will attempt to provide answers to the following pertinent questions: (1) What are the needed hard and soft skills (abilities, attributes and competencies) expected of graduating engineers? (2) What transformation do engineering education programs have to experience to accommodate advancements in technology and globalization and what kind of educational reform is needed for engineering programs and institutions? (3) What is the role and scope of each of the constituencies of engineering education for a globalized world? (4) What role does globalization play in the generation of modern and industry-ready engineers? (5) What are the challenges of globalization in educating the engineers of the future? And (6) What impact does globalization have on Quality Assurance systems and Accreditation processes?

Globalization has undoubtedly affected how and what Higher Education Institutions offer as formal and informal programs and how they engage learners of the 21st century. It has also given rise to the notion of having a converged (universally agreed upon but not necessarily uniform) set of qualities associated with graduates from engineering programs at H. E. Institutions across the globe.

2. Globalization and Education

Many write in defense of globalization and many see it as widening the divide between the rich and the poor. This view is especially true for developing countries and economies as they wrestle with the challenges of globalization. The International Monetary Fund confirms the opportunities linked to globalization but see its progress as skewed towards developed
economies. Developed countries, leaning on strong infrastructure and investments in research, often set the course in terms of scientific discoveries, knowledge creation, and technology advancements and integration. Developing countries, on the other hand, are caught playing “catch-ups” and find themselves having to deal with self-defeating issues like the brain drain, political instabilities, societal injustice, and internal/external turmoil. In fact, developing countries find themselves in an inescapable position as consumers of knowledge with limited contribution to the creation and advancement of knowledge. Higher education institutions in developing countries, though manned by administrative and teaching staff often educated in developed countries, constantly attempt to play similar roles to their counterparts in the developed world with little, if any, contribution to the creation of knowledge. Due in part to their formal training and building on acquired knowledge, faculty members in developing countries often mimic what is done in the developed world and offer similar (copy and paste) programs and curricula. However and despite their noble intentions, these attempts are feeble as they ignore local issues and overlook regional contexts. This is in addition to the fact that the supporting infrastructure is quite different and there are differences across cultures. Most of all, the learning opportunities and experiences are lacking. In that regard, globalization widens the divide between developed and developing economies.

The globalized world is a knowledge-based world that is built on knowledge/information production and transmission. Production of knowledge is founded on the availability of high-technology industries and investments and correspondingly the contribution of highly-skilled workers (e.g. engineers). Transmission of knowledge and information requires the use of communication networks collaborating together using technology. To be a global player, the production of knowledge can not be expected to be done within the walls of educational institutions alone but rather within the context of shared responsibilities of both academia and industry. In addition, learning by doing is essential. Hence a partnership between industry and academia becomes an urgent need. The “information society” is rather supported by the digital revolution relying on extensive electronic networks, communication devices, e-tools, and digital libraries. In that regard, globalization presents an opportunity to be an active participant and to play the global game.

In a call for action on educating engineers as global citizens, Grandin and Hirleman (2009) offer a number of recommendations. As always, opportunities and recommendations are accompanied by challenges. There are a number of inevitable challenges due to globalization’s impact on education. Naming a few:

- Mobility for graduates
- Compatibility of programs and of graduates
- Recognition of degrees
- Benchmarks, standards, and metrics selection
• Agreement on terminology
• Institutional specifics and region-level contexts
• Emergence of non-traditional institutions and programs
• Internal/external QA systems/policies
• Reciprocity and mutual recognition of accreditation decisions
• Legitimacy of accreditation agencies
• Quality assurance in transnational education and across borders

In lieu of restating what others have stated on the challenges presented by globalization, the reader is directed to a report prepared by Altbach et al. (2009) for UNESCO’s World Conference on Higher Education. The author tends to agree with a statement made by Nayyar (2008): “We should not allow markets and globalization to shape higher education. Instead, we should shape our agenda for higher education so that we can capture the opportunities and avoid the dangers unleashed by markets and globalization.”

3. **Attributes and Competencies of Engineering Graduates**

Much research has been carried out for the purpose of defining the attributes and competencies of future engineering graduates. In a study conducted by the U.S. National Academy of Engineering in 2004 - “The Engineer of 2020: Visions of Engineering in the New Century” - The report stated that “technology has shifted the societal framework….. [with] new developments in nanotechnology, logistics, biotechnology, and high-performance computing.….. a growing need for interdisciplinary and system-based approaches, demands for customerization, and an increasingly diverse talent pool. The steady integration of technology in our infrastructure and lives calls for more involvement by engineers in the setting of public policy and in participation in the civic arena.” In another study carried out by the UK’s Royal Academy of Engineering (2007) - “Educating Engineers for the 21st Century” - Industry and academia emphasized that “university engineering courses need redesigning for the modern economy”.

3.1 Graduate Skills and Readiness for Employment

Crebert et al. (2004) emphasized that higher education programs must find different ways to integrate transferable skills that can be used in a variety of situations in the workplace. Atkins (1999), in a study of the employability skills of British university graduates, found that a gap existed between the requirements of employers and the skill sets of university graduates. Laker and Powell (2011) promoted the notion of acquiring soft skills and posited that soft skills are a necessary component of any employee's skill set and form an integral part of an employee's
training process. In attempting to provide a global model for engineering competence, Lohmann et al. (2006) stated that "many new competencies needed by engineers today are professional skills (sometimes called the 'soft skills')" (p. 119). They claimed that these soft skills had become necessary for engineers to be able to function in a globalized environment and to succeed transnationally. Additionally, in their review of the skills of modern engineers, Shuman, et al. (2005) stated that while technical skills remain a prominent component of the engineer's skill set, soft skills have become equally important. On the expectations of American employers, Back and Sanders (1998); Beder (1999); and Balaji and Somashekar (2009) to name a few found that employers were more likely to recruit applicants who showed a higher level of soft skills as opposed to those who only exhibited a high level of technical ability (hard skills). Sharma and Sharma (2010), on a study on Indian engineers, claimed that soft skills had become an increasingly important part of success in the engineering field in particular and that these skills could be successfully instilled in students during the education process.

Riemer (2002) pointed out that language and communications skills form an integral part of an engineer's abilities. Engineers must be able to utilize new technologies to communicate, particularly when the communication must occur on a global scale. Furthermore, multilingual skills have quickly grown into a requirement in the globalized work environment. Firms operating on international levels require that their engineers be able to communicate across cultures. In an Australian review, Greenwood (2007) stated that employers and employees had been placing an increased importance on the ability to write and speak effectively. Additionally, Lohmann et al. (2006) formulated a conceptual model for the success of engineers on a transnational basis. Farr and Brazil (2009) found that team skills and leadership skills played an important role in American engineers' career. The global and competitive workplace requires an engineer that is able to work in a multicultural, multidisciplinary environment (Nair et al. 2009). Wallen and Pandit (2009), in a study of Irish engineers' skills, found that engaging engineers in community-related activities helped bolster a variety of soft skills. Engineers in the modern workplace must be able to prove that their skills are current and that they are able to update their skills knowledge to better suit the evolving work environment (Greenwood, 2007).

3.2 Engineering Skills and Education

In his paper on the international standards of engineering educational programs, Fuchs (2006) recommended that educational institutions should re-focus the coursework required of engineering students to allow them to work more effectively within social and global contexts. Design makes up an important part of the engineering education process (Dym et al., 2005). Additionally, Conlon (2008) stated that social and environmental responsibility had increasingly become an important part of the engineering profession.

Problem solving skills and experimental design are key components of overall design skills. Additionally, data collection and analysis skills, which complement experimental design
skills, further aid engineers in nurturing their design skills. In his review of the history of engineering education, Prados (1998) highlighted a shift in the paradigm of American engineering education in the mid-to-late 20th century, where curricula which were once based upon practice and design became more concerned with academia and theory. Of particular relevance to the observed lack of soft skills in engineering graduates is the concept of emotional intelligence (Scott & Yates, 2002). In contrast to academic intelligence, which may govern aspects such as an individual’s technical ability, emotional intelligence dictates the quality of an individual's human interactions. Finally, in an investigation on whether the “professional skills” could be taught and assessed (Shuman et al. 2005), the authors gave an extensive review of what is being done in the field of engineering education to respond to the challenge of acquiring the soft outcomes. The authors proposed the use of “service learning and its complementary component – global service learning”.

### 3.3 Engineers with Business Skills

Along with the relevant technical and soft skills required of a modern engineering graduate, research has identified the need for engineering professionals to function as businesspeople (Martin et al. 2005). There is a need for more rounded engineering professionals who can function in global, social, financial, technical, and commercial contexts. From a European perspective, Birch (2007) stated that engineers must be able to connect the business world with the scientific community in order to drive innovation. Many engineers find that their career paths naturally lead them to managerial and executive positions, requiring the ability to function with more than just technical skills. Engineers have transitioned from their traditionally purely technical roles to managerial ones that require a sense of business practices and leadership skills (Nguyen, 1998; Palmer, 2002; Goh et al., 2008). Finally, in a Malaysian review of international engineering standards by Zaharim et al. 2010, it was found that several skills expected of engineering graduates existed worldwide. Utilizing a compilation of skills/abilities internationally, they built a comprehensive framework of the technical and non-technical skills required for employability in Malaysia.

### 4. Globalization and Quality Assurance and Accreditation Requirements

Various bodies and stakeholders have attempted to define the skills that are expected of engineering graduates. The US-based Accreditation Board for Engineering and Technology programs (ABET), for example, lists the following eleven skills as expected outcomes of accredited engineering programs (ABET, 2012). Criterion 3 lists what is called “Student Outcomes”, also commonly known as Program Educational Outcomes. They are a mix of hard and soft skills *each and every graduate* must demonstrate having by the end of their undergraduate programs (also known as “a-k”).
Other accrediting bodies, around the world (ASIIN, CET, EUR-ACE, etc.), have specified similar graduate qualities. The World Federation of Engineering Organizations (WFEO) has dedicated a publication titled “IDEAS” which featured themes and activities closely related to Quality Assurance and Accreditation. In edition 16 of IDEAS, Greenwood pointed out that “accreditation and assessment manuals include tables of attributes and competencies”. In the most recent edition of IDEAS (edition 17), Nasr (2012) made the notion that it would not be worthwhile to re-invent the wheel in reference to developing a set of outcomes for engineering graduates that is too different from the sets developed by accreditation agencies worldwide. The “exercise” of following procedures for Quality Assurance and Accreditation would, in principle, bring global views together on the issue of “graduate abilities and expected competencies”. The International Engineering Alliance (IEA) developed a set of “professional competency profiles” and it could be concluded that graduate engineers (from any corner of the world) that are on the International Register of Professional Engineers (of the IEA) should be similarly competent. The notion of “Qualifications Frameworks” may be worthwhile investigating if supported by verifiable outcomes, evidence of graduates’ capabilities, and meaningful experiences.

Furthermore, there are “constraints in designing systems” which are related closely to globalization: “economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.” This is particularly true for engineering firms which operate on the global scene. It is therefore suggested that globalization is driving engineering education towards having a converged set of abilities for engineering graduates who would be ready and equipped to hit the global workplace. The IEA has summarized a list of 12 broad categories of characteristics that are required of practicing engineering graduates worldwide through the Washington Accord, which represents a mutual agreement amongst international engineering bodies that recognizes the equivalence of engineering programs. The graduate attribute profile produced through the Washington Accord defines attributes that engineering graduates are required to display within complex engineering contexts and included the following major headings (IEA 2009): (1) Engineering Knowledge, (2) Problem Analysis, (3) Design/Development of Solutions, (4) Investigation, (5) Modern Tool Usage, (6) The Engineer and Society, (7) Environment and Sustainability, (8) Ethics, (9) Individual and Teamwork, (10) Communication, (11) Project Management and (12) Finance, and Lifelong Learning.

Similarly, EUR-ACE accredits European engineering programs and is supported by bodies such as Commission des Titres d'Ingénieur (CTI) in France and ASIIN in Germany. It has provided 6 main categories for engineering graduate skills as follows (ENAEE 2008): (1) Knowledge and understanding, (2) Engineering analysis, (3) Engineering design, (4) Investigations, (5) Engineering practice, and (6) Transferable skills. These are similar in nature to those provided by ABET and IEA.

In a recent study submitted to the European Journal of Engineering Education by Ramadi, Ramadi, and Nasr (2013), potential gaps between industry expectations and perceptions of
engineering graduates' skill sets as perceived by engineering managers in the Middle East and North Africa (MENA) region were explored. Thirty six skills were identified. A Principal Components Analysis consolidated these skills into 8 distinct categories. These categories overlap to a significant extent with those grouped by IEA and ENAEE.

Therefore, based on the literature pertaining to the skill sets of modern engineers, accrediting agencies of engineering programs, engineering educators, curriculum designers, and the perspectives of the engineering industry, one may compile a list of skills which are essentially desired of engineering graduates. This list of compiled skills relies heavily on lists produced by accrediting bodies, such as ABET, the International Engineering Alliance (IEA), and EUR-ACE to name a few.

5. **Recommendation for the Stakeholders of Engineering Education**

Answering to accountability, customers’ trust, and differentiation; engineering programs often define their constituents. A probable listing is as follows: (1) Engineering Programs themselves, (2) Academic Institutions, (3) Students, (4) Parents, (5) Support Foundations, (6) Government, (7) Industry/Profession, (8) Advisory Boards for Engineering Programs, (9) Accrediting Agencies, (10) Professional/Licensing Bodies (Order of Engineers, Professional Engineer, etc.), and (11) Ministry of Higher Education and related committees on initiation and certification of programs and institutions.

This paper offers a number of recommendations to the various constituencies as they each contribute to the making of the engineering graduate in a globalized modern world, a “global engineer” fit for the challenges of a globalized world:

5.1 **To Engineering Programs Themselves and to the Academic Institutions**

1. Form affiliations with other institutions worldwide (issuing of dual degrees)
2. Engage and partner with global industries (engineering practice on a global scale)
3. Emphasize global aspects by upgrade and update the list of needed competencies
4. Carry out cyclic curriculum reviews to specify achievement of program outcomes
5. Encourage and reward faculty members to carry out globally-relevant research
6. Offer programs and degrees which are compatible with the needs of a globalized world
7. Perform orientation sessions to students and their parents on the evolving expectations of the engineering profession in a globalized world
8. Incorporate a “mobility” program for students in the form of an international experience
9. Integrate technology into the curriculum to meet the needs of the globalized world.
5.2 To Students, Parents, Support Foundations, and Governments

1. Solicit answers from engineering programs on how they are dealing with the challenges and opportunities of globalization
2. Ask to see evidence of students’ experiences and related abilities of the graduates which acknowledge dealing with globalization
3. Partner (support foundations and governments) with universities and industry and invest in creativity and innovation – the hallmarks of being competitive in a globalized world
4. Allocate funds (support foundations and governments) to support global sharing and exchange of knowledge and information
5. Support high schools in strengthening science and mathematics curricula.

5.3 To Industry and Advisory Boards of Engineering Programs

1. Engage the global engineering practice (engineering industry) by making it available for visiting professorships, residencies, seminars, and internships opportunities for students
2. Partner with universities and government in promoting technology/innovation
3. Work with and contribute to professional societies in specifying global competencies
4. Make man-power available to assist accrediting bodies in the evaluation of programs
5. Participate in lessening the effects of “brain drain” by utilizing technology.

5.4 To Professional/Licensing Bodies, Accrediting Agencies, and Ministries of H.E.

1. Make becoming a “licensed engineer” a requirement for the practice of engineering everywhere in the world
2. Make holding the title of “an engineer” be based on some form of a standardized evaluation beyond that experienced to earn the degree from a HEI
3. Establish global standards in relation to accreditation and quality assurance
4. Formulate a system for quality assurance in transnational education and across borders
5. Promote the notion of “substantial equivalence”
6. Engage in the formulation of a “Qualification Framework” for each degree level
7. Explore the generation of a “ranking system” that is contemporary/global
8. Form and contribute to the establishment of international networks.

6. Conclusion

Globalization has opened societies and cultures on each other. Firms and engineering businesses have turned global. Higher education institutions supply engineering firms with (supposedly) industry-ready graduates. Therefore, the abilities/attributes/competencies of engineering graduates are no longer linked to the traditional roles of design and technical
competence. Engineering accrediting bodies as well as world organizations concerned with the “making” of an engineer and the engineering profession are making progress in specifying the abilities of the modern and world-ready engineer. Engineering programs must equip their graduates with contemporary and modern technological tools. The various constituencies can play basic roles and functions so that the graduate is indeed global having a set of competencies that are transnational and can work across borders. H.E. institutions and accreditation agencies, along with other constituents, need to collaborate and share best-practices since globalization seems to be driving convergence of H.E. as well as QA systems and policies. In other words and to be active global players, H.E. Institutions can no longer play their traditional roles and should partner with other constituents in setting up programs which equip graduates with the “tools” to face global problems. In that regard, this paper concluded with a set of recommendations which aim to strengthen the possibility of producing an engineer with a global set of abilities, skills, and competencies.

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References


ENGINEERING LEARNING OUTCOMES ASSESSMENT

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Abstract

A major component of designing modules and programs is learning outcomes assessment, which is determining what the student has learned after completing a module or a program. Assessment generally passes through four stages: defining what students should be capable of doing (i.e. the learning outcomes), assessing their learning (i.e. outcomes assessment), analyzing the results, and carrying out changes to improve teaching and student learning. In an attempt to cope with the global trend of shifting from teacher-centered to student-centered learning, the Lebanese International University is in the process of implementing a roadmap to assessment. This paper details the different phases of the adopted assessment plan and provides examples to the already achieved ones.

Keywords: Learning outcomes, outcomes assessment, assessment tools, direct measures, indirect measures, continuous improvement.
1. Introduction

The content of a course has traditionally constituted the start point for designing modules and programs [1]. Basing design on content revolves around two key elements: the teacher’s input since teachers select the content and the method of instruction, and the degree to which students understand the material. Such an approach is commonly referred to as a teacher-centered approach.

The teacher-centered approach lends itself to criticism due to its inability to determine precisely what a student is capable of doing after passing a course or program. This encouraged a shift in international education trends from the teacher-centered to the so-called student-centered approach [2]. The primary focus of a student-centered approach is the desired abilities a student is expected to develop once a course or a program is completed. As a result, this approach is an outcomes-based approach, where learning outcomes state what students are capable of doing at the completion of the learning period.

In engineering education, the outcomes-based approach forms the basis of the educational reform being currently implemented by educational institutions and professional organizations around the globe. In addition to technical knowledge traditionally focused on by engineering schools, industry places a premium on equally important attributes such as communication skills, teamwork, emotional intelligence, ethics, and professionalism. Accounting for this broad set of attributes naturally shifted focus to learning outcomes. This was a game changer for engineering education.

In the context of learning outcomes assessment, faculty members usually advocate the use of grades as an indication of the capabilities of students. The fact that grades are awarded based on the degree to which a student meets the faculty member’s standards and expectations makes it difficult to infer what a student is capable of doing. Learning outcomes assessment should, however, provide evidence of students’ skills and knowledge that can be linked to specific learning outcomes and not requirements and specifications set by the faculty member [4].

Grades are not suitable for learning outcomes assessment for two reasons. First, the course content may not be the same among faculty members teaching the same course.

The second reason is that the grading policy is subjective and depends on the faculty member. That’s why grades do not reflect what the student knows or can do, and do not provide information about what topics or concepts he did not understand or how his learning can be improved.

Program learning-outcomes assessment for the curriculum differs from classroom learning-outcomes assessment in several ways, most notably the following. Curriculum
development starts with faculty members defining the objectives their students need to achieve when they complete the program. After defining the objectives, faculty members determine the program outcomes or, equivalently, what students should know or be capable of doing in order to achieve the objectives. Developing the curriculum through a set of major and general education courses comes next. Students familiarize with basic concepts in the lower division courses. Throughout the remaining of the curriculum, these concepts are then applied in courses as students move from knowing and understanding a concept to developing an ability to apply that knowing and understanding in different ways and in multiple scenarios. This process demonstrates the cumulative learning effect of specific concepts and skills taught through individual courses. Indeed, the program-outcomes assessment should reflect student-achievement-specific outcomes as a culmination of several classes and activities throughout the curriculum.

This paper introduces a conceptual framework for academic assessment at the School of Engineering of the Lebanese International University, a definition of academic assessment, a general model of assessment, and a discussion of steps involved in any type of academic assessment.

### 2. An Approach to Assessment Cycle

Assessment is a cycle that consists of the following: learning outcomes definition, measurement of outcomes, analysis of results, and recommending changes to improve programs and activities. Being focused particularly on improving student learning, academic assessment addresses student-learning goals and conducts measurements of learning [5]. Assessment is best thought of as a continuous and dynamic process, as it adapts and responds to changing local and global dimensions of knowing. Figure 1 depicts the cyclical nature of assessment, as faculty members are always investigating, intervening, interpreting, and improving.

![Figure 1: The assessment cycle.](image-url)
2.1. Definition of Learning Outcomes

Step 1 of the assessment cycle is defining learning outcomes which includes the following elements: review of the program mission and goals, defining learning outcomes that are consistent with the goals, and finally course mapping which is basically saying which courses cover what outcomes.

2.1.1. Mission Statement

At this point in the assessment cycle, the mission statement has either to be created, if it does not exist, or reviewed to cope with changes in the program. The mission statement represents the purpose that achieving the program outcomes is meant to serve. Reaching a general agreement in its development affects the degree to which it has value and significance among faculty members. It should reflect their points of view toward the program, inform the students what the program is to accomplish, and provide *raison d’être* of the program.

For instance, engineering students have the right to know the purpose an introductory course in linear algebra serves. In this respect, a clear mission statement not only facilitates reaching a consensus among faculty members on the program goals and outcomes, but also aligns the efforts of students and faculty members with the purpose of the program.

The mission of the Electrical and Electronics Engineering Department at LIU is captured in the following paragraph:

“The mission of the Department of Electrical and Electronics Engineering is first to support future engineers to develop and build their careers in the field of electrical and electronics engineering. Graduates will be successfully able to integrate the fundamentals of electrical and electronics engineering with design/implementation practices to develop innovative solutions to complex technological problems. They will work as professional engineers or participate in graduate university programs in electrical and electronics engineering or other related fields.”

2.1.2. Goals

Goals of an academic program are statements of what the program is to achieve or become in the long run. The statements can be general but should give direction to the program through affecting decisions related to its scope, requirements, and priorities and scope.

A successful academic program relies, among other factors, on agreement on its goals, comprehending what the program is to achieve and establishing a link between the goals and the curriculum.
The program goals of the Electrical and Electronics Engineering Department are given in the following statement:

“The undergraduate program prepares students with expertise in electrical engineering and technology through theoretical and hands on practices.”

2.1.3. Learning Outcomes

Upon reaching a consensus on the program mission and goals, faculty members proceed with the definition of specific learning outcomes. These outcomes should be consistent with goal statements, which in their turn have to be aligned with the mission statement of the program. In contrast to goals, which are broad statements, learning outcomes present a clear, accurate and specific account of the required level of learning to be achieved in the process of earning a degree and meeting program goals. Table 1 shows how learning outcomes can be derived from program goals.

Table 1: Learning Outcomes derived from program goals.

<table>
<thead>
<tr>
<th>Program Goals</th>
<th>Student Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outcome 1</td>
</tr>
<tr>
<td>Goal 1</td>
<td>×</td>
</tr>
<tr>
<td>Goal 2</td>
<td>×</td>
</tr>
<tr>
<td>Goal 3</td>
<td></td>
</tr>
</tbody>
</table>

It is important that faculty members make sure that learning outcomes provide answers to the following three questions:

1. What knowledge and information should students in a given major acquire?
2. What skills and competencies should students gain?
3. What values, attitudes or qualities should be instilled in students?

It is worth mentioning that the discussion about learning outcomes should not be restricted to faculty members. Other stakeholders with different perspectives such as students, employers, and alumni can provide valuable input.

In discussing learning outcomes, faculty members usually start with reviewing the program mission statement and goals. Additional suggestions and ideas can be obtained by checking learning outcomes of departments offering similar programs.

The objective is to come up with an expansive list of relevant learning outcomes that can be later narrowed to a number between three and five. The selected outcomes should meet the SMART criteria:

Specific as to what the learner will be able to do
Measurable can be observed by the end of the program or module
Attainable can be achieved within scheduled time and given resources
Relevant oriented to the needs of the learner and the institution
Time-bound can be completed by the end of the program or module

Narrowing the list the outcomes is challenging task that is usually tackled using the Delphi technique. This technique consists of the following. First, each faculty member anonymously ranks the outcomes in the list by assigning a numerical value to each of them. Then, an impartial facilitator computes the scores, ranks the outcomes, and announces the rankings. This process is repeated until faculty members reach an agreement and a minimum number is retained.

Intended learning outcomes are concerned with what students in the major should know and are capable of doing upon completion of the program (student-centered) rather than with what faculty members teach (teacher-centered). Finally, making learning outcomes public is important, as it helps students in the program become aware of the where their direction is heading and be more involved in the learning and assessment process.

2.1.4. Course-Outcome Mapping

Departments typically use course mapping to determine how learning outcomes are addressed in the course offering, i.e. each course covers what outcomes. In general, a table, with one axis containing the program learning outcomes and the other containing courses, is used to represent a course map. The cells of Table 2 show the learning outcomes covered by each course.

<table>
<thead>
<tr>
<th>Program Learning Outcomes</th>
<th>Course 1</th>
<th>Course 2</th>
<th>Course 3</th>
<th>Course 4</th>
<th>Course 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome 1</td>
<td>×</td>
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<td>×</td>
<td>×</td>
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</tr>
<tr>
<td>Outcome 2</td>
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<td>Outcome 3</td>
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<td>Outcome 4</td>
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</table>

Not only does course mapping provide a view of how each course is mapped to the program learning outcomes, but also shows the weight or emphasis assigned to each outcome. For instance, Outcome 1 in the Table 2 is mapped to five courses and is therefore given greater significance than Outcomes 3 and 4.
Another advantage of a map is that it identifies redundancies or gaps in the map. The above example shows that only one course currently covers Outcome 4. This may be appropriate if a single course is strongly oriented toward the intended outcome. For instance, development of research skills might be one of the intended learning outcomes for an academic program, and it might occur that only one course covers this outcome. In reviewing such a course map, faculty members have to decide whether the outcome is addressed less prominently in other courses (for instance, research skills may be taught directly in only one course, but may be required by students in other courses). If it addressed by a single course, faculty members have to decide whether it is sufficient to have this single course covering a high-priority learning outcome.

In summary, a course map can determine the extent to which the program currently addresses the list of intended learning outcomes. Moreover, it can display the degree to which a course stresses a specific outcome. Furthermore, it may be useful to show the time allocated to each outcome in each course. For developmental outcomes, descriptors such as low, medium, and high can be used to indicate the level of achievement expected in each course and how student achievement is building up during progress through the major.

### 2.2. Assessment of Learning Outcomes

At this step of the cycle, faculty members employ one or more methods to collect information about whether students are achieving the intended learning outcomes. Assessing program learning outcomes includes selecting assessment tools, setting performance benchmarks, implementing the assessments, and obtaining results from the assessments. This is usually a resource-demanding step, which, depending on the assessment method selected, may require some or all of the following: experience in developing and scoring instruments, faculty and/or staff time for implementing and scoring assessments, money for buying instruments, and the use of some class time for implementing assessments.

#### 2.2.1. Selection of Assessment Tools

Selection of an assessment tool should strike a balance between the ability to obtain detailed information and the need to keep the process feasible and manageable. Assessment tools can generally be assigned to two categories, direct and indirect [6]. Under some circumstances, it becomes necessary to use multiple assessment tools to get a more holistic view of student learning and overcome the disadvantages of a single tool, but with added effort and expense.
**Direct Measures:**

Direct measures of assessment are measures in which the products of student work are evaluated given the learning outcomes for the program. Activities from coursework such as projects or specialized tests of knowledge or skills are examples of direct measures. In all cases, they involve the evaluation of student learning demonstrations. The assessment of a given learning outcome should use at least one direct measure.

**Indirect Measures:**

Indirect measures of assessment are measures in which students judge their own ability to achieve the learning outcomes. Indirect measures are called so since they are not based directly on student academic work but rather on how students perceive their own learning. Alumni may also be asked how and to what extent the program prepared them to achieve learning outcomes. In addition, people in contact with the students, such as supervisors and employers, may be asked to provide feedback on the effectiveness of program graduates. For indirect measures, the assessment is based on perception rather than direct demonstration.

**2.3. Analysis of the Assessment Results**

Step 3 of the assessment cycle involves analyzing the results of Step 2. Faculty members interpret the assessment results in light of the intended learning outcomes. Understanding of the results must then become part of a broader faculty conversation across the academic program.

In interpreting assessment results, the first element is to compare the actual outcomes to the benchmark or the outcomes that were intended (as identified in Step 1). The comparison determines whether the programs learning outcomes were achieved and students are learning what was intended, and whether there is room for improvement on any of the intended outcomes that were the subject of the assessment. In case of anomalous results, the comparison indicates if a problem exists with the assessment instrument itself or with the student learning outcomes. Faculty members must consider these points in order to begin to understand the assessment results.

Once the faculty members conducting the assessment are confident of their findings, they should disseminate them to all program faculty members for discussion and interpretation. This can be achieved through faculty meetings, committee discussions, e-mail, etc. Assessment results almost always indicate some room for improvement in the program.

Assessment results should never be framed in such a way so as to unveil a particular person's shortcoming. Shortcomings should be considered as opportunities for
improvement and faculty members are urged to ask how and what can we do better? Viewed from this perspective, assessment becomes opportunity to improve and do a better job for the students.

2.4. Recommending Changes Based on the Results

The fourth and final step of the cycle is to use the analyzed results of the assessment to improve the academic program through recommending changes. These program changes must be directly related to the assessment results. If the original assessment has been well designed, it will likely identify one or more general areas where the program could be improved. Either the original assessment or possible follow-up studies will suggest the specific concerns that need to be addressed.

Despite the fact that assessment results can point the way and suggest specific improvements, it is the duty of faculty members and administrators to reach a decision that balances the original intended learning outcomes, the available resources, and the other competing priorities of the program and the school.

Using assessment results to make improvements in programs initiates a new cycle of assessment. After the program change has had a chance to take full effect, a new assessment is conducted, beginning as before with confirming the original mission statement and intended learning outcomes, and proceeding through evidence collection, interpretation of results, and any further modifications of the program that are indicated by the second round of assessment. Depending on the nature of any program changes, the time elapsed between the completion of the first assessment cycle and the beginning of the second may be as short as one semester or as long as a few years.

3. Conclusion

In this paper, we presented a roadmap for Engineering Learning Outcomes at the Lebanese International University. This roadmap consists of four steps. First, we start by defining the intended learning outcomes, then we assess them, review the results, and finally we implement the changes. Future work will report the first results of the assessment cycle and the decisions based on these results.
References


A three-pillar Engineering educational system:
Student – Faculty member – Academic Institution

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Abstract

This paper aims at defining and analyzing the contributions and incomes added by the academic institution, the faculty members and the students themselves toward building an educational program that emphasizes knowledge and competencies required or known as a must for future engineering graduates. It all starts with designing a multifaceted challenging curriculum that allows future engineers to gain competencies for professional practice. This curriculum recognized by international organizations such as ABET and supported by the direction board of the university should provide a platform for faculty members committed to the advancement of engineering profession and ready to instill in students the incentive to strive toward the excellence of engineering and be fully equipped for a promising carrier in their work field. This circle of engineering education would not be completed without the feedback of students in many terms. This three-pillar system is explained throughout this paper and a case study of the engineering educational system in the Lebanese International University is treated and discussed.

Keywords: Educational program, Engineering, Academic institution

Introduction

The aim of the engineering educational system is to help students develop the ability to create and apply knowledge, think critically, communicate easily and clearly, demonstrate skills, engage in professional development and show maturity, sense of responsibility and leadership[1]. On the other hand, a successful system should help the faculty member to participate actively in professional field or engineering education, teach engineering, apply and spread his knowledge of instruction and be active in research. However, the faculty member owes to the system dedication
and devotion. He should provide many services internally such as participating to the curriculum enhancement, supervising and mentoring students and coordinating with other faculty members [2]. Externally, a faculty member should be updated with latest news and technologies, establish connections on both levels industrial and academic, should seek funding and grants for research projects and find training and work opportunities for his students. On the other hand, in order to establish a strong educational system, the academic institution supported by the presidency board of the university should provide a suitable environment and all the financial needs. It also has to establish relations and connections with the government, public organizations, industrials to create and maintain a direct link between its personnel and the outer community and to acknowledge and render for the institution reputation [2]. In other words, both the institution and the faculty members have their own contribution in order to generate competent graduated engineers and to provide them with the tools and knowledge to pursue any opportunity and be able to grab it. Still, the system cannot be successful and efficient as much as it is aimed to be without a feedback from the students in order to close the loop. This feedback may have many forms and be expressed in terms of evaluation prior to the graduation or community work and alumni following the graduation. The complete system may be found in Fig. 1.

The three-pillar system generates engineers capable and ready for consultation, evaluation, planning, design review and approval, project management and even supervision roles. Engineers should be aware of the environmental and safety impacts, the national laws, and have a sense of education, manner and ethics [3]. As stated previously, each of the faculty members, the academic institution and the student should contribute equally in order to have a successful engineering educational system that allows attaining the goal and developing future engineers with adequate and appropriate competencies and knowledge.

The paper is divided as follows: Section II discusses the role and the duties of the faculty member and defines the needed and suitable profile. Section III deals with the institution’s effect and contribution on the process. Section IV closes the loop by underlining the role of the student himself. Section V presents a case study about the educational system in the Lebanese International University. Finally, section VI ends with a summarizing conclusion.
1. Faculty member

A faculty member has a direct impact on the success of the educational system, notably in engineering. First of all, he/she has to gain appropriate qualifications in order to be allowed to enter the system. Those are verified throughout the hiring process within the institution and should cover the following axis:

- **Personal Environment**: The background of the faculty member is of major importance in defining his character, personality and qualities as he should be self confident, respectable, charismatic, sociable and friendly. These are very crucial factors when it comes to his relation with the students. These factors allow the faculty member to be a good mentor and adviser for the students and in the same time, trustable and reliable.

- **Educational background**: The faculty member’s degree is an important factor. He has to hold at least a Master’s degree, however a PhD degree remains preferable and a key factor that allows his promotion. On the other hand, the type of institution and its rank are important since, the faculty member has to gain his PhD from a reputable university with an international recognized degree. Furthermore, if the institution is accredited, it would be considered as a plus, notably in the northern American system.

- **Industrial Experience**: For many educational systems, the industrial experience is a must. It allows the faculty member to gain additional technical experience (Design, implementation, supervision, teamwork…). It also provides experience in term of management of (project, product, team…) and allows having a second view angle based on the requirements and the needs of the market. Moreover, the faculty member will establish connections that will allow him to use within the university and help students to integrate the professional network throughout projects, trainings and even post graduate employments.

- **Research Experience**: It is a fundamental criterion that defines the rank of the faculty member. Based on this rank, this latter may be allowed to supervise PhD students, launch research projects and properly represents the university in outer conferences and meetings. It is recommended to have at least two full time professors in each department.

Having all the requirements cited above, the faculty member has multiple functions and tasks to assume throughout his career and that are mainly repartitioned over 4 parts:

- **Industrial relations**: The faculty member is asked to maintain relations with the industry and collaborate with it in order to provide the student the opportunity for a technical internship. He also has to be active within the industry in order to improve the institution’s reputation so it would be easier for the students to grab an employment post to their graduation. The organization and preparation for a career day or an industrial day or even taking students repetitively to visit industries is in the core of the faculty member duties.

- **Community and connections**: The faculty member should represent the university nicely and adequately in every opportunity and try to promote for it. A good image of the institution where he works is very advantageous for the faculty member himself.
- **Research activities**: The faculty member has research responsibilities both internally and externally to the institution. Internally, he has to be active in research and participates to at least two annual conferences. Externally, he should be present and active in every exhibition, conference, meeting or gathering. Since research labs and tools are expensive, he has to participate partially by seeking grants and funds for projects nationally and internationally.

- **Internal tasks**: Beside the main role of the faculty member, which is teaching, this latter should be always available for students for any help or advice. He also has to participate actively to the curriculum enhancement, to the course offering, to the course coordination and updates. He is also required to perform some paper and administrative work.

In order to be efficient, not only the faculty member performance should be evaluated but also should be heard and should have the right to freely express any concern or worry he has. An interaction – evaluation system should be implemented and has to allow the faculty member to evaluate and be evaluated by each of the academic institution direction, the students and other faculty members.

Note that all of this would not be possible without a push from the academic institution that has to provide the appropriate environment, tools and help to back up him in his decisions and moves. Also, the faculty member should be well oriented and prepared in order to easily adjust himself to the changes in the surrounding. A multi campus and international university is strongly affected by the globalization and the faculty member faces new set of challenges for education in engineering disciplines and has to keep abreast of the general globalization trends. Faculty members have to instill in the system active and cooperative learning tools, focus on the technology enhancement and improve continuously the learning methods [4]. The faculty member roles and duties described above are summarized in Fig. 2.

![Fig.2 - First pillar: The faculty member](image-url)
2. Academic institution

The academic institution hosts students and prepare them to be effective engineers. It allows them to grow within a suitable environment that incorporates the latest technology achievements and emphasizes learning. It should pursue excellence in basic and applied research and contribute to the expansion and innovative application of state of the art knowledge to the benefit of the society. The academic institution strength lies in the innovative learning environment that integrates in-class instruction along with multidisciplinary laboratories and the effective delivery systems with problem-solving capabilities. However, the institution has many obligations and missions to fulfill towards the students. It has to maintain a good reputation, establish a level of connections and communication within the society and be up to date with all the national and international changes regarding engineering issues, technologies, and formal agreements. Besides providing teaching tools and means, the academic institution has the following tasks:

- **Budgets and funds**: The academic institution has to be financially strong and capable of providing and ensuring all the needs and tools for both its students and personnel and allow them to grow professionally in a suitable respectable environment. It also has to seek outer funding and grants and establish connections with other institutions in order to mutually benefit from laboratories and tools.

- **Agreements and Accreditation**: The degrees offered by the institution should be agreed and admitted nationally and internationally. Therefore, agreements are to be made with the ministry of higher education and other public institutions. Also, in order to maintain a high level of proficiency and acknowledgment in the engineering society, the academic institution should seek ABET accreditation [5] (for engineering). It also has to be in touch with the research society and push its faculty members to be active in several societies such as IEEE, CNRS…

- **Connections and Alumni**: The academic institution maintains its connections with its graduated students by organizing a professional alumnus that will help future graduates to easily integrate industries via the help of its alumni and the surrounding professional network. This will provide a solid link between the institution and the industrial network allowing students to be directly connected to the work field [6].

- **Implication of globalization on educational needs**: International scope should be a priority for the academic institution. Teaching methods and provided services should meet with the flow of foreign students and answer their concerns. Agreements that cover trade in education services, innovations related to information and communication technologies (ICTs), with emphasis on the role of the market and the market economy need to be maintained and encouraged by the institution. Also, the need to expand educational opportunities to meet the social demands for more education and the economic demands of the global economy for better-educated workers means that academic institutions with the help of governments need to increase their expenditures on education [7].

By working, interconnecting and collaborating with these different parties, the academic institution via its educational program and with the aid of its faculty members will allow to
generate graduate students eligible to be competent and knowledgeable engineer ready to enter the field work. This process is resumed in Fig. 3 below. Note also that the effectiveness of a system cannot be fulfilled without a self evaluation based on well defined criteria. The evaluation process involves students, faculty members and the direction board. A ranking criterion will allow defining the performance of the person under study and seeing whether he is accomplishing his duties or not. The student is evaluated based on his grades. An overall GPA will set his level that may go from failure to success with honorable grades. The personnel is evaluated based on others evaluations that will define the level of dedication, hard work and achievements he has fulfilled for the sake of the institution.

3. **Student**

The student is the core of any institution and its image in the community. He/she will reflect the institution level and will have a direct effect on its reputation. The student will take from the institution all what he needs, gain competencies, skills, knowledge and becomes an engineer ready to enter the society and has his own contribution to the advancement of engineering and technology. The interaction happens on two levels: Academic Institution – Student and Student – Community (or work field) as it can be clearly seen in Fig. 4 below.
On the first level, the student will gain from the academic institution the following:

- **Synthesis and creation of knowledge**: The graduate will read and synthesize engineering courses. He will describe fundamental theories of logic and mathematics, and apply knowledge that he gained throughout the different courses he shall take. Students will demonstrate achievement of one or more of the following to satisfy this competency: Report writing, Presentation and communication, Definition and execution of a project, Design and implementation of a project. The graduate will also describe common research methods in his/her discipline, read and evaluate engineering research, and apply research findings to the solution of practical problems in his/her discipline [8].

- **Critical & reflective thinking**: The graduate will develop a personal vision of inclusive engineering practice, identify the relationship of his/her discipline to the broader field of engineering, and critically evaluate theory and practice.

- **Education, Ethics and Contemporary issues**: The graduate will take courses covering legal issues, ethic issues, safety and environmental friendly issues. He will learn to be a moral, respectable engineer and faithful to his work.
Identification and application of engineering problems: The graduate should acquire knowledge of and an ability to use effective approaches for choosing a course of action or developing appropriate solutions. He has to have the ability to make decisions and take action consistent with available facts, constraints, and anticipated consequences. He has to identify issues, obtain relevant information, relate and compare data from different sources, and identify alternate solutions. He has also to identify, develop, and analyze engineering designs and/or specifications; plans and modifies methods.

Use of modern engineering tools: The graduate should be informed of recent technology and of available software and tools that will help him perform effectively his work.

These points discussed above should be provided and guaranteed by the academic institution that has a main role to instill into the students the incentive and the knowledge that will allow them to become good engineers. Once equipped with all this scientific baggage, they will be ready to enter the community and the field work. On this level, the graduate is asked to fulfill the following:

- Ascending responsibilities and Commitment: The graduate should be ready to take on and handle ascending responsibilities going from technical assistance, to design and study up to supervision roles. He has to have commitment to his work, to the institution that has hired him and has full devotion and dedication. In other words, he has to be up to the challenge.

- Proficiency and leadership: The graduate should be trustable and can be counted on. He should demonstrate skills and abilities to coordinate, facilitate and participate in collaborative approach to the completion of tasks or assignments.

- Education, ethics and contemporary issues: Idem as above.

- Identification and application of engineering problems: The graduate should be able to well define the problem, locate the issue and suggest a feasible solution. He should be able to identify and plan for resources, to approve engineering designs and/or program/project specifications of other engineers/design professionals to meet desired compliance with engineering principles, standards, statutes, codes, regulations and design. He also has to have a supervisory role and monitor and ensure that the program / project meets specification and design and also be capable of negotiating and defending design changes. Finally his role includes the ability to coordinate and administer programs, activities and protocols, the ability to manage resources, monitor activities and assess environmental risk, safety, and quality control associated with the program.

- Professional engagement & development to community: The graduate will demonstrate the disposition for life-long learning and continuous professional development. He will continuously participate in workshops and other professional development opportunities related to engineering. He will identify communities of practice within his/her discipline and participate within these communities. He shall also participate actively in state, regional and national professional organizations, conduct professional development workshops in engineering and be involved in engineering outreach events [9].

However, in order to close the loop, a feedback is required continuously from the student in order to improve and enhance the engineering educational system. This feedback may have two forms:
Prior to graduation: The student is required to make an objective evaluation for each of the faculty member, the chair, the dean and the system itself. Vice versa, all of these have to make inter-evaluation among them in order to continuously improve.

Post to graduation: The graduate is strongly advised to join the institution’s alumni and participate actively to all its activities. He should be present in annual meetings to share his experience, inform and orient future generations. He also has to help the institution to implement and improve its connections inside the professional network by mainly providing and ensuring work opportunities for students.

4. Case study: School of Engineering – Lebanese International University

The purpose of this study is to enlighten on the engineering educational system in the Lebanese International University (LIU) [10] and see where it stands with respect to the criteria presented above. The Lebanese International University, founded in 2000, is the largest and fastest growing private university in Lebanon. Presently, LIU has around 20,000 students enrolled in its five schools: Pharmacy, Engineering, Education, Arts and Sciences, and Business. This figure represents 13% of the overall number of students enrolled in private higher education institutes in Lebanon. LIU’s School of Engineering has approximately 3,000 fulltime students enrolled in the following programs: Surveying, Mechanical, Biomedical, Electrical, Electronics, Computer, Communications, and Industrial. With campuses spread across major cities and geographical regions throughout Lebanon, LIU has become the fastest growing university among the country’s 45 private higher education institutions. LIU also has expanded regionally (Arab countries) and internationally. LIU presence spans Yemen, Senegal, Morocco and Mauritania. Currently, more expansion is planned both locally and internationally. This multi campus and multi disciplinary university makes it extremely hard to communicate and coordinate among the different campuses raising the challenge when it comes to building a strong, pertinent and reliable educational system. However the devotion, the existing competency, the will and the hard work allow somehow to reach nearby the goal and to set a well defined foundation and structure for the educational system. Below, a debriefed snap about the LIU system implemented in the school of engineering is presented.

- Faculty Member: According to Fig. 2, the faculty member has to gain particular qualifications and has duties toward the academic institution and the students. In LIU, we try to seek and cover the required criteria as much as it is possible. Table 1 below resumes the different activities that relate to the faculty member. Each task/activity he is involved in is linked to one or more of the required criteria. The ongoing work is toward creating a suitable environment for the faculty member to be able to devote completely for the students. Note that all of the criteria are pointed to and handled within the school of engineering. Of course, much work and improvement are required since it is a nonstop evolution process.
• **Academic Institution**: According to Fig.3, the institution has the obligation to provide a suitable environment for both faculty members and students, with an appropriate budgeting. It has to establish connections with the surrounding environment (organizations, government, industrials) and through the aid of faculty members has to generate competent and knowledgeable engineers. Table 2 relates all the requirements described previously in this paper to the current situation in LIU. We can easily note that it has a complete staff; it has established multiple connections and agreements with several parts. These agreements should be however multiplied, improved and extended to other institutions. Furthermore, more focus and devotion should be addressed to the ABET accreditation and the Alumni establishment that are essential for a successful institution. Though many steps are currently in the process in order to imply globalization on educational needs, much still needs to be done.

• **Student**: In compliance with Fig.4, the student has a direct relation with the academic institution and the community / field work. He takes from the institution where he has his engineering profile built in order to contribute to the community prior and post to his graduation. In the LIU, the student involvement may be approached as discussed in Table 4 below. Note also that the process is closed loop by the different evaluations and feedbacks of the students.
### FACULTY MEMBER

#### Examined Criteria vs. Fig. 2

<table>
<thead>
<tr>
<th>Qualifications</th>
<th>Educational Background</th>
<th>Industrial Experience</th>
<th>Research Experience</th>
<th>Personal Environment</th>
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<td>Interview 1: Chair and Dean – Discussion of the Resume and Application</td>
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<td>Interview 2: Engineering council – Verification of the competencies and skills on both teaching and research levels for the applicant</td>
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<td>Interview 3: Board of the University – Verification of the background, future plans and the aimed goal of the applicant</td>
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#### Hiring process

- **Interview 1:** Chair and Dean – Discussion of the Resume and Application
- **Interview 2:** Engineering council – Verification of the competencies and skills on both teaching and research levels for the applicant
- **Interview 3:** Board of the University – Verification of the background, future plans and the aimed goal of the applicant

#### Duties

- **Research Committee:** Forms for updated CV, conference request, research funding, Thesis supervisory… Establishment of a ranking criteria: e.g. 6 years of teaching and 10 points of publications to be promoted from assistant to associate professor Establishment of a hierarchy: Faculty member -> Research Department Leader -> Chair -> Dean for funding research issues Organization of workshops and seminars
- **Activities and Connections:** Sponsoring conferences and exhibitions Communication with CNRS: grants for research projects IEEE members: Policy implying that faculty members should be members of organizations and associations Participation to competitions (with MOT and MOE) Communication with LIRA: Establishing projects with industrials and initiating contacts between students and industries Organization of career day, industrial day, engineering school day: In order to promote for the university, help students integrate the work field, create pre graduate and post graduate training opportunities…
- **Active Committee:** Student advising and mentoring Department, industrial and research meetings Course and campus coordination Evaluation system (Inter faculty members, of & by chair, of & by dean, of & by students) Elaboration of documents and files (course files, petition, transfer file, make up exams, petitions…) Various committees (proctoring, promoting, offering, syllabus enhancement…)

#### Table 1 - Faculty member duties and qualifications - LIU

<table>
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<th>ACADEMIC INSTITUTION</th>
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<td>Faculty Members</td>
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<td>More than 100 Faculty members enrolled in the process in the school of engineering, of which more than 60 full timers.</td>
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<td>6 Departments on different campuses</td>
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<td>Individual agreement with other institutions for multi purposes (PhD Supervisory, research collaboration, events sponsoring and collaboration…)</td>
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<td>Community and Industries</td>
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<tr>
<td>Collaboration with LIRA (many agreements and trainings with industrials)</td>
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<td>Collaboration with CNRS (many research grants)</td>
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Collaboration with other academic institutions such as CEDRE
French PhD program (Actually 3 PhD students in collaboration with French laboratories)

Government and organizations
Projects and collaboration with MOT
More Degree validation with MOE
Convention of cooperation with international universities in Europe, Canada, Africa…
Accreditation in process with ABET
IEEE standards: IEEE members and sponsoring IEEE conferences

Alumni - Connections
New committee recently created for the organization of the Alumni
Personal investments and connections made individually (Faculty members)

Implication of globalization
Partnership and engagement with external parties (industries, research societies, universities)
Expanding opportunities & increasing demand for talent through various collaborations
Expanding access to higher education through PhD and Masters programs
Financing and supporting studies for great global problems (environmental and economical issues)

<table>
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<th>Table 2 - Academic Institution obligations – LIU</th>
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<td>STUDENT</td>
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<td>Into the community / work field</td>
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<td>Feedback</td>
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| Table 3 - Student involvement - LIU |

5. Conclusion

This paper discusses the basic requirements for an engineering educational system. In order to prepare students effectively to become competent and knowledgeable engineers ready to enter the work field, it was shown that the educational system relies on three pillars: The faculty member, the academic institution and the student himself. All of these three contribute equally and have duties and obligations. The interaction between these three pillars has been discussed thoroughly throughout this paper. A case study about the school of engineering in the LIU was treated and its internal system was compared to the three pillar model. It has been shown that it tends to converge toward the model, but still lacks some evolution. Particularly, thought the faculty member profile answers completely the requirements revealed in the model, the academic institution and the student involvement require further work and improvement.
References


REGIONAL AGREEMENTS ON THE TRAINING OF ENGINEERS
ARGENTINA IN MERCOSUR AND LATIN-AMERICA

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Abstract

Geopolitics has changed radically over the past two decades and has moved from a bipolar to a multi-polar world.

This has resulted in the formation of regional associations, and in our region were formed the Common Market of the South (MERCOSUR), the Union of South American Nations (UNASUR) and the Community of Latin American and Caribbean States (CELAC).

The education and practice of engineering must adapt to these circumstances and in this sense, regional or global agreements on training and quality assurance substantially equivalent are basic factors for the academic and professional recognition.

The integration of Latin-America engineering and thus the rising of the potential for development of multilateral projects is an obligation of engineers and their representative associations, because only then will the integration policies be technically viable and sustainable designed by the national states.

Key words: Internationalization, quality, mobility, Argentina, Latin America
1.- Introduction: Multi-polarity and regionalization.

The transition from a bipolar world to a multi-polar one, the increasing incidence of world’s economy on the emerging countries, the crisis in the developed world, the sustainability of the development, the environmental change and the problems with energy and natural resources among other things, are factors that have changed the geopolitics in the last two decades.

As a direct consequence, the world was arranged regionally, forming in our region the “Common Market of the South” (MERCOSUR) that has substantially advanced not only in the exchange of products but also in the services it provides.

More recently the “Union of South American Nations” (UNASUR) and the “Community of Latin American and Caribbean States” (CELAC) were created.

2.- The internationalization of Engineering

Professional practice and training of Engineering must be adapted to those circumstances and in that sense the regional or global agreements of training and substantially equivalent quality assurance are basic factors, to which the policy of academic mobility plan and recognitions of degrees for the professional practice must be founded.

From the 8th World Congress of Engineering Education, the Formation of the Engineer for the Sustainable Development (WCE) which was organized in the city of Buenos Aires on October 2010 by the Argentinean Center of Engineers (CAI) and the Federal Council of Engineering Deans (CONFEDI) and with the sponsorship of the World Federation of Engineering Organizations (WFEO), we can highlight the paragraphs below:

For this purpose, it is needed to train engineers in the required quantity, with standards of international quality and, with curricular strategies that favor the local and regional pertinence of their knowledge in order to assist with the urgent task of recognizing, identifying, and characterizing the priorities that allow the diagnosis, proposition, planning and contribution to the sustainable proposals in each of the areas that concern them.

Countries via their most powerful authorities and the multilateral organisms must be aware of it and must establish their increasing plans by education policies of Engineering and the search for early professional vocations.

Taking all this into account, we discover very convenient aspects such as the creation of spaces for Higher Regional Education, the creation of activities for research, the development and transfer of knowledge and experiences related to the necessities of the different regions, the articulation of these efforts and initiatives with social sectors, either state or economic related, the support of the quality education in its different levels either starter or intermediate, and the introduction to the different programs for engineers’ training such as the promotion of entrepreneurial culture, the permanent reflection on the Engineer’s social responsibility and the environmental and social impact of the practice of this profession.

This is a challenge that we need to take and it is a joint obligation for states, universities, social organizations and enterprises.
3. - The training of Engineers in the South Common Market (MERCOSUR)

3.1. Higher Education in the Educational Sector of MERCOSUR

As an essential tool of the process of integration, it was generated in the higher education a regional academic space in the Education Sector headed by the Council of Ministers of Education.

Three major blocks of work were defined:

- Recognition: A career recognition system as a mechanism for the approval of the degrees to ease the mobility among the region; to motivate the process of evaluation in order to improve the quality of education and to ease the comparison between the training processes of academic quality.

- Mobility as a tool for the creation of a common regional space for higher education. This program is centered on projects and activities of academic and institutional matters, student mobility, a system to transfer college credits, and the exchange between professors and investigators.

- Inter-institutional cooperation: Implementation of joint actions between universities in order to develop partnership programs among undergraduate and graduate students in projects of joint investigation, in the creation of excellence networks and in the work with other levels of education in the training of professors.

3.2. Certification system of university careers for the regional recognition of the academic quality of each degree in MERCOSUR and other associated states (ARCUSUR system)

ARCUSUR is the continuation of a process with similar characteristics, called Experimental Mechanism of Accreditation (MEXA), which was applied on different careers of Agronomy, Engineering, and Medicine between 2003 and 2006 in careers of Argentina, Brazil, Paraguay, Uruguay, Bolivia and Chile, with a total of 62 certified careers in which 19 were Agronomy, 29 Engineering, and 14 Medicine.

After the experience with MEXA, it was considered convenient the installation of a permanent certification system for the quality of training in a university level among the region.

According to the Decision Nº 17/08 signed in San Miguel de Tucuman, Argentina, the 30th of June 2008, it was approved the transcript that establishes the definitive basis for the System ARCUSUR, by the document “Agreement on the creation and implementation of a certification system of university careers for the regional recognition of the academic quality of its degrees in MERCOSUR and associated states”

These agreements are applicable to the careers of Agronomy, Architecture, Nursery, Engineering, Medicine, Dentists and Veterinary. In this case Engineering is applicable to the fields of Civil, Electricity, Electronic, Industrial, Mechanic and Chemical.

Participants on the first call were Engineering careers from Argentina, Bolivia, Brazil, Chile, Colombia (Colombia asked for the integration to the system although it is not an associated...
member of MERCOSUR), Paraguay and Uruguay. On the second call Venezuela and Ecuador were incorporated too.

On the first call of Engineering there has been participation from Argentina with a total of 20 careers according to this detail: Civil (2), Electronics (5), Industrial (5), Mechanics (2), and Chemical (4).

### 3.3 Mobility programs and Inter-institutional cooperation

The aim is to encourage not only the teaching and learning of the culture together with the customs of the host country, but also the sense of community among students from different countries.

- **Regional Academic Mobility Program for Certified careers (MARCA) – Engineering:** This is the first mobility program for undergraduate students from MERCOSUR managed by its members and associated States. The aim is to exchange students from certified careers of the ASCU-SUR System, with the objective of strengthening the certified careers, encouraging inter-institutional cooperation, and reaching the target of regional integration. This came into force in the year 2006 (for Engineering careers in 2008).

- **Teachers Mobility Program for partnership projects with universities among graduate courses that participate in the MARCA Project**

- **Pilot Mobility Programs in the European Union Support Program of Mobility from MERCOSUR in Higher Education.** It is a project from the Education Sector of MERCOSUR (SEM) that emerges from a financing agreement between MERCOSUR and the European Union, signed the 16th of April 2008. One of the outcomes of the project is the implementation of a Pilot Mobility Program in 2012, for 180 students enrolled in careers that do not integrate the ARCU-SUR System.

- **University Association Program for the Mobility of Teachers of Undergraduate Courses from MERCOSUR.** This is a program of mobility for teachers assembled in projects of university association, for undergraduate careers, in careers not certified by the regional accreditation mechanism of Argentina, Brazil, Paraguay, Uruguay or Chile.

- **Program for the Support to Joint Research Projects:** The general aim of this program is to stimulate the exchange of teachers and investigators of the State Members and the members of MERCOSUR, linked to Excellency Doctorates Programs of Higher Education Institutions, pursuing for higher levels of human resource training of different knowledge areas.

- **Program for the Strengthening of Postgraduate Studies from MERCOSUR:** The Partnership Program for the Strengthening of Postgraduate Studies is one of the strategic axes of this action. It is settled on the principle of cooperation by a flexible outline of academic partnership, in which a postgraduate or a postgraduate network of academic excellence of major relative development strengthens a postgraduate or a network of postgraduates of minor relative development. This project aims to the decrease of regional inequalities that are found in Higher Education, to the support of human resource training in the level of postgraduates, to the support of research activities in deficient areas and/or vacancy areas, to the contribution in the increasing of students and postgraduate teachers exchanges, improving in this way the quality of the offered courses.
• Program of Associated Postgraduate Centers in Brazil – Argentina (CAPG-BA): The program is aimed for the academic exchange of quality postgraduates in priority areas between High Education Institutes of both countries. The responsible entities for the coordination of the Program are: in the Brazilians side, Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and in the Argentinean side, Secretaría de Políticas Universitarias (SPU). The program promotes the exchange among postgraduate students and professors-investigators; it also seeks the mutual recognition of credits obtained in the associated institutions of this program by the co-ordination of the thesis and the co-bachelor, and encourages the exchange of integration experiences of postgraduate teaching between both countries.

• Program of Associated Centers for the Strengthening of Postgraduates in Brazil – Argentina (CAFP-BA): One of the weaknesses of the postgraduates system is the lack of homogeneity in its geographical distribution, either in qualitative or quantitative terms, generating an inequality situation in the university systems. The general aim of this Program is to create the necessary mechanisms to reduce these regional inequalities that are present in higher education, training and consolidation of research groups. Also, among its objectives, to give support on the training of postgraduate human resources to the research activities in deficient areas and/or vacancy ones, to increase the mobility of teachers taking advantage of the courses offered by the receptive and leading institution, and to improve the quality of the offered courses.

3.4. Recognition of undergraduate degrees of MERCOSUR

On May 2010, on the city of Buenos Aires, it was carried out the I Meeting of the Work Group for the recognition of the undergraduate degrees from MERCOSUR with the presence of Argentina, Brazil, Paraguay and Uruguay.

For the elaboration of this Strategic Plan 2011-2015 it was considered necessary to deep in the involvement of accreditation and join the recognition of the titles with the ARCU-SUR System.

It was defined as a goal the revalidation of undergraduate degrees in certified careers from the ARCU-SUR System and, as a purpose, the collective and regional construction of a mechanism in charge of that goal.

Together with the work referent to the construction of the mechanism for revalidation, the relative aspects to the specific professional exercise will be approached for each degree. In this way the revalidation of the degrees will be joined with the overcoming of asymmetries.

4. Argentinean Engineering in Latin America

4.1. Bilateral Agreements

In a bilateral way, Argentina has signed agreements of degree recognition with Chile, Colombia, Ecuador and Mexico and in all of these cases, this recognition will be automatic for the certified careers by the national systems of accreditation, after the pedagogical panels agree and verify that the systems of training and accreditation of the countries that signed are equivalent.
In all of the agreements, it is expected that those diplomas or degrees obtained by the careers which count with the valid accreditation at the time of the validation request in their country of origin, will be granted for the effect of professional exercise the direct validation of the degree. In this case, the Bilateral Committee of Higher Education Experts will elaborate a list of certified careers, which will incorporate all areas of knowledge.

Because of all these, this governmental action, in the case of Argentina, counts with the technical support of the Federal Council of Engineering Deans (CONFEDI), due to the fact that it must be coordinated by the states, but analyzed and worked in detailed by the faculty associations of Engineering, the national accrediting entities and the professional colleges, in order to complement the national particularities with the regional vision and that the actions contribute to mutual benefits.

4.2. Latin-American Agreement of Accreditation of Engineering (ALAI)

Although the region has similar cultural and social roots, the development of higher education had totally different realities that are now obstructing integration.

To change this situation, it is necessary to develop a strong mobility among undergraduate or postgraduate teachers and students, together with the continuity of the official approval of careers according to the own criteria and standards of each country, encouraging diversity and relevance in the training, and in that way, the creation of mechanisms that allow this exchange.

The Monte Alban’s Declaration, which was signed after finishing the First Latin-American Meeting about Accreditation of Engineering Programs in September 2001 in Mexico, by the representatives of Argentina, Bolivia, Chiles, Colombia, Costa Rica, El Salvador, Spain, Mexico and Paraguay, states that: “the current accreditation and evaluation systems of Engineering and the ones that are in different levels of development, in the national and international system look forward the recognition of “substantially equivalent”, in the way that they help to the improvement of education, the professional mobility, the exchange of information and experience, and to the actualization of professional and academic knowledge.

On May 2010, representatives from Argentina, Bolivia, Chile, Colombia, Guatemala, Central America, Mexico and Paraguay met in the city of Tlaxcala (Mexico) for the II Latin-American Meeting about the Accreditation of Engineering Programs and released the Tlaxcala declaration that states:

“That the activities pertaining to Engineering and Technology fields are basic factors for the sustainable development of the regions and countries that make up an important element for the improvement of the population’s quality of life”.

“That in most of Latin-American countries there has been a substantial progress in the implementation of accreditation processes of Engineering Programs in National and Regional levels”.

“That this processes and accreditation systems of Engineering have as a common objective the improvement of the quality of Engineering’s preparation, and they introduce common characteristics in the criteria and in adopted processes”.

“That these national and regional efforts converge to a mutual recognition system in Latin-America that allows student’s mobility and eventually enable the future bi-national or multi-national agreements of professional mobility”.


“That these facts represent a great advance in relation to the obtained agreements in the I Latin-American Meeting about Engineering Accreditation Programs, expressed in Monte Alban’s Declaration and that it is needed to keep working on the traced paths”.

For all these reasons, it is stated that:

- It is needed to count on a structure that allows us to move quickly towards the proposed objectives in Monte Alban’s Declaration.
- The richness of the diversity and pertinence in the training of professional engineers in Latin-America should be preserved.
- To achieve these objectives we commit to work in a joint way with the elaboration of a proposal for an entity, that allows to boost and reinforce the accreditation processes for the Engineering programs in the countries of the region, and at the same time it allows to facilitate the reciprocal recognition of certified programs based on internationally recognized criteria, standards and parameters of quality.

In October 2010, on the VIII World Congress on Engineering Education held in Buenos Aires, thirteen representatives of different countries signed the Latin-American Agreement on Engineering Accreditation (ALAI), which in 2011 formed its first executive committee at the meeting in Guatemala.

Members of this agreement as partners, are the organizations of Latin-American countries that have a public activity recognized by the Engineering accreditation programs in its own countries, either of governmental or private nature, whether academic, professional, or labor union organizations, and have signed the agreement by its certified representatives, which will give them the categorization of “ALAI Associates”.

The most relevant areas that should be regulated by the ALAI will be, in their order of importance

- Compatible Accreditation systems and recognition as “substantially equivalent”.
- The establishment of Latin-American standards and parameters for the accreditation of Engineering teaching programs
- The exchange of pairs of raters.
- The exchange of accreditation experiences
- The participation on recognitions for professional mobility

The participants of ALAI are representatives from Argentina, Brazil, Chile, Colombia, Mexico, Paraguay, Central-America (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama), and The Caribbean, (Dominican Republic, Haiti and Jamaica).

The first Coordinating Committee was made in November 2011 with the representatives of Argentina, Central-America, Chile and Mexico.
5. The incorporation of Latin-America and the Caribbean

5.1 General situation

From the governments of Latin-American countries there is an advance, with the inconveniences caused by the historical asymmetries, with a strong political decision on the achievement of integration.

Latin-America has common history, culture, deficiencies, dreams and challenges. But essentially, if it acts as one, it has an incomparable potential by taking its own decisions in the search of its exclusive benefit and of its people.

Over the last decades the institutional changes have been of a historic importance, of which we can mention:

- Consolidated democracies in every Latin-American country
- The enforcement of basic human rights
- According to the reports by the United Nations Economic Commission for Latin America (CEPAL) for the first time in two hundred years of history, there has been an economical rising and a decrease of poverty and discrimination.
- Consolidation of regional blocs as (MERCOSUR)
- Denial to the creation of the Free Trade Agreement (ALCA) in 2005.
- The establishment of the Union of South American Nations (UNASUR) aims to build a participatory and consensual area of integration and unity in the cultural, social, economic and political development among its members using political dialogue, social policies, education, energy, infrastructure, finance and the environment, among others, leading to eliminate inequality, to achieve social inclusion and citizen participation, to strengthen democracy and to reduce the asymmetries within the framework of the strengthening of the States’ sovereignty and independence.

5.2 The role of Engineering on integration

The development of multinational projects between Latin-American nations and The Caribbean towards achieving the essential goals for our peoples quality of life:

- Basic infrastructure and of services,
- Energy sovereignty,
- Food sovereignty,
- Technology sovereignty in strategic and primary areas,
- Creation of more and better employments
It requires joint and compromised work from the Engineers of the region. For this, it is indispensable to know each other and to trust each other, and trust in order to conceive, design, deploy and operate in multilateral projects.

**Conclusion**

**To train engineers with supranational-regional perspective**

Based on what has been stated, it is a challenge for every country of the region to train engineers with a supranational and regional perspective and for that it is necessary to consolidate and delve actions that are being developed by the governments and national associations of Engineering, which allow, to cover every country of the region in reasonable deadlines and incorporate this vision in the formation of future engineers and in the agenda of every engineering faculty of each university.

The general aims must be:

- To promote at a regional stage a high level of convergence in the training of engineers, by the common accepted definitions, of professional and learning results.
- To develop professional profiles, learning results and desirables competencies in terms of generic and relative competencies for each area of study including essential content, skills and knowledge.
- To facilitate transparency in educative structures and to foster the innovation by communicative experiences and the identification of good practice.

It is necessary to move further with the next actions:

- To increase the mobility of undergraduate or postgraduate teachers and students by the states compromise of increasing their support and by the universities cooperation of making progress in reciprocal recognition agreements of academic matters. (Currently only 25% of mobilities and exchanges are intra-regional).
- To increase the use of TIC’s for the development of cooperative activities between universities of different countries, such as the creation of Communities of Practice, Virtual Communities of Consortium (CVC), and Virtual Working Teams.
- To keep moving forward on the mutual recognition of different accrediting agencies of each country; on the first instance, in a bilateral way and to evolve to a multilateral integration. These actions will allow the whole or partial recognition of studies depending on the different academic offerings of the region.
- To foster among students the learning of different languages on the region and the learning of different cultures in order to promote the professional performance on different cultural, social and political environments of the region. For this, it is needed the review of the current curricula, from the perspective of the subsequent practice of the profession on the region, and to define the projects and programs that help students to understand other countries’ reality.
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The Bologna Process and its Impact on Engineering Education in the Arab World

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Engineering education is playing a pivotal role in the economical and social developments in addition to its impact on sustainable development. The EU countries have grasped and comprehended this role and developed a new approach and paradigm for higher education in general and with a special emphasis on engineering education through the so called “Bologna Process”. This process was initiated by the higher education ministers for developing Europe as a one Higher Education Area called (EHEA) capable to advance and promote the higher education to serve cause of Europe in one hand and to compete at the international level. The new system has been encouraged and adopted by all the engineering higher education institutions in the EU member states.

This paper presents the challenges were facing the engineering education in Europe before the initiation of Bologna Process. The challenges include but not limited to: the titles of academic degrees, the periods of study for a particular degree, the recognition of the degree outside the territories of the granting country, the accreditation and validation of the programs abroad, the pursuing of education for higher degree in other systems, the obligations towards the professional agencies, the requirements of job market, and the needs of the work place.

In addition the paper presents certain aspects adopted in the Bologna Process that the engineering education in the Arab World may benefit from and to adapt. The adoption of those aspects will elevate the engineering education in the Arab World to reach the international level. The pertinent issues suggested to pursue are related to:

1. Developing a framework for the different higher education degrees in engineering and technology specialization and the requirements for obtaining the degree.
2. Renovating the mechanisms for developing the degree programs to shape graduates who are able to develop themselves on continuous basis and to interact positively with the new developments in his field.
3. Linking the degree programs with job opportunities or with continuation of study for higher degrees.
4. Identifying the graduate attributes and who to implant certain aspects in the curriculum to enhance to develop those attributes.
5. Enhancing the learning outcomes to serve the needs of the industrial, serviceable and social sectors.
6. Meeting the recognition, accreditation, and quality assurance requirements.
   Developing the lifelong learning process.
7. Augmenting the joint programs among the different specializations and between different universities.
8. Facilitating the mobility of students and faculty members and nonacademic staff.
ENGINEERING EDUCATION FROM DIFFERENT GLOBAL PERSPECTIVES

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Abstract

In the paper different global perspectives of perceiving engineering education have been discussed in the categories of key driving impacts and responses. The influence of particular global-scale phenomena and trends on the evolution of engineering education have been considered. The paper ends with proposals of possible future institutional solutions in the area of engineering education and invitation to further discussion on the presented proposals.

Keywords: engineering, education, global, international, technology, university, world.

1. Introduction

The present status and future of engineering education could be discussed from different global perspectives among which following seem to be particularly important (Figure 1):

- Global Education Market. Engineering Education perceived in terms of economy: internationalization of supply and demand for education services, export and import of the services, costs and benefits of providers and customers.
• Globalization of Technology. Since antiquity technology has played an important role in the convergence of societies. Presently, the number of globally spread technologies is increasing rapidly as well as the level of advancement of the technologies.

• Global Engineering Projects. Global Hi-Tech challenges in the areas of energy, global transportation and logistics systems, space systems, environment protection, disaster monitoring and relief - but also Low-Tech challenges in the areas of facilitation and improvement of the quality of human life (water supply and purification, sewage systems, roads) in the poorest regions of the world.

• Global Information & Communication Systems. Development of international distance learning and teaching, increasing reach of education, possibility of worldwide publishing and availability of literature (textbooks, manuals, research papers, lectures, presentations), access to databases, improved teacher-student communication, development of virtual forms of education, facilitated lifelong learning.

• Global Employers of Engineers. Transnational corporations, global institutions and superstructures employing engineers but also providing supplementary education and training programs to meet the requirements of their global-scale activities.

2. Global Education Market

According to 2013 Global Industry Analysts Report [1], the global market for Education Services is projected to reach US $ 357 billion by 2018, driven by growing demand for Education and Training Services in developing countries.

Following key factors shaping the market could be distinguished:

• Supply and demand imbalance between educational needs and educational capacities, particularly in the developing world (Figure 2 shows the demand in selected regions and countries),
Mismatch in education quality (graduates knowledge and skills versus employers requirements),
Growing competitiveness in the labor market,
Appearing opportunities to take under control international flows of education services,
Increasing needs for comparativeness and recognition of qualifications.
Employers demand for cross-cultural awareness and international adaptability of graduates.

In response to the mentioned above impact factors following solutions and trends have appeared:

Organized exchange (ISEP, WISE, ASSE, ERASMUS Programme, SOCRATES Programme) as well as export-import trade of education services (Figure 3 shows the example of distribution of tertiary students in OECD countries),

The rise of supplementary education and training to meet the demand of employers,

Despite (or maybe as a result of) the economic crisis people tend to upgrade their skills or obtain additional educational qualifications in attempts to improve their employability,

Emergence of the global superstructures and multi-national corporations in the education and training sectors (Apollo Group Inc., Cambium Learning Group Inc., Career Education Corporation, CL Educate Ltd., Daekyo Co. Ltd., ITT Education Services Inc., New Oriental Education &Technology Group),

Establishment of international branch campuses overseas, expansion of international affairs offices in universities.

Creating international accreditation systems enabling validation quality of education (e.g. EUR-ACE), worldwide rankings of universities, adoption of international academic credit systems (e.g. ECTS),
• Modifying the old and creating new programmes, courses and curricula oriented to international skills and competencies of students (cross-cultural communication and management, linguistic skills, personal and professional adaptability in international environment).

Global education market, global competition in education have reshaped many aspects of engineering education. To what extent the market orientation of engineering education and training is influencing the mission, the personality and professional profile of future engineer - seems to be one of the fundamental questions. Another important question is what changes in functioning, in priorities and in resource allocation of technical universities have been driven by the global education market forces.

3. Globalization of technology

Technology together with economy, politics and culture has been always mentioned as one of the fundamental driving forces of globalization. Today it seems interesting to discuss the feedback i.e. the influence of globalization on technology or the mutual interactions of globalization and technology.

![19th century manufacturing technology](http://en.wikipedia.org/wiki/History-of-globalization)

Although historians differ in distinguishing particular periods of globalization they generally agree that technology played crucial role in every period. In 19th century industrialization allowed cheap production of household items using economies of scale, while rapid population growth created sustained demand for commodities [2]. 19th century Great Britain become the first global economic superpower because of superior manufacturing technology and improved global communications such as steamships and railroads. Following factors driving globalization of technology could be distinguished:

• Globalization of trade, development of global market, mobility of capital,
• Multinational production, international fragmentation of production, foreign outsourcing,
• Development of international technical standards and regulations,
• Increased mobility and migration of people and products,
• Growing similarity of demand for household devices in different regions of the world
Following tendencies have appeared as a response:

- Growing demand for new technologies of worldwide use required by global market, transmission of ideas for new products and new technologies around the globe,
- Increasing number and level of advancement of globally spread technologies, rapid transfer of technologies,
- Increased sales of licenses and patents, mutual recognition of patents,
- International servicing and spare parts logistics, cross-servicing, international logistic supply chains for spare parts, modules and maintenance media,
- Development of international R&D laboratories (within corporations and universities), internationalization of R&D publications,
- Students participating in international projects within university-corporation collaboration, international competitions for students in designing new technologies and innovations organized by transnational corporations,

Globalization of technology influences education programs, courses and curricula as well as research programs of most of technical universities and faculties making them more and more similar. From the perspective of globalization of technology it seems not too early to discuss on globalization of engineering education. The important and urgent subjects of the discussion seem for instance knowledge and skills given for future engineers working in the area of service, maintenance and logistics as well as for those employed in the sphere of international sales of new technologies and products.

4. Global engineering projects

The term “global engineering” has been used in different contexts. In the names of companies it has usually reflected the company’s ability to worldwide business activity, manufacturing products that compete in the global market, providing engineering services or conducting projects in worldwide scale (e.g. Global Engineering & Construction, Global Minerals Engineering, Global Engineering Construction Company, Global Marine Engineering, Global
“Global engineering” could be also interpreted as human activity meeting the grand challenges of contemporary and future world for engineering. Those challenges - the phenomena and tendencies generating global problems are the key factors which are stimulating global engineering projects:

- Climate change,
- Natural disasters,
- Environment degradation, pollution,
- The running out sources of energy,
- Unequal quality of human life in different regions, poverty,
- Urbanization, population growth.
- Social unrests and threats to international security.

The responses are:

- Establishing international programmes oriented towards the mentioned above problems, e.g.: UN Environment Programme (UNEP), Transboundary Water Assessment Programme (TWAP), UN Development Programme (UNDP), International Hydrological Programme (IHP), UN Human Settlements Programme (UN-HABITAT), Disaster Management Programme,
- Creating institutions for conducting projects connected with the programmes, e.g.: UN Office for Project Services (UNOPS), Global Environmental Facility (GEF), UN Office for Disaster Risk Reduction (UNISDR), International Committee on Global Navigation Satellite Systems (ICG).

Sponsoring, supporting and funding the global programmes and projects by institutions like United Nations, World Bank, OECD, regional international organizations, national governments, transnational corporations and companies,
• Sponsored international education and research programs conducted by universities and R&D institutions participating in the global programmes and projects.

From the perspective of global engineering projects the new approach seems necessary in shaping personality and professional profile of engineering education graduates. Engineering projects that cover multiple countries, politics, cultures - create special challenges for future engineers – project executors and managers: project leadership, cross-cultural management, legal, conceptual and managerial responsibilities, project management contract laws, teams and inter-organizational relationship, conflict resolution etc. The subjects of education in this area would be also: international project phases, life cycle project management, tendering processes, risk evaluation, project realization, timing, casting, planning.

5. Global information & communication networks

In numerous opinions global information & communication networks (I&CN) have constituted the essence of globalization – the core of globalizing society since the end of 19th century (Fig.7).

Figure 7. Eastern Telegraph cable network in 1901
Source: http://en.wikipedia.org/wiki/Global_network

Today following key factors influencing I&CN could be distinguished:
• Strengthening feedback between globalization and the development of I&CN,
• Increasing reach, density and traffic capacity of I&CN (expanding cyberspace),
• Rapid development of information and communication technology (ICT), the optoelectronics revolution,
• Continuous demand for enhancement of hardware (e.g. portability) and software (e.g. search engines) making the usage of I&CN in everyday work (business, banking, management, education, research, engineering) easier, more efficient and effective,
• Appearance of crime and terrorism in cyberspace.
The responses are:

- Worldwide network-based virtual organizations in different areas of human activity (also in education and R&D),
- Social Networks – the new ways of sharing opinions, views and knowledge,
- Increased role of knowledge and innovation in world economy,
- Development of the so-called “Digital Economy”,
- Common using I&CN as a tool of self-education and getting knowledge outside the traditional education and R&D institutions as well as a tool of the lifelong learning,
- Development of the cyber security methods, tools and systems.

When considering engineering education from the perspective of the global information & communication networks following aspects seem important:

- I&CN as a subject of engineering education (e.g. the necessity of introducing courses on I&CN to education programs in different engineering disciplines and specializations, taking into account the cyber- security issues),
- The influence of the I&CN development on the engineering education contents, methods, tools and organization (e.g. the scope of distance learning, the decline of traditional books, manuals, textbooks, creating virtual students' project teams),
- Bridging the barriers of time and distance in relations: professor-student, student-student, professor-professor,
- Creating international or global networks of technical universities and faculties.

6. Global employers of engineers

The data from global labor market indicate the increasing demand for engineers and technicians despite the crisis and growing unemployment in many regions (Fig. 8)

Figure 8. Demand for technicians and engineers on global labor market in 2011
The biggest transnational corporations (TNCs) are technologically oriented (Fig. 9) and are the main global employers of engineers in all the areas of their worldwide operations (production, services, sales, R&D, logistics, education and training, management and even in public relations and marketing). Since long time engineers have been also employed in different international, regional and global organizations, commissions, committees, working groups - as experts, advisors, executives, leaders and managers. Following key factors influencing the behavior and evolution of transnational corporations could be distinguished:

- Increasing fragmentation and geographic distribution of production stages and logistic chains,
- Appearing opportunities to penetrate new markets (Central and Eastern Europe, Post-Soviet Asia, China, the post-local-wars stabilized regions in Balkans, North Africa, Middle East),
- Still existing and appearing new regions with political, social and economic instability,
- Demand for speeding processes of introducing innovations and new technologies,
- Growing needs for versatility, mobility and adaptability of the employed personnel.

As responses following tendencies could be distinguished:

- Evolution from traditional, the head office centered structures of management to decentralized network centered structures,
- Decentralization of decision-making and growing self-determination of the corporations’ overseas subsidiaries connected with the need for strengthening employees’ awareness of corporation mission, goals, values and behavior patterns (appearance of the so-called “corporate culture”).
• Appearance of “virtual companies” created for executing given project in given time,
• Ability to move jobs overseas in the cases of crisis or instability in the regions of operation,
• Simultaneous introducing innovations and new technologies in every unit of the corporation instead of the so far sequential steps (first in central company, then gradually in the overseas subsidiaries),
• Development of the internal (managed by the TNCs) education and training systems.

From the perspectives of global labor market and global employers of engineers the fundamental issues for engineering education seem to be connected with the differences between the requirements of the employers and the knowledge and skills given by universities. The main reasons of the differences or even discrepancies originate from the different assumptions or different views on the “specialization versus generalization” issues as well as from different opinions on the spectrum of positions and areas of employment (also on future professional career) of graduates. Most of universities are still preferring traditional narrow, professional profile (justified, among others, by the limited time of education) whilst the global employers (particularly the TNCs) require additional knowledge and skills, what results in creating by TNCs their own internal education and training systems.

7. Conclusions

From the considered global perspectives it seems not too early to start discussion on future Global Engineering Education. First international engineering education programs appeared as a response to the needs of global education market rather than to the global challenges connected e.g. with the U.N. programmes oriented towards solving the global issues (poverty, environment pollution, energy). Following future solutions could be discussed:

• Virtual Global Technical University basing on the distance teaching and learning, able to create international virtual teams for solving given R&D problems in given time,
• Global EE Network of the so far existing universities in different countries with synchronized and coordinated courses and curricula in selected areas of engineering, broad exchange of faculty and students (the international networks of technical universities have already emerged not only in education but in the R&D areas as well),
• Multi-campus distributed university (World University of Technology) with international chancellor’s office subordinated to WFEO and with branch campuses located in different regions (mainly in the developing countries),
• Single-campus World University of Technology, subordinated to WFEO, located in one of the developing countries, totally oriented towards the U.N. global issues with mission: “to educate humanity serving engineers”.

The idea of the mentioned above options presented by the author for the first time during the 7th World Congress on Engineering Education held in 2006 in Budapest has been then developed in details in a series of papers published in IDEAS [3, 4, 5, 6, 7] and discussed during next congresses.
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- عضو اللجنة العلمية في نقابة المهندسين

تمييز:

يقتضى هذا الملف تشخيصًا لواقع التعليم الهندسي في لبنان ومشاكله، سواء بالنسبة لمؤسسات التعليم المرخصة قانوناً في لبنان أو فيما يتعلق بالخريجين القادمين من المؤسسات التعليمية من مختلف دول العالم. كما يعرض لأنظمة ودرجات التعليم الهندسي، جودة التعليم والآليات، شروط الممارسة، النظام الأوروبي وتطبيقه في التعليم الهندسي، سوق العمل، تعزيز البحث العلمي، والمشاكل التي يجب معالجتها للمحافظة على صحة الهندسة.
بعد نضال طويل للقوى الطلابية والمجتمع المدني، وبعد تأخير زاد عن ثلاثين سنة على
إنشاء الجامعة اللبنانية (تأسست سنة 1953)، باشرت كلية الهندسة في هذه الجامعة قبول

وقد شكلت هذه الكلية معطفاً في السياسة الترخيصية للدولة اللبنانية في إتجاه فتح كليات
متخصصة وتطبيقية تستفيد منها أبناء ذوي الدخل المحدود الذين لم يكن بمقدورهم متابعة
تعليمهم خارج لبنان أو الاشتغال إلى إحدى كليات الهندسة في لبنان: الجامعة الأمريكية
(تأسست سنة 1866، وكلية الهندسة فيها سنة 1950) أو في الجامعة البسويه (تأسست سنة
1872، وكلية الهندسة فيها سنة 1920) أو في الهندسة المعمارية في الأكاديمية اللبنانية للفنون
الجميلة سنة 1944، الذين يتوفرون تعليماً هندسياً مربعاً ولكن بتكلفة عالية، مع قدرة إستيعاب
محدودة للطلاب.

ومنذ نشأتها، حافظت كلية الهندسة في الجامعة اللبنانية على مستوى علمي مُتقدم (تشهد
عليه الامتحانات الوظيفية والأكاديمية التي تجري في لبنان وفي الخارج)، ساهم في تعزيزه
المستوى العالي لامتحان الدخل والذي يفترض لاجتيازه حصول الطالب على معدل 12/20 في
امتحانات عادلة ونزية، توازي في مستواها الامتحانات التي تجريها أعرق الجامعات في العالم.

إنشاء كلية الهندسة في الجامعة اللبنانية لم يروى ظناً للبنانيين لدراسة الهندسة ولم
يستوعب الطلاب على المهنة، فالإعداد المقبول للدراسة في جميع فروع كلية الهندسة لم تتجاوز
500 طالب، ومعدل عدد المخرجين سنوياً هو بعدد 360 مهندساً من كافة الفروع، لذلك بقي
الطالب على الإنشاب إلى التعليم الهندسي ومعه مشكلة إضطافة التلاميذ على أوباب الأحزاب
والجمعيات للحصول على منحة من هنا أو مساعدة من هناك. ساهمت دول المصرف الاستردادي
مشكورة في حلّها جزئياً من سنة 1970+1984، وبعد ذلك قدمت مؤسسة الحريدي خدمة وطنية
كبرى بمساهمتها في تقديم منح ومساعدات لجميع اللبنانيين الراغبين بالدراسة في داخل لبنان أو
في خارجه، وبإعداد كبيرة (1985+1995) وفي اختصاصات رفيعة المستوى كالهندسة وغيرها
ولا تزال مستمرة في سياساتها.

وفي سنة 1996، كانت الطفرة الكبرى في عدد المؤسسات التي تُدِّعى تعليماً هندسياً،
حين قامت الحكومات اللبنانية المتعاقبة بمنح تراخيص لجامعات ومعاهد جديدة بعضها لديه
الحق في تدريس الهندسة، والبعض الآخر يدعي الحق له بتدريس الهندسة، والبعض الآخر
1 - التعليم الهندسي: لمحة تاريخية:
يعمل بدون أي ترخيص، ويكتفي بمكتب تسجيل للطلاب لمنح شهادات بأسماء جامعات خارجية أو باختصار أسماء لجامعات جديدة.

المشكلة الكبرى كانت في تجاوز أحكام المرسوم رقم 9274 الصادر في 7 تشرين الأول سنة 1996 الذي يُحدد الشروط والمعايير والمواصفات المطلوبة لمنح ترخيص إنشاء مؤسسة تعليم عليٍّ، والمشكلة الأكبر كانت في تفسير قانون التعليم العالي الخاص، والمنسوب ذات الصلة (9274، 8864) والإجازة لكل "شخص معنوي" واعتبار "الشركة" شخصًا معنويًا، مما جعل البعض يستفيد من هذا الواقع للحصول على ترخيص يفتح معاهد تعليم عالية ولكن بدافع الاستثمار.

وكان من نتيجة الطفرة في عدد مؤسسات التعليم الهندسي في لبنان أن أصبح معدل المتخرجين من داخل لبنان نسبةً إلى المتخرجين من خارجه هو حدود 1/5 بعد أن كانت النسبة توازي 1/10 للسنوات قبل العام 1990. وإذا كان في ذلك نوعًا من الإيجابية، بحيث يبقى اللبناني داخل وطنه، فإن الوجه السلبي يكمن في تراحم المؤسسات التعليمية على حسب الطلاب مما يؤدي في بعض الأحيان إلى قيام البعض بنتائج على صعيد المستوى والقبول، وهناك من يتجاوز ذلك إلى حد الترقيع الآلي وحسب الأرصفة وغير ذلك.

فتفتقد المؤسسات التعليمية في الهندسة أو في غيرها، يفرض مشكلة تمويل أساسية بدأت جميع الدول تعاني منها مما انعكس سلبًا على إستقرار المؤسسات التعليمية وعلى إمكانية استئدائ الخبرات الكفوفة وتأمين البنية التحتية من مختبرات وتجهيزات ومكتبات وغير ذلك، من هناك كان لا بد من وضع إجراءات قانونية إدارية ومالية لضمان الأجواء وتحسين المستوى ومواقبة التطور العلمي وأسواق العمل.

2 - آلية الحصول على إذن مزاولة مهنة الهندسة:

أنتِ القانون رقم 149 الصادرة سنة 1951 إقتراح إعطاء إذن بمزاولة مهنة الهندسة إلى لجنة مُنِّها لجنة المهندسين لدرس طلبات المرشحين والشروط المتوفرة في حامل الشهادات في الهندسة على أن "لا تقل مدة دراستها عن أربع سنوات على الأقل" صادرة عن جامعة معترف بها وتسمع لحاملها بممارسة المهنة على أراضي الدولة مانحة الشهادة. إضافة إلى شروط أخرى، مثل حيازة البكالوريا اللبنانية قبل بدء الدراسة الجامعية قانون 81/18 (بعد سنة 1981)، سجل علمي... وغير ذلك، يُصار بعد ذلك إلى تقديم طلب للتسجيل في نقابة المهندسين تدرسه.
لجنة خاصة فيها ليصدر قراراً بتسجيله بعد وضع الرسوم المتوجب بعدها صاحب العلاقة لقب "مهندس".

كما أن القانون "لجنة المهندسين" الحق بإصدار وإعتماد لائحة بالجامعات والمعاهد التي تتعترف بها من خارج لبنان والدرجة العلمية المقبولة من كل جامعة.

وفي سنة 1997 صدر قانون مزاولة مهنة الهندسة رقم 636 الذي عدل في اسم اللجنة لتصبح لجنة "مزاولة مهنة الهندسة"، واشترط لمنح حامل الشهادة الهندسية إذنًا بممارسة المهنة، أن يكون حائزاً على شهادة من جامعة أو معهد مُخَصّص بها داخلاً لبنان أو على شهادة دبلوم، أو شهادة تؤمّن شهادة الهندسة الصادرة عن الجامعة اللبنانية بالنسبة للجامعات من خارج لبنان.

وإيضاً إلى النصوص القانونية المرعية الإجراء، جهدت لجنة مزاولة مهنة الهندسة خلال عملها على حماية مهنة الهندسة من الانفلاش والتشرّد، ونود الاستمرار النسبي في عملها لبلغ عدد المنتسبين إلى نقابة المهندسين إلى ضعف العدد الموجود حالياً، بنفس الامكانيات الإدارية والأمنية التي كانت سائدة.

وقد شرّطت اللجنة الحصول على درجة الماجستير علوم في الهندسة من الجامعات ذات المنهاج الأمريكي (وهذا منطقياً جداً باعتبار السنة الأولى الدراسية في المنهاج الأمريكي الشامل لدبلوم الثانوية العامة). كما شرّطت على الحصول على الدبلوم في الهندسة مدة خمس سنوات من الجامعات ذات النظام السنوي أو الزهري، وباحتفاظ عدد الأرصفة في الرخصة أن لا تقل عن 160 رصيداً نصف سنوياً من الجامعات التي تحتفظ بنظامها الخاص.

كما أوصى المنتسبون بعدم قبول الشهادات في الهندسة المبنية على نقل أرصفة من الامتناع الفني إلى الشهادة الجامعية... وبعد قبول حملة شهادات الهندسة المبنية على الدبلوم الجامعي في التكنولوجيا TS (ويوجد مشروع قيد البحث، يقضي ب上がって التحصيل الجامعي لفترة لا تقل عن ثلاثة سنوات إضافية والحصول على شهادة ماجستير مسبوقة بعد من الأرصفة لا يقل عن خمسين رصيداً إضافياً تُعتبر متممة لشهادة DUT إلى شهادة البكالوريوس في الهندسة).

يُبقى أن نشير إلى أن القانون أعطى لجنة صلاحية اختبار بإصدار لائحة بالجامعات والمعاهد التي تقبل شهاداتهما، وبالتالي أعطاه صفة لجنة إعتماد هندسية. لذا لا بد من الإشارة إلى الملاحظات التالية:
- مارست لجنة مزاولة مهنة الهندسة عملها كهيئة إعتماد لإصدار لائحة بالجامعات والمعاهد المعترف بها، ولكن بطريقة غير مباشرة، بواسطة تقييم دليل المؤسسة الجامعية أو من خلال معلومات مستوحاة من أشخاص قادمين من هذه الجامعات، أو بواسطة ما يسمع الأعضاء عن مستوى هذه الجامعات. أي أن آلية عمل اللجنة لم يحددها القانون ولم يوفر لها بنية إدارية مساعدة.

- لاستقاء المعلومات عن الجامعات ودراستها وتحليلها، أو للقيام بزيارات ميدانية للإطلاع المباشر على أحوال الجامعات في الخارج من مختبرات وهيئة تعليمية ومبادئ وغير ذلك، أي القيام بإجراءات التقييم والتدقيق التي تجريها هيئة الاعتماد... لذلك فإن اللوائح التي تصدرها اللجنة، قد تكون صائبة أو قد يشوبها بعض الخطايا ولكن في ضوء الإمكانات المتاحة لا يمكن إجراء أكثر من ذلك.

- بالرغم من ذلك، لم تستطيع لجنة مزاولة مهنة الهندسة من الإلتزام التام باللائحة وعدم قبول شخص لم ير د اسم الجامعة التي تخرج منها فيها، وذلك لأسباب إجتماعية، وفي أغلب الأحيان سياسية، مما جعل اللائحة تمتد وتتوسع ويضم إليها جامعات لا تعرف الكثير عنها ولا عن مستواها. لذلك نرى ضرورة تقليص عدد الجامعات الواردة في لائحة الجامعات المعتمدة إلى الحد الأدنى أخذاً في الاعتبار الجامعات الأولى في العالم، والجامعات التي تمنح اختصاصات هندسية غير متوايرة في بلدنا أو في اختصاصات تحتاج إلى إمكانات كبيرة على صعيد التجهيزات والمختبرات، وعدم قبول أية جامعة مشكوك في مصداقيتها لجهة منح الشهادات وسهولة قبول الطلاب.

- التعليم الهندسي داخل لبنان – نظام LMD:

1- واقع التعليم الهندسي داخل لبنان:
منذ سنة 1996 بدأت نقابة المهندسين تستقبل سنوياً بحدود 1500 مهندساً جديداً من حملة إجازة مزاولة مهنة الهندسة، توزعت أعدادهم وفق الجدول التالي:

<table>
<thead>
<tr>
<th>السنة</th>
<th>عدد المتخريجين من حملة إجازة مزاولة مهنة الهندسة عدد الطلبات المعلقة أو المرفوعة</th>
<th>العدد</th>
<th>المعدل</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
يُستفاد من هذا الجدول، أن نسبة المتخرجين من جامعات داخل لبنان قد ارتفعت لتبلغ حدود 500% (5 متخرجين من داخل لبنان في مقابل متخرج واحد من خارج لبنان). هذه النسبة كانت ومنذ سنة 1952 وحتى سنة 1996، بحدود 1/20 تقريباً، وفي أحسن الحالات بعد إفتتاح كليات الهندسة في الجامعة اللبنانية وجامعة بيروت العربية وغيرهم أصبحت النسبة بمعدل 1/10 تقريباً. وما يعني فتح المجالات أمام الطلاب اللبنانيين لدراسة الهندسة من جامعات في داخل لبنان وهذا مؤشر إيجابي ولكن يلزم وضع ضوابط أكاديمية لقبول الطلاب وتخرّجهم.

وفيما يلي أسماء الجامعات داخل لبنان التي يحق لها إصداء التعليم الهندسي حسب تسلسل إنشائها:

- الجامعة الأمريكية.
- الجامعة اليسوعية.
- الأكاديمية اللبنانية للفنون الجميلة "اليا".
- الجامعة اللبنانية.
- جامعة بيروت العربية.
- الجامعات الجديدة المنشأة بعد سنة 1996 والمعترف بها من لجنة مزاولة مهنة الهندسة:

1 - الجامعة اللبنانية الأمريكية (عدا الهندسة الميكانيكية).
2 - جامعة الروح القدس.
3 - جامعة البلمند.
4 - الجامعة الأطلونية (هندسة معلوماتية وإنطارات).
5 - جامعة سيدة اللوية.
6 - الجامعة الإسلامية (هندسة معدات طبية ومعلوماتية).
7 - معهد العلوم التطبيقية في الجامعة اللبنانية بالتعاون مع الكونсерفاتوآن الوطني للعلوم والمهن (CNAM - فرنسا).

8 - الجامعات المرخصة بتدريس الهندسة ولم يصدر إعتراف بها من لجنة مزاولة مهنة الهندسة:
1 - الجامعة اللبنانية الدولية (جامعة البقاع سابقا).
2 - معهد الحريري - الكندي في المشرف (الترخيص في مستوى البحاريوس في الهندسة فقط).

وهناك جامعات ومعاهد لا يحق لها بتدريس اختصاصات الهندسة، ولكنها تدعي الحق بإداء التعليم الهندسي، ولذا فهي تقوم بتدريس الهندسة خلفاً لأي الهيئات الملونت بها تقرر هذا الحق، وبالتالي فإن شهاداتها قد تدرس في اللجان الخاصة التابعة للوزارة (مجلس التعليم العالي لجنة الفنية، لجنة مزاولة مهنة الهندسة...). وقد تكون بحاجة لترخيص ومرسوم للسماح لها بتدريس مهنة الهندسة، وهذه الجامعات والمعاهد هي:

1 - معهد الكمبيوتر والإدارة الجامعي.
2 - معهد C&E.
3 - معهد AUST.
4 - معهد AUT.
- وغيرهم بل معظم الجامعات الجديدة.

وقد قامت بعض الجامعات الجديدة بفتح فروع لها في المناطق لتدريب الهندسة وغيرها، وهذا يشكل مخالفة قانونية واضحة لأن الفروع تحتاج إلى رخصة وإلى مرسوم.

لذلك، وما أن هذه المعاهد والجامعات قد باشرت بالتدريس والتحفيظ، فستكونكرة النتاج، وسيزداد عدد الخريجين حاملين شهادات في الهندسة غير معترف بها، وسيزداد الضغط السياسي على الهيئات الناظمة وعلى النقابة... للاعتراف بها وشهاداتها، لذلك فالملزوم حل هذه المشكلة قبل تفاقمها.
الثانوية العامة اللبنانية والثانوية الفنية والامتياز الفني والدبلوم الجامعي

في التكنولوجيا:

- الثانوية العامة:

إشترط القانون 18/81 حيزة البكالوريا اللبنانية (الثانوية العامة اللبنانية) قبل الإنتساب إلى التعليم العالي مهما يكن الاختصاص. وبالتالي فإن لجنة المهندسين إشترط دراسة 5 سنوات بعد حيزة الثانوية العامة اللبنانية أو الإنتساب إلى التعليم الهندسي بعد دراسة ما قبل الجامعية توازي 13 سنة.

ولا تحتسب دراسة السنة الأولى الجامعية "الفرشمن" الأمريكية ضمن عدد السنوات أو الأرصدة المطلوبة لنيل الشهادة في الهندسة.

أما فيما يخص البكالوريا الفنية، فيحق لحاملي شهادة إنتهاء المرحلة الثانوية الفنية بدراسة الهندسة وفق مسالك تحصيل جامعي يحدها وزير التربية والتعليم العالي، ولكن التجربة تشير إلى أن الكثير من الطلاب لا يلتزمون بهذه المسالك، بل يتابعون تحصيلهم الجامعي في اختصاصات بعيدة عن اختصاصهم في المرحلة الثانوية الفنية، مما يؤدي إلى تعديل في مسالك التحصيل، وحتى في بعض الأحيان قبول المتخرج بغض النظر عن إختصاصه في البكالوريا الفنية.

ولكن ذلك ليس بالأمر المهم بالمقارنة مع مستوى حاملي الشهادات الفنية، فقد أثبتت تجارب إمتحانات الدخول في الجامعة اللبنانية (منذ تاريخ إنشائها) وفي غيرها من الجامعات، أن أي من حملة البكالوريا الفنية لم يستطع إختياد الدخول والنجاح فيه، وهذا بالأمر المنطقي، ويعود إلى أن هذه الإمتحانات تتم في مواد كالرياضيات والفيزياء والكيمياء ومن نهج الثانوية العامة اللبنانية... وهذا ما دفع معظم الجامعات العربية والكبرى في لبنان لدعم قبول تسجيل حملة البكالوريا الفنية في اختصاص الهندسة، مما دفع بهؤلاء إلى الإنتقاد بالجامعات الجديدة أو بالسفر إلى الخارج إلى جامعات لا تضع شروطًا للإنتساب إليها...

من هنا يجب العمل على سن تشريعات لحد من إلتحاق حملة البكالوريا الفنية بالتعليم الجامعي بشكل عام وبالهندسي بشكل خاص، وذلك عن طريق إجراء إمتحانات تمهيدية في الرياضيات والفيزياء وغيرها من المواد لكل من يرغب بمتابعة تعليم عالي جامعي وأكاديمي، وإلا متابعة تعليمهم العالي في اختصاصات فنية (إمتياز فني، معاهد تكنولوجية،...
((...)، مما يستوجب أيضاً سلسلة تشيريات لتصحيح الوظائف التي يحق لهما الدخول إليها والعمل فيها، لأن الوضع الحالي هو غير مقبول بحيث لا يعرف حاملوا الشهادات الفنية إلى أي من الوظائف يحق لهما العمل فيها. كما أن معظم الوظائف تحتاج إلى شهادات جامعية أكاديمية، والقليل جداً منها يساوي حملة الشهادات الفنية بخلاف درجاتها كشرط للقبول والتدقيق.

ومن المعلوم أن التعليم المهني يحتاج إلى تجهيزات ومختبرات واسئلة متخصصة، تفوق كليتها تجهيز المدارس التي تسدي التعليم العام، وبالتالي فما الفائدة من فتح تعليم مهني وتكنولوجي إذا كان حاملوا الشهادات الفنية سيتعينون مع غيرهم من طلاب التعليم العام الأكاديمي في الجامعة ويتركون بالتعليم العالي الجامعي، بدلاً من الالتزام بالتعليم الفني. نضيف إلى ذلك فإن مستوى الطلاب المنتمون إلى التعليم المهني هو أقل من مستوى طلاب التعليم العام، والمسؤول أن الرأسون في التعليم العام يتحقون بالتعليم المهني وهذا أمر يجب النظر بجدية إليه لإصلاحه.

ب - الامتياز الفني والهندسة الفنيّة:

المشكلة الأخرى في التعليم التقني هو انتقال بعض من حملة الامتياز الفني إلى الهندسة وتقوم بعض المؤسسات في خارج لبنان وداخله بمحاولة سنوات الامتياز الفني بالسنوات الجامعية وهذا ليس منطقياً لأن التعليم الجامعي الأكاديمي يختلف بشكل كبير عن التعليم الفني في طبيعته وفي توجهاته...

وفي إطار الهيكلية الجديدة للتعليم المهني التي وافق عليها مجلس الوزراء في جلساته بتاريخ 8/8/2000، قد أوجد شهادة دبلوم مهندس فني مدتها خمس سنوات، هذه الشهادة لا تعرض لها لجنة مزاولة مهنة الهندسة كونها غير جامعية، ولا تخضع لأحكام قانون تنظيم التعليم العالي، ولا يوجد لها توصيف وظيفي، وتستدعي التباسات عند المباشرة في تطبيقها.

لقد رفضت لجنة مزاولة مهنة الهندسة الاعتراف بشهادات حصل عليها أصحابها بعد معادلة سنوات دراسية من شهادة الامتياز الفني بسنوات جامعية... وبما أن عدد هؤلاء يزداد فيجب إعطاء هذا الأمر الɒمامة التي يستحقه وإصدار مرسوم لتنظيم عملية الانتقال من الامتياز الفني إلى الجامعي، كما ترفض اللجنة منح مزاولة مهنة الهندسة إلى حملة شهادات الهندسة الفنية أو التطبيقية.
ج - المعاهد الجامعية:

بعد مراجعة ملف الأكاديمي المودع لدى لجنة المعادلات عن هذه المعاهد بتاريخ 25/10/2002، لا يسعنا ويشكل عام إلاّ أن نورد بعض الملاحظات التالية:

1 - في فلسفة المعاهد الجامعية المرخصة في المرسومين 2143 و3585:

من المرجح أن الترخيص لبعض المعاهد الجامعية كان يهدف بشكل أساسي (كما جاء على لسان مسؤولون في وزارة التعليم العالي والحكومة في حينه) إلى إيجاد فئة من الخريجون بمؤهلات تقع بين التعليم الجامعي العالي الكلاسيكي والتعليم العالي الفني والتطبيقي (أسوة باليابان وإيطاليا وبعض الدول المتقدمة)، وإن الدبلوم الجاهزي للتكنولوجيا الصادر عن هذه المعاهد التكنولوجية (معظم المعاهد الجامعية قام بتغيير تسمية شهاداته لاحقاً إلى بكالوريوس وماجستير وغير ذلك) كان يهدف إلى ضخ كيوارد فنية إلى سوق العمل تختلف طبيعة عملها عن حملة الشهادات الجامعية (الإجازة، دبلوم دراسات عليا، دبلوم في الهندسة وغيرها). وإذا كان قرار لجنة المعادلات (الذي اتخاذ تحت ضغط غياب التوصيف الوظيفي وفي ضوء مرسال مجلس الخدمة المدنية السائل عن حال ومستوى هؤلاء الخريجين)، القاضي باعتبار الدبلوم الجاهز في التكنولوجيا إجازة جامعية في سبيل التوظيف والذي جرى تعديله لاحقاً ليصبح معاولاً للإجازة الجامعية والمطلق على أساس كون الدراسة في هذه المعاهد توازي ثلاث سنوات (كما هو الحال بالنسبة لشهادة البكالوريوس الجامعية).

لقد شجع هذا القرار بعض المعاهد الجامعية، وفي ظل غياب الرقابة وغموض التقارير الفنية وفقدان الملفات الأساسية الأصلية، وفي ضوء مراسلة الترخيص الغامضة والمهمة والواسعة التأويل إلى فتح إحصصائيات مختلفة غير فنية لم تكن واردة في ملفاتها الأصلية، ولم تكن هي في صدد إنشائها، كما شجع هذه المعاهد الحديثة إلى توسيع نشاطها باتجاه إحصصائيات جديدة في الهندسة، وإدارة الفندق، و إحصصائيات مالية وإدارية وفنية، وإلى درجات تُثنى البكالوريوس إلى دبلوم دراسات عليا وحتى دكتوراه (هذا مع الإشارة إلى أن جامعات عريقة جداً وأساسية لم تستطع حتى الآن من فتح دبلوم دراسات عليا في الهندسة، أو الإدارة إلا بالتعاون فيما بينها أو مع جامعات دولية فرنسية وغير فرنسية).

2 - كما أشرنا، وفي ضوء غياب الترخيص الصريح بفتح كليات

withstanding the previous extracted content.
عُلِى الترجمة الحرفية لكلمة "هندسة" والتي لا تعني بأية حال من الأحوال مفهوم الدرجة الأكاديمية في الهندسة "Diplôme d'ingénieur" أو "Engineering"، "Ingénierie"، "Architecture" في اللغة العربية هي الهندسة المعمارية والتي لا تعني مطلقاً هندسة معمارية بل "عمارة"، كما أن كلمة "Génie" ليست مطلقاً دبلوماً في الهندسة وإن كانت الترجمة العربية هي إجازات في "الهندسة" الميكانيكية، المدنية أو الميكانيكية وغير ذلك.

3 - مخالفة مرسوم الترخيص:

إن الترخيص بفتح كليات جديدة (كلية للهندسة مثلاً) يتطلب مرور ملف على مجلس التعليم العالي الذي يشارك حكماً في جلساته نواب المهن الحرة عندما يكون الترخيص يطال واحدة من هذه المهن، وبناءً على ذلك، نلاحظ ملاحظات نقاش المهندسين على كلية الهندسة في الجامعة الإسلامية، الدروح القديس، جامعة البقاع (اللبنانية الدولية)، فقط دون غيرها.

ومن الملاحظ أن المراسيم التي صدرت بالترخيص بفتح معاهد وجامعات جديدة جاءت صريحة وواضحة بشأن الترخيص في تدريس الهندسة، كمراسيم المتعلقة بالجامعة الإسلامية، LAU، اللوزة، البلند، العلوم التطبيقية وغيرها. بينما لم تتم الإشارة أبدًا إلى كليات أو CNAM إلى اختصاصات هندسية في باقي الجامعات المعاهد، مما يعني أن المُشترط قد قصد فعلاً عدم الترخيص. وعلى سبيل المثال، فإن المرسوم رقم / 3585 لحظ صرامة فتح اختصاص في كلية الهندسة في جامعة الكسكليك، بينما إكتفى بتعداد أسمااء المعاهد والجامعات الأخرى، (مع تأكيد نقيب المهندسين إن ملفات هذه المعاهد لم تحتوي على اختصاصات هندسية عند عرضها على مجلس التعليم العالي في حضوره).

4 - مخالفة الأعراف الأكاديمية:

تُلِجَ هذه الجامعات إلى إجراء حسومات أكاديمية على مواد وتوزيع الطلاب، أو الاستعانة بشهادات تمنحها جامعات أخرى من خارج لبنان، وعدم وجود عدد كافٍ من الأساتذة لحملة الدكتوراه في الاحتراف، والهم من كل ذلك ضعف المستوى التربوي للبرامج والمناهج المُوزعة حديثاً أو قديماً لدى مجلس التعليم العالي. وفي قراءة دقيقة لهذه البرامج نلاحظ أنها أقرب إلى المستويات الفنية منها إلى الجامعة كما أن عقود الأساتذة غير واضحة إن لجها كونها عقوداً بالتفريع أو بالساعات أو لجها صحتها، وصخة الدراجات الأكاديمية التي يحملها أصحابها.
مقارنة بين التعليم الهندسي والتعليم الأكاديمي الجامعي:

1- عدد الأرصفة:

أ - يدرس الطالب للحصول على شهادة DUT حوالي 90 رصدأً موزعة على ثلاث سنوات (نص مرسوم تنظيم المعاهد التكنولوجية على 2700 ساعة تدريس بما فيها الأعمال التطبيقية).

ب - يدرس طالب الهندسة ما يزيد عن 160 رصدأً على الأقل موزعة على خمس سنوات يكون الفارق بينهما حوالي 70 رصدأً على الأقل.

2- امتحانات الدخول:

أ - لا يوجد إمتحان دخول إلى المعاهد التكنولوجية (ما عدا المعهد الجامعي للتكنيجيا في الجامعة اللبنانية).

ب - يوجد إمتحانات دخول إلى كليات الهندسة في الجامعة اللبنانية، اليسوعية، الأمريكية. ويطلب معدلات نجاح عالية في الشهادة الثانوية للإنمبراس إلى كليات الهندسة، مثلًا، في سوريا، الأردن، الولايات المتحدة، بريطانيا وغيرها.

ما يعني عدم المساواة بين المواطنين في فرصة الاختيار للدراسة الهندسة، بين من يدخل مباشرة إلى إحدى كليات الهندسة المعترف بها وبين من يلتقي معهد جامعي للتكنولوجيا ثم يتابع دراسة في الهندسة.

3- المواد العلمية البحثية والتأهيلية:

أ - كليات الهندسة:

- الجامعة اللبنانية: يدرس الطالب ما يقارب 26 مادة موزعة على ستين (حوالي 70 رصدأ) في مواد هي: الرياضيات على أنواعها، ميكانيك، هيدرونيك، فيزياء، كيمياء، فزياء السوائل إلخ.

- يدرس الطالب في الجامعات الأمريكية ما يوازي 60 رصدأ في المواد العلمية البحثية.

- في فرنسا والجامعة اليسوعية يدرس الطالب حوالي 70 رصدأ (برنامج يشبه برنامج الجامعة اللبنانية).

ب - المعاهد التكنولوجية:
لا يدرس الطالب سوى عدة أرصفة فقط في الرياضيات والفيزياء، بل يغلب على دراسته في السنوات الثلاث طابع الدراسة الفنية.

لذلك نرى ضرورة إجراء دراسة عملية، لموضوع الانتقال من التعليم الجامعي التكنولوجي إلى التعليم اليدني وغيره، ومعادلة سنوات الدبلوم الجامعي للتعليم الفني (DUT) سنوات تعليم هندي. ومع أن اللجنة وافقت فقط على السماح لحملة شهادات من الجامعة اللبنانية بمتابعة دراسة الهندسة، كون الطلاب المنتسبون إليها هم من حملة الثانوية العامة اللبنانية.

ويخضعون لامتحان دخول يوازي امتحان الدخول إلى كلية الهندسة، ويشترط من تحصيل مواد إضافية قبل متابعة دراسة الهندسة لمدة سنتان على الأقل. وهناك إقتراح قيد الدراسة يجعل المدة ثلاثة سنوات أو 90 رصيداً نصف سنوياً على الأقل للحصول على شهادة في الهندسة مبنية على DUT شهادة.

ومن المعلوم أن حملة الدبلوم الجامعي في التكنولوجيا يخضعون في فرنسا إلى امتحان دخول بعد الحصول على مواد إضافية للانتقال إلى التعليم الجامعي العالي.

ذلك، فالمطلوب (من الوزارة ومن النقابة) إصدار تعاميم إلى الجامعات المرخصة داخل لبنان وإفادة بشروط قبول حملة الدبلوم الجامعي في تكنولوجيا (DUT)، وبعد جواز قبول حملة الامتناع الفني (TS) لملتزمة الدراسة ومعادلة سنوات الدبلوم الجامعي بالسنوات الجامعية في الهندسة... خصوصاً وإن بعض الجامعات يعتبرها هؤلاء صيداً مريحاً بسبب عدم قدرتهم على الامتثال إلى الدولس في الجامعات العربية الكبرى وحتى عدم قدرتهم على إجتياز شروط الدخول فيها.

- 5 - نظام تدريس الهندسة في لبنان والتحوّل إلى نظام LMD:

تعتبر بعض الجامعات داخل لبنان النظام الأمريكي المبني على الأرصفة (الجامعة الأمريكية، الجامعة اللبنانية الأمريكية وغيرها)، والبعض الآخر يعتمد النظام السنوي (الجامعة اللبنانية، الجامعة اليهودية، الجامعة العربية وغيرها)، كما اختفت تسمية الشهادات من جامعة إلى أخرى فبالنسبة من النظام الأمريكي، أطلق تسمية "بكالوريوس علم في الهندسة" بعد من الأرصفة يساوي 160 رصداً على الأقل كالجامعة الأمريكية اللبنانية، وهذه، والبعض الآخر شهادة "البكالوريوس في الهندسة" وبدنتها خمس سنوات كالجامعة العربية، أو
البكالوريوس في الهندسة: 90 رصيداً، وماجستير في الهندسة: 60 رصيداً كجامعة البلمند.

كما أطلقت الجامعة اللبنانية والجامعة اليسوعية تسمية "دبلوم في الهندسة"، مدتها خمس سنوات، على شهادات التخرج لديها.

ويشكل عام، فإن لجنة المهندسين اعتمدت مبدأ الاعتراف بالشهادات التي لا تقل مدة دراستها عن خمسة سنوات وعدد أرصدتها لا يقل عن 160 رصيداً، مبدأ عام للعتراف والقبول بأية شهادة صادرة عن لبنان أو من خارجه؛ أما بالنسبة للهندسة المعمارية، فإن عدد السنوات هو ستة سنوات وعدد الأرصدة لا يقل عن 180 رصيداً كشرط للعتراف بشهادة في الهندسة المعمارية.

وفي السنوات الأخيرة بدأت الجامعات التي تتبع النظام الفرنسي أو النظام المدني على السنوات بالتحول إلى نظام LMD (Licence, Master, Doctorat) الذي أقره وزراء التربية والتعليم في الاتحاد الأوروبي فيجتماعهم في مدينة بولونيا في إيطاليا، والذي دعا فيه دول الاتحاد إلى المباشرة باعتماد النظام الأوروبي للوحدات European Credit Transfert (ECTS) وجاء ذلك خلال ما يسمى "إعلان بولونيا" (Processus de Bologne).

والخطوط العريضة لهذا النظام هي:

- أ - سلم الشهادات الجامعية:

  - الإجازة (بالفرنسية و بالإنكليزية): تتكون من 180 Rصيداً موزعة على ستة فصول دراسية بمعدل 30 Rصيداً للفصل الواحد.

  - المスター (بالفرنسية والإنجليزية): تتكون من 120 Rصيداً موزعة على أربعة فصول دراسية بمعدل 30 Rصيداً للفصل الواحد.

  - الدكتوراه (بالفرنسية و بالإنكليزية): لا تقل مدة تحضيرها عن ثلاث سنوات. (وستقوم لجنة خاصة بتعيين رئيس الجامعة اللبنانية بإعادة النظر بالأنظمة الحالية للدكتوراه بما يتوافق مع النظام الجديد).
ب - نظام الأرصدة:

• يعتمد في تقييم ما يحصله الطالب في الجامعة على تقييم جملة الجهد الذي يبذل للتحصيل (ما بين ساعات متاحة للدروس النظرية والتطبيقية والأعمال الموجهة وساعات العمل الشخصي بما فيها تلك التي يخصصها لتحضير ما يطلب منه والساعات التي يخصصها لمراجعة الدروس وتحضير الامتحان والتقدم إليه).

• يعتمد مبدأ التساوي بين ساعات الحضور وساعات العمل الشخصي بحيث يقابل كل ساعة حضور، على مستوى الإجازة، ساعة عمل شخصي. أما على مستوى الماستر فيمكن اعتماد تناساب آخر لأن الجهد الشخصي المطلوب من الطالب هو أكبر.

• يقيّم تحصيل الطالب بوحدة قياس موحدة هي الرصيد (الرصيد الأوروبي).

• يَتمّ كل 20 ساعة من مجمل جهد الطالب برصيد واحد.

• إن اعتماد مبدأ 30 رصيداً للفصل الدراسي الواحد يُترجم بـ 300 ساعة حضور في الفصل الواحد على مستوى الإجازة.

• يعادل الرصيد 15 ساعة حضور إزامى منها 10 ساعات للمحاضرات على الأقل، و 5 ساعات أعمال تطبيقية، على أن يُعتبر كل 3 ساعات مختبر أو أعمال تطبيقية يساوي ساعة حضور واحدة (في الهندسة).

• إضافة إلى ساعات الجهد الشخصي للطالب.

ج - المقررات:

• يعتمد النظام الجديد المقررات كوحدات تعليمية.

• يُشكل المقرر الواحدة التعليمية الأساسية ويتناول موضوعاً واحداً على مدى فصل دراسي واحد.

• يخصص كل مقرر بعدد من الأرصدة وفقاً لعدد ساعاته تطبيقاً للقاعدة المحددة تحت عنوان "التقييم بالأرصدة".
يراعى في صياغة المقررات أن تكون متوسطة الحجم ولا يزيد عدد أرصدتها عن 6 أرصلة. كما يُفضل عدم تقسيم المقررات تسبيلًا لإدارة النظام.

يُصنف المقررات التي تكون كل شهادة إلى: مقررات إلزامية ومقررات اختيارية بشروط محددة ومقررات حرة يختارها الطالب من بين المقررات التي توفرها مختلف كليات الجامعة.

يُحدد قرار إنشاء الشهادة المقررات الإلزامية بالإسم ومجموع أرصة المقررات الإلزامية وشروطها ومجموع أرصة المقررات الحرة.

لا يجب أن يقل مجموع أرصة المقررات الإلزامية في الإجازة عن 120 رصيداً وأن لا يزيد مجموع أرصة المقررات الحرة عن 20 رصيداً.

يتم توصيف المقررات وفقاً لنموذج خاص (عدد الأرصة، اسم المادة، مضمون المادة وأهدافها، إلخ).

ترتبط المقررات فيما بينها بالأسبقيات بحيث يتطلب التسجيل في مقرر ما مستوى معرفي ومهارات حصلتها الطالب في مقرر سابق أو أكثر وفقاً للقواعد التالية:

(أ) الارتباط بالأسبقية هو حصول الطالب على علامات لا تقل عن 40/100 في امتحان المقرر السابق.

(ب) لا إرتباط بالأسبقية بين مقررات الفصل الأول والفصل الثاني من السنة الدراسية الواحدة.

د - طرائق التعليم:

يشكل انتقال الجامعة اللبنانية والجامعات الأخرى إلى النظام الجديد خطوة مهمة باتجاه تحولها إلى جامعات ذات مستوى أكاديمي معترف به عالمياً. لكي تتصور كل جامعة إلى هذا المستوى، عليها أن لا تكتفي بتعديل نظامها وإعادة هيكلة شهاداتها لتتوافق مع ما هو معمول به عالمياً. إن عليها أيضاً أن تغير في مفهومها للتعليم العالي فتطلق على التعلّم وتحدد نحو التكوين. إن عليها أن تقوم بتحديث الإختصاصات التي توفرها وتحديث محتوى المواد التعليمية، كما أن عليها أن تُجدد في طرائق التعليم وطرائق التقييم. ولعل الفكرة الأساسية في هذا التوجه هي أن يكون الطالب محور العملية التعليمية، بحيث يُزوّده الجامعة بمفاتيح المعارف والمهارات.
من جهة، وأساليب البحث والتعلم الذاتي من جهة أخرى. إن هذا الانتقال يطرح أمام الأساتذة ضرورة مراجعة تعليمهم محتوى وطرق، بشكل فردي وجماعي، تواصلًا لتحقيق النقلة النوعية المطلوبة.

ولقد باشرت الجامعات العاملة داخل لبنان والتي تعتمد النظام السنوي (الجامعة اللبنانية، اليسوعية، الكسليك، وجامعة بيروت العربية) تدويل برامجها لتطبيق نظام LMD والرصدة، وذلك في موازاة تطبيقه في فرنسا وغيرها من الدول الأوروبية...

ولكنها، حافظت على خصوصية التعليم الهندسي (والطبي وغيرها من الاختصاصات التطبيقية)، واعتمدت توزيع الأرصفة وعدها 300 رصداً، على خمس سنوات للحصول على شهادة "مهندس" معترف بها لمزاولة مهنة الهندسة، وأطلقت تسمية "ماستر" على هذه الشهادة (دبلوم مهندس: درجة ماستر) التي يمكن الحصول عليها مباشرة دون المرور بمرحلة الإجازة (البكالوريوس) وذلك لتحقيق مبدأ العادلة مع باقي الشهادات المماثلة في غيرها من الاختصاصات. وبالتالي تكون دراسة الهندسة قد استفادت من قواعد نظام الأرصفة مع المحافظة على مدة الدراسة وعدد الأرصفة اللازمة وهذا ما هو جاري في فرنسا وبقية الدول الأوروبية.

بقي أن نشير إلى أن بعض الجامعات ومنها كلية الهندسة في الجامعة اللبنانية لا تزال تطلب الحصول على شهادة DEA دبلوم دراسات معمقة ومدتها ستنات لمتابعة الدكتوراه، والبعض الآخر يعفي من شروط الحصول على شهادة DEA لمتابعة دراسة الدكتوراه، بل يمكن متابعتها فورًا شروط الحصول عليها بعد ثلاث سنوات دراسية على الأقل بيليها تقديم مناقشة أطروحة.

كم تجدر الإشارة إلى أن بعض المؤسسات التعليمية في داخل وخارج لبنان قد أنشأ برامج تدريس جديدة، بدرجات جديدة، مثلًا: ماستر مهنية Master Professionnel حاملها دخول سوق العمل وليس لمتابعة الدراسة، وذلك في موازاة الماستر البحثية Master de recherche التي تسمح بمتابعة الدراسة ودخول سوق العمل... هذه الشهادات لا تتعتلي الحق بممارسة الهندسة، إذا لم تكن مفروضة بدرجة مهندس:

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٥ - التعليم الهندسي خارج لبنان:

ينشر اللبنانيون في جميع دول العالم، وبالتالي فإن الشهادات الواردة إلى لجنة مزاولة مهنة الهندسة تأتي من جميع دول العالم دون إستثناء، من الشيشان وأفغانستان وسيرلانكا وحتى أوروبا والولايات المتحدة ودول أمريكا اللاتينية ومن آسيا ومن أفريقيا... وما ذكرنا سابقاً فإن عدد المتخرجين من دول خارج لبنان قد تقلص بدرجة كبيرة بعد سنة 1996 لتصبح نسبتهم 5/1 تقريباً بعد أن كانت بحدود 20/1 سنة 1969، تاريخ إقرار أول قانون لتنظيم نظابة المهندسين.

وبشكل عام، يتواجد المتخرجون اللبنانيون من ثلاثة مناطق أساسية، كل منها نظام أكاديمي:

- أوروبا وبشكل خاص من الجامعات الفرنسية.
- الولايات المتحدة الأمريكية وبعض الدول الأوروبية الكبيرة، ككندا، بريطانيا، أستراليا.
- دول المعسكر الاشتراكي السابق، وخصوصاً من روسيا وأوكرانيا وبيلاروسيا وبعض دول البلطيق.

ولقد أجاز القانون رقم 149 و636 إلى لجنة المهندسين إقرار لائحة بالجامعات المعتمدة، بعد مصادقة وزير التربية والتعليم العالي، وبهاء على ذلك أصدرت لجنة مزاولة مهنة الهندسة سنة 2002 لائحة جديدة بالجامعات المعترف بها وقَّصَصَت فيه عدد الجامعات المعتمدة، التي كانت واردة في اللوائح التي أصدرتها اللجنة قبل صدور القانون رقم 636، وإشترطت اللائحة الحصول على شهادات بدرجة ماجستير في الهندسة، أو شهادات مدتها خمسة سنوات على الأقل بعد من الأرصدة لا يقل عن 160 رصيداً تصف سنواتاً للهندسة و 180 رصيداً تصف سنواتاً للعمارة...
ولقد اعتمدت اللجنة في إصدارها بلائحة الجامعات المعترف بها، أن تكون شهاداتها معترف بها في بلدها ومن هيئات إعتماد معروفة عالمية (ABET في أميركا، CEAB في كندا، NAAB للعمارة، CTI في فرنسا…)، ولعدم قدرة لجنة مزاولة مهنة الهندسة على إجراء عمليات تقييم مباشرة لجامعات من خارج لبنان، ولا حتى على إجراء زيارات علمية لها، فقد اكتشفت باختبار الجامعات المركزية في العواصم، وتلك التي تتمتع بصيد تربوي معروف أو بسماع الأصواء عن تاريخ الجامعة، مستوى خريجيها وخير ذلك، إضافة إلى المعلومات التي يوفرها ليل كل جامعة أو تلك الموجودة على شبكة الإنترنت. وبالرغم من صدور اللائحة فإن خروقات لها تتم باستمرار حيث ترضخ اللجنة لقبول مُتخرجين من جامعات جديدة غير واردة على اللائحة لأسباب شقيقة إجتماعية أو سياسية وغير ذلك ...

لذلك نرى ضرورة التقييم العام بلائحة الجامعات المعتمدة التي أصدرتها اللجنة وتعديلها بهدف بعض الجامعات (وفقًا لما يتلاد إلى اللجنة من مخالفات للأعراف الأكاديمية). وضمن أخرى بعد أخذ رأي هيئات الاعتماد الدولية وخصوصا CTI وABET وغيرها.

ومن المعلومات أن خدمات هيئات الاعتماد قد تطال جامعات خارج بلادها، فسائلًا، تقوم لجنة الألقاب الهندسية في فرنسا (CTI Commission de Titres d’Ingénieurs) بالتعرف شبيهة بهيئات الاعتماد الأمريكية ABET: ECPD بالعابد لجامعات التي تُدرَّس الهندسة داخل فرنسا أو في خارجها، ويمكن الطلب منها إجراء تقييم وأعتماد لأية مؤسسة تعليمية في لبنان، وهي قامت بالتدقيق بجامعات هندسية في بلغاريا، وفي المجر، بناءً على طلب مُقدم من هذه الجامعات وقد أوردت هذه الجامعات بعد تقييمها وقبول إعتمادها.

الدرجات الهندسية (خارج لبنان):

- Bachelor of Science in Engineering بكالوريوس علوم في الهندسة
- Master of Science in Engineering ماجستير علوم في الهندسة
- MSC, BSC Arch. بكالوريوس وماجستير علوم في الهندسة المعمارية
- (BA, MA) Bachelor in Architecture بكالوريوس ماجستير في العمارة
هذه الدرجات هي المقبولة من لجنة مزاولة مهنة الهندسة، بعد التأكد من اعتمادها على
PE أو NAAB أو ABET لائحة من الولايات المتحدة، وهي شهادة غير جامعية تميزها
(Professional Engineer) متخصصة تتيح لحاملها العمل على أراضي الولايات المتحدة، وتشمل إلى مواد الاختصاص مواءم
في القانون وغير ذلك، وتبعد باستمرار لكل فترة زمنية.

وبعد صدور القانون رقم 636 عادت اللجنة واتشترطت الماجستير كشرط لمزاولة مهنة
الهندسة. كما تمنح الجامعات الأمريكية شهادات أخرى لا تقبل بها اللجنة ولا تعطي صاحبيها
حق بمزاولة مهنة الهندسة، كونها شهادة فنية أقرب إلى التعليم الفني والتعليم التكنولوجي:
(BSC, MSC of Science in Engineering Technology)
- بكالوريوس علوم في التكنولوجيا الهندسية.
- ماجستير علوم في التكنولوجيا الهندسية.
- بكالوريوس وماجستير في التكنولوجيا الهندسية.
(Bachelor, Master in Engineering Technology)

وهذ هذه الدرجات تعترف بها هيئة إعتماد خاصة تابعة لـ ABET، وهي شهادات ذات طابع
فنى أو تقني، وبالتالي لا تعترف بها في لبنان.

7 - الشهادات الصادرة عن الجامعات الفرنسية والفرنسوفونية

تعتبر لجنة مزاولة مهنة الهندسة بالشهادات الصادرة عن الجامعات الفرنسية التي
تعترف بها لجنة الأقباط الهندسية CTI، ويشمل عام فإن جامعات فرنسا تمنح شهادات دبلوم
مهندسة بعد دراسة ثلاثة سنوات مسبوقة بدبلوم DEUG 1, 2 أو دبلوم رياضيات - فيزياء مدتة
ستان من كلية علم أو غير ذلك وبعد إجتياز إمتحان قبول خاص، وبالتالي فإن إجمالي
الدراسة للحصول على شهادة في الهندسة من فرنسا هي خمس سنوات.

مؤخرًا، جرى البدء بالانتقال إلى نظام الأرصدة الأوروبي، وحافظت الجامعات الهندسية
Diplôme (Licence en genie)
على مبدأ الخمس سنوات ولكن بعض الجامعات عدت في تسمية الشهادة لتصبح
د.ingenieur: garde mastère

كما تمنح الجامعات الفرنسية شهادة إجازة في اختصاص هندي (DESS)، وماجتريز في الهندسة وغير ذلك
وهذ هذه الدرجات لا تعترف بها لجنة مزاولة مهنة الهندسة في لبنان أسوة بهيئة الاعتماد
CTI لا تعترف بها أيضاً.
كما تشترط الجامعات في فرنسا، للانتقال من الدبلوم الجامعي في التكنولوجيا أو الامتياز الفني إلى الهندسة إجتياز إمتحان دخول بعد إجراء تأهيل لمدة تقل عن سنة يسمح بعدها بمتابعة دراسة الهندسة. (مع وجود حالات استثنائية وقبول طلاب في الهندسة على أساس التدريس، وحتى منح شهادات هندسة على أساس تقييم المعترف المهنية).

وعلى الصعيد الأوروبي، فإن اللجنة تعترف بالشهادات دبلوم مهندس الصادرة عن الجامعات التقنية في ألمانيا (Teshnishe Universität)، وكانت اللجنة قد أعلنت سنة 1993 الاعتراف بشهادات دبلوم مهندس الصادرة عن المدارس الفنية العلمية (FH) وهي درجات هندسية موزعة لشهادات الهندسة التطبيقية (Ingénieur d’application) التي تمنحها بعض الجامعات الأوروبية.

8 - جامعات دول أوروبا الشرقية وروسيا

تسعى دول الاتحاد الأوروبي حالياً إلى مساعدة جامعات دول أوروبا الشرقية المهولة للدخول في الاتحاد الأوروبي، وتشكل عام فقد إنخفض بشكل حاد عدد الخريجين اللبنانيين من جامعات أوروبا الشرقية سابقاً وحتى من جامعات روسيا. ولبنان نادرة ما يصل إلى اللجنة طلبات قادمة من دول أوروبا الشرقية، خصوصاً بعد أن تحولت هذه الجامعات إلى جامعات مدفوعة، برسوم إنساب تساوي حوالي 3000 دولار للسنة الواحدة. وفي مقابل ذلك فقد زاد بشكل ملحوظ عدد الخريجين من جامعات أوكرانيا وبيلاروسيا، بحيث يشكل هؤلاء ما نسبته 50 من عدد اللبنانيين المتخرجين من جامعات خارج لبنان، وحوالي 90% من عدد المتخرجين من جامعات دول المعسكر الاشتراكي سابقاً.

مما يوجي بعدم جدية منتهائية في الدراسة وفي الانتساب، ويجب تعزى ذلك بالظروف الشاذة بين الدرجات التي تمنحها الجامعات في هذه الدول أو حتى من الجامعة نفسها. وفي ترجمة الاختصاصات، أو في طريقة قبول الطلاب (بالكالوريا أو بدونها)... فإن الجامعة تمنح بكالوريوس، دبلوم، وماجستير... وكل هذه الشهادات لها نفس سجل المواد، مما يعني أن الدبلجة العلمية هي غب الطلب. كما أن سجل المواد هو نفسه مما تكون مدة دراسة الطالب في الجامعة، أو حتى لو إنقل من جامعة إلى أخرى...

كما نلاحظ تناقضات بين شهادة أخرى أو تطابق شامل و Tâm. إضافة إلى صعوبة التأكد من الدور الفعلي الإلزامي للطالب في الجامعة، إلى صعوبة التحقق من صحة الشهادة والإقامات والتوصيات.
وللغرابة، نلاحظ اللوحات الإعلانية في شوارع لبنان للترويج للدراسة في جامعات أوكرانيا أو بيلاروسيا واللغات الفرنسية أو الإنجليزية، وهذا مخالف للأصول الأكاديمية. لجهاة أن تكون اللغة غب الطلب، أو لجهاة تطبيق نفس الشروط على ابن البلد، أو لجهاة القيام بإعلانات ترويجية.

كما أن بعض “المستثمرين” في لبنان يعقد إتفاقيات تعاون مع بعض هذه الجامعات، وينتج عنها شهادات لا نعرف مصدرها الفعلي ولا كيف تم الحصول عليها.

لذلك، نرى ضرورة وقف ظاهرة الترويج للدراسات بواسطة مكاتب تجارية، وعدم قبول شهادات صادرة عن جامعات مشكوك في جنوبها أو في مستوى شهاداتها أو في طبيعة الدراسة الإلزامية فيها....

وفي مقابل هذه المشاكل، لا بد من الاعتراف بأهمية ودية بعض الجامعات الأخرى في موسكو وسان بطرسبرغ وفي صوفيا وبراغ ويندباست وغيرها، لذلك نلاحظ أن عدد القادمين منها في تناقص متسارع، خصوصاً بعدما أصبحت الدراسة مدفوعة وعدم إعطاء منحة دراسية للطلاب الأجانب.

9 - الشهادات الصادرة عن جامعات الدول العربية:

تمنح أغلب الجامعات في الدول العربية شهادات بكالوريوس في الهندسة مدتها خمس سنوات، وهناك جامعات أخرى في مصر والعراق ولبنان تمنح شهادة مدة دراستها أربع سنوات أو أقل. وبالتالي فإن لجنة مزاولة مهنة الهندسة تترعرع بشهادات صادرة عن بعض الجامعات الوردة على لائحة الجامعات المعتمدة، شرط أن تكون مدة دراستها خمسة سنوات أو بدرجة ماجستير... كما يفترض أن تكون الجامعة مقيولة من إتحاد المهندسين العرب. وفي السنوات الأخيرة إنشر التعليم الخاص إنتشاراً واسعاً في الدول العربية، مما أثار الشكوك والريبة في المستوى وفي شروط القبول والمحافظة على معايير الجودة. لذلك، فإن اللجنة، وأسوة بنظرتها إلى الجامعات داخل لبنان، لا تزال متسددة في قبول متخدين من جامعات خارج إطار لائحة الجامعات المعتمدة والتي تحوي معظم الجامعات الموجودة في عواصم الدول العربية والتي تتمتع بمصداقية وتاريخ طويل.

اقترحات حول بعض الحلول الممكن إعتمادها في قبول الجامعات:
التعليم العربي النمطية:
- إزالة هذا الواقع في التعليم نرى ضرورة:
  - إقفال المكاتب التجارية التي تروج للتعليم في خارج لبنان.
  - عدم جواز وضع إعلانات تسويقية وترويجية للجامعات.
  - حصر عدد الجامعات المعتمدة من خارج لبنان إلى أقصى حد.
  - عدم قبول المتخرجين إلا بدرجة ماجستير وما فوق.
  - الطلاب من الجامعات إعداد سجل عمليات موزع على السنوات مع عدد الأرصدة ودرجة النجاح.
  - الطلاب من السفارات اللبنانية في الخارج إحصاء عدد الطلاب المقيمين في كل دولة وتزويد أسمائهم إلى وزارة التربية والتعليم العالي.
  - قيام وفد علمي من الوزارة والنقابة بإجراء زيارات ميدانية علمية لمباشرة المؤسسات التعليمية للإطلاع على أوضاعها الأكاديمية ومختبراتها.
  - إلغاء الجامعات ومعاهد لبنان بإجراء تقييم ذاتي لأدائها.
  - مشاركة هيئة الأعتماد الهندسي الموتوقة CTI، ABET في بعض المؤسسات التعليمية للإطلاع على أوضاعها.
  - قائمة الحماة ومساهمة البحوث، كما أن البرامج التعليمية تلعب دوراً أساسياً في تخرج كفاءة علمية تستطيع تلبية حاجة.

- التعليم العلمي وسوق العمل:
  - يكثر الحديث في الآونة الأخيرة عن ربط التعليم بسوق العمل، ولكن لم يحدد أبداً بشكل واضح كيف يجب أن تؤثر. ولكن المركزي إن حجم الاقتصاد يجب دوراً كبيراً في تنمية سوق العمل، كما أن البرامج التعليمية تلعب دوراً أساسياً في تخرج كفاءة علمية تستطيع تلبية حاجة.
المجتمع وبالتالي حاجة سوق العمل... ولقد أثبتت تجارب الدول المتقدمة، أن تكون حجم الاقتصاد يستلزم تجاوزاً بالدولة الاستراتيجية من جهة، إلى الابتكار والإبداع من جهة أخرى. وإذا كان الطلب الاستراتيجي يبحث عن الابتكار والإبداع والاستثمار التمويلي، فإن الابتكار والإبداع لا يأتي من السماء بل هو نتيجة سياسة تربوية وبحثية تؤدي إلى إنشاء البشر وتوصيف أفكار المعرفة فيه، فالبحث هو الذي يوضع مجالات الإبداع يؤدي إلى الإبتكار...

من هنا فإن تكون حجم الاقتصاد يحتاج إلى البحث العلمي، وهنا دور المؤسسات التعليمية. فكلما كبر حجم الاقتصاد كما زادت فرص العمل وتوسع السوق! ولعلني لا أبالغ إن قلت: إن المحرك الأساسي للاقتصاد ومعه سوق العمل هو في القطاعات الإنتاجية المرتبطة بتطور التكنولوجيا وخصوصاً الصناعة، فهي الأقفر على خلق وظائف جديدة وتأمين معدات نمو مقبلة (الصين، اليابان، إسرائيل، مالزيا، ...). وعندما نتكلم عن الدول التي تستوعب الكوارد العلمية، يتتبادر إلى ذهننا فوراً تلك الدول الصناعية الهامة التي تمسك بزمام الاقتصاد العالمي (الصين، الولايات المتحدة، فرنسا وخرى)، وقد وقفت الأفريقي الأقرب من خبر في أن لبنان لابد منه وضعاً حاكي لا يشبهه فيه أحداً. فمن الاستقلال شكلت القوى العلمية والفنية (تجار، حرفيون وغيرهم) المركز يعتمد الاقتصاد اللبناني على طريق الأسعار التي يرسلها هؤلاء المغتربين من الخارج، حتى إن بعض النهوضة العرقلية والاقتصادية التي شهدتها لبنان قبل الحرب وفي السنوات الأخيرة لحق الفضل فيها إلى هؤلاء. فالخريجون اللبنانيون يطلبوا إعتمدا على الهجرة كحل معيشي لتثمين حياة كريمة.

واليوم، وفي غياب الإحصاء الدقيق عن فرص العمل، وإنكاش الاقتصاد اللبناني، أخذت الهجرة طابعاً أكثر حدة من ذي قبل، فخريجونا يطعون فوراً إلى العمل خارج لبنان، إن في الدول العربية أو في أوروبا وأميركا والتي يعتمد عليها عن المعرفة، حيث أصبحت اليد العاملة المهاجرة (لبنانيون، عرب، أسيويون وخرى، ...). هم الخزان الأساسي لملأ النقص في كلاهم (خصوصاً في مجالات الأبحاث العلمية المتقدمة، بعد أن بدأ مواطنهم يعرفون عن الإتحاد بالاختصاصات الطويلة الأمد أو المرة بنظرهم، إما للرفاية التي يعيشون فيها أو لأسباب أخرى (أطباء، مهندسون، إلخ...).

إزاى ذلك، فلا بد من طرح موضوع تفاعل البرامج التعليمية مع سوق العمل من وجهة نظر تتعلق بـ:

1 - تطوير البرامج التعليمية بما يتوافق مع سوق العمل.
2 - تكبير حجم الاقتصاد لتوسيع آفاق سوق العمل، وخلق وظائف جديدة عن طريق تشجيع البحوث العلمية لرفد الاقتصاد الوطني بفرص إنتاج وتطوير جديدة من جهة، وتطوير معارف الأساتذة بما يخدم العملية التعليمية من جهة أخرى.
3 - الإعداد الجامعي لكادرات التعليم الهندسي داخل وخارج لبنان وحصر هذه الطاقات.

من هنا كانت صرخة نقابة المهندسين في لبنان واعتراضاً على الترخيص العشوائي للجامعات الخاصة في لبنان وعلى أساس (6 و6 مكرر) أو على أساس إستثمار مادي، لا سيما منها تلك التي تدرس الهندسة أو التي تمنح درجات وتسميات شتى في حقول الهندسة دون توفر المستويات العلمية والفنية المطلوبة وبالتالي لا يسمح لمخرجيها بمراولة مهنة الهندسة في لبنان والتسجيل في النقابة. ومن المناسب أن نقرر أولاً، أن التعليم الهندسي والجامعي ليس في حد ذاته هدفاً من أهداف المجتمع ولكنه أحد الوسائل لتنمية الموارد البشرية اللازمة للتطوير والتقدم، وعليه فإن احتياجات المجتمع هي التي تحدد دور مؤسسات التعليم الهندسي وإعداد خريجها، ومستوى ونوع التعليم الذي يتم في هذه المؤسسات بهدف:

1 - إعداد وتدريب الكوادر المتخصصة اللازمة للعمل في قطاعات الإنماء والإنتاج والخدمات.
2 - تحقيق رغبة الطلبة (أوأولياء الأمور) في التعليم بغض النظر عن فرض العمل الهندسي البحت أو غيره.
3 - تحقيق مزيد من التنوع في التعليم الهندسي في الاتجاهات المختلفة:
   أ - تعليم تكنولوجي/تعليم تكنولوجيا مقدمة.
   ب - تعليم هندي عام/تعليم تخصصات دقيقة ومقدمة.
   ت - تعليم للسوق المحلي/تعليم للسوق العالمي.
   ج - درجات تحصيل فنية، علمية، عالية أو متوسطة إلخ.

إن التقييم الحالي للتخصصات الهندية سيعتاج لمراجعة من مؤسسات التعليم ومن نقابة المهندسين بالتعاون مع وزارة التعليم العالي.
وفيّد بدأت هذه المراجعة في بعض الدول المتقدمة، حيث تقوم جامعات عدد من الولايات المتحدة وبريطانيا بمنح درجة هندسة عامة ويجد خريجو هذا التخصص العام فرصة عمل في أعمال تحتاج إلى الحس الهندسي ومهارات فنية أخرى. وإذا رغب أحد خريجي "الهندسة العامة" في العمل في تخصص محدد فعليه الالتحاق بالدراسات العليا ليحصل على دبلوم في التخصص الذي يرغب فيه.

وهو نوع آخر من التخصصات الذي بدأ ينتشر، وهو الدرجة المزدوجة.

وهذا النوع من التعليم يحصل فيه الخريج على درجة في الهندسة ودرجة أخرى في الإدارة أو القانون أو غيرها.

لذلك، إننا نرى أنه على مؤسسات التعليم الهندسي أن تتعاون مع عالم العمل في مجال البحث عن التخصصات التي يحتاجها المجتمع وتقدمها له بدلاً من الماضي وراء ما يتصوره الطلبة أنه تخصص مطلوب.

وباستعراض للتحديات التي تواجه المتدربين من التعليم العالي يمكن استشراق توجهات تطوير البرامج التعليمية:

- أن العبور من التعليم العالي الهندسي وغير الهندسي إلى عالم العمل قد أصبح معقداً ويجد إلى مؤهلات إضافية.
- قدرة المؤسسات التعليمية على تقديم تعليم عالي نظري أو تطبيقي يسمح للمتدرب بالدخول إلى عالم العمل.
- بناء شخصية الطالب وتمكينه بالمعارف وتنمية عملية الإبداع في شخصية.
- فقدان وظائف قديمة واستحداث وظائف جديدة.
- زيادة متطلبات أرباب العمل للجهة الشروط المعرفية التي يرونها مناسبة لهم في ظل العرض المتواصل لحاملي الشهادات.
- إخفاق معدل الوظائف في القطاع الحكومي وزيادة عدد الوظائف في القطاع الخاص.
- زيادة معدل الوظائف في قطاع الخدمات وفي اقتصاديات المعرفة.
- زيادة الطلب على معارف إضافية في شهادة الدكتوراه، خصوصاً في مجالات المعلوماتية والاتصال.
11 - الإجراءات المساعدة للتعليم العالي:

لذلك، وتتلاقى البرامج التعليمية مع حاجات المجتمع وأصحاب العمل ينبغي حث هذا الأخير وتقديم الحوافز له (إجراءات قانونية، بواسطة جمعيات الخريجين، إعفاءات ضريبية...

إلى) للقيام بإجراءات مساعدة للتعليم العالي وهنا يكمن دور النقابة، مثلاً كأن:

1- أن يشارك بفعالية في العملية التعليمية عن طريق مشاركة أخصاصهم منظ في
تعليم مواد الاختصاص وفي المواد التي تتغير بشكل مستمر (مع الإشارة إلى أن
المعيار العالمي لـ% معدل أساتذة الساعة بالنسبة لأساتذة التفرغ هي 40% بالساعة. 60% نفرغ).

2- أن يزود التعليم العالي بالاحصائيات اللازمة ويتعاون معه للحصول على النتائج
المطلوبة.

3- أن يقدم التسهيلات اللازمة للطلاب للقيام بأعمال التدريب والتأهيل المهني.

4- أن يساهم في تمويل تجهيزات البحث العلم.

5- أن يعتبر التعليم العالي استثماراً مؤجلاً. ويساهم في بعض نشاطاته، خصوصاً بعد
تقنيات الموازنات الحكومية في التعليم.

6- أن يسمح ويساعد في الانتقال من العالم الأكاديمي إلى العالم المهني دون شروط
وعقيدات.

7- أن يقوم بتقديم خدمات توجيهية واستشارات مفيدة للطلاب.

12 - حصر الطاقات وتناول مجالات العمل:

هناك حاجة إلى التطرق لموضوع الكفاءات الهندسية في ضوء الوقائع والحقائق التالية:

- إحصاء كفاءاتنا وهذا متتوفر عن طريق نقاوة المهندس.
- تحديد حاجاتنا للسوق الوطنية في جميع قطاعات الهندسة، وللأسواق العربية والعالمية
و هذا صعب التحقق.
درس مشاكلنا القائمة والمستقبلية بأبعادها الحقيقية، في محاولة لإستخلاص العبر ورسم طريق المستقبل، ووضع خطة وطنية مستقبلية لتحديد أهداف التعليم العالي بشكل عام والتعليم الهندسي بشكل خاص.

هكذا خطة يجب أن تهدف إلى فتح آفاق جديدة في الاقتصاد وتنميتها وتكييفه بهدف خلق وظائف جديدة، يكون البحث العلمي أساساً فيها. وأننا نعترف سلفاً، بأن العمل شاق لعدم دقة المعلومات المتواجدة عن حاجات وسوق العمل، بسبب عدم توفر كامل الإحصاءات نتيجة النزعة الفردية في لبنان وأحياناً الحرص على كتمان المعلومات بحجة المحافظة على أسرار المهنة والعمل.

وهذه ما سماه لنا بالقول، أن الكفاءات الهندسية اللبنانية هي في معظمها وليدة المبادرات الفردية والدفوع الشخصي المتأنث أحياناً بظروف طارئة أو خارجية لا أثر للتخطيط أو التوجيه العام فيها.

إن لبنان يعاني في الواقع دوراً صعباً، فهو بلد نامي عليه أن يتصرف بحذر الراغب في المحافظة على أكبر قدر من كفاءاته لتنمية موارده الخاصة، وفي الوقت نفسه، هو بلد مُكثمت نسبةً يعتمد على تصدير الخدمات والكفاءات ويجد فيها مورداً طالما ساهم في دعم اقتصاده.

وبإعطاء صورة واضحة عن تطور عدد المهندسين المسجلين في نقابة المهندسين في بيروت، منذ تأسيسها نورد ما يلي:

<table>
<thead>
<tr>
<th>السنة</th>
<th>عدد المهندسين</th>
<th>سجل من كان مهندساً في حينه في لبنان</th>
</tr>
</thead>
<tbody>
<tr>
<td>1952</td>
<td>235</td>
<td></td>
</tr>
<tr>
<td>1962</td>
<td>1099</td>
<td></td>
</tr>
<tr>
<td>1972</td>
<td>3239</td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>5730</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>14226</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>26624</td>
<td></td>
</tr>
</tbody>
</table>

وفي العام 2003 سجل في النقابة 932 مهندساً بحيث أصبح عدد المهندسين المسجلين في نقابة المهندسين في بيروت لغاية نهاية العام 2003 / 27556 مهندساً وفقاً لـ نقابتي المهندسين في بيروت وطرابلس / 32814، فيما بلغ عدد الحاصلين على إذن مزاولة مهنة الهندسة في لبنان / 37000 مهندساً. مع الإشارة إلى أن عدد المهندسين المنتخرجين من جامعات في داخلي لبنان أصبح أضعاف عدد المنتخرجين من جامعات في خارجه.
وبعد مراجعة الجداول المتعلقة بالاختصاصات، يتبيّن أن الجذع الأساسي للجسم الهندسي، كان منذ البداية وما يزال قائمًا في حق الهندسة المدنية والهندسة المعمارية، حوالي 58%. 38% منهم في الهندسة المدنية و 20% منهم في المعمارية، وهم في تزايد مستمر. أما الكهربائيون والميكانيكيون، فيبلغون 30%， والزراعيون 7%， والباقي 5%， من اختصاصات مختلفة.

إن الجسم الهندسي في لبنان اليوم، يزيد عن / 37000 مهندسًا، ولا يزال ينمو المطرد يحتفظ بملامحه الأساسية التي رافقت نشأته، فالهندسة المدنية والعمارية لا تزال تستقطب معظم الخريجين، في حين أن تقدم الصناعة وغيرها منذ بداية السبعينات استطاعت أن تولد اختصاصات صناعية جديدة، وذلك ظاهرة طبيعية في كل المجتمعات لأن الصناعة حيث كانت تبقى المجال الأوسع والأرحب للمهندسين والتقنيين. ولكن في لبنان لا نزال نرى أن عدد الاختصاصات الصناعية محدودًا نظراً لضعف الصناعة نفسها.

إن عدد المهندسين في بعض الاختصاصات لم يبلغ حد التضخم، غير أن ذلك يفرض اليوم وقبل فوات الأوان توجيه طليانا إلى الاختصاصات التي ستحتاج إليها في المستقبل، وأن نحترمهم ليومن موافقًا على أن يكون لهم دور كبير حجم الاقتصاد وتعزيز البحث العلمي؟؟

إن الصناعة مدعوة اليوم إلى تحمل مسؤولياتها في هذا الصدد فهي المؤهلة للاستيعاب العدد الأكبر من المهندسين.

ولكن، عندما نتمعن في دراسة الإحصاءات المتعلقة بتطور عدد المهندسين وتوسيعهم على مختلف الاختصاصات نطرح السؤال على أنفسنا وهو: ماذا سيجل بالمهمة بعد بضع سنوات أو ما هو مصير الأجيال الفترية التي تتجه إلى اختصاصات كانت لسنوات خلت تعتبر قمة النجاح المهني والمادي.

ولعد إلى أوضاعنا نحو المهندسين، طبعاً إننا لا نجهل أن مهنتنا ليست الوحيدة المزدحمة وأن هذا لوضع مشابه في جميع المهن الحرة وفي بعض القطاعات الأخرى، ومواجهته تقضي بعُني هذه المشكلة على أعلى المستويات، وأنه بدون إحصاءات صحيحة وقليل من التصميم والتوجيه لتدارك هذا الواقع، يُخشى أن تبقى جميع الجهود مجرد أمنيات، فينتج عنها هجارة كثيفة للأمغة، وبما أن المتأخرين هم دائمًا الذين يرحلون فقط هذه الظاهرة الأخيرة أشد خطرًا لأنها تؤدي بطبيعية الحال إلى هبوط للمؤهلات والمستوى.
13 - فرص العمل الهندسي في لبنان:

إن فرص العمل لدى المهندسين تتحصى في ثلاثة:

أ – القطاع العام:

إن معيار تطور القطاع العام في الدول المتقدمة هو بنسبة ما يضم هذا القطاع من الكادرات العلمية والتقنية، ومعه نرى أنه في لبنان ينفرد هذا القطاع حالياً حسب الكادرات الملحوظة له في السبعينات، من نقص في عدد المهندسين يقدر بحوالي 6000 مهندس. مركز، وفيما لو اعتمد التطور بولوج المكتن لعماله فسينتج عن ذلك أوسع الفرص لمشاركة المهندسين الأحصائيين في هذا المجال، يضاف إليها فرص العمل التي يمكن أن تؤمنها البلديات بما لو قررت وسمح لها بالاستعانة بالمهندسين لتقديم المساعدة بالتخطيط ومواجهة تطهير الأعمال العمائية والإحصائية والبيئية. وإننا نأمل أن يتتطور ويشتهر هذا القطاع في شتى مجالاته ومستقبل الدورة الاقتصادية حياتها وكامل نشاطها.

يبقى أنه على الدولة أن تعمل على إقرار وفرض الإلزامية اعتماد المواصفات الفنية، خاصة تلك المتعلقة بأعمال البناء التي أعدتها النقابة وأحالتها إلى مؤسسة المقاييس والمواصفات اللبنانية لإقرارها بحريتنا بأجراً سابقاً تباعياً. ونأمل أن تحمي غيرها من الهيئات لا سيما الصناعية منها إلى المبادرة لوضع المواصفات اللازمة، يقيناً بما سينتج عن ذلك من فرص للعمل أمام المهندسين اللبنانيين.

ب – القطاع الخاص:

لا يزال قطاع البناء يمتص العدد الأكبر من المهندسين وهو مستمر على معدالتها في السنوات الأخيرة، وإعطاء فكرة عن ما بلغه العمل في القطاع الخاص نذكر هنا بعض الإحصائيات المتعلقة بالبناء المدنى والممارسة:

المساحة المخصصة: متر مربع (المراجع نقابة المهندسين)

<table>
<thead>
<tr>
<th>السنة</th>
<th>المساحة المخصصة (المتر مربع)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>4,243.393</td>
</tr>
<tr>
<td>1965</td>
<td>3,944.653</td>
</tr>
<tr>
<td>1966</td>
<td>4,600.450</td>
</tr>
<tr>
<td>1997</td>
<td>9,660.691</td>
</tr>
<tr>
<td>1998</td>
<td>8,168.737</td>
</tr>
<tr>
<td>1999</td>
<td>6,905.620</td>
</tr>
<tr>
<td>2000</td>
<td>5,481.101</td>
</tr>
</tbody>
</table>
كان عدد المهندسين في النصف الأول من الستينات يقارب 1500 مهندسًا 50% منهم يعملون في القطاع العام، وتوزع حجم هذه الأعمال في حينه على شريحة لا تتجاوز نصفهم، فيما نرى اليوم أن نسبة المساحات المخصصة السنوية زادت بنسبة حوالى 30% فيما تضاعف عدد المهندسين العاملين في هذا القطاع بما يفوق 25 ضعفًا.

أما في القطاع الصناعي وفي القطاعات الأخرى يبقى هناك قصور كبير بالاستعана بالمهندسين الإختصاصيين، نأمل أن يزول رؤيا مع تفهم أصحاب العلاقة مصلحتهم واحتياجاتهم في طلب خدمات المهندسين في حقول كثيرة، دراسة وتتشنداً، لا سيما في حال تم إعداد وإقرار إلزامية تطبيق المواصفات الفنية والإشراف على الأعمال الصناعية والإنجاهية.

أما في القطاع الزراعي، فالوضع أصعب في ضوء معاناة هذا القطاع أن لجئة الإنتاج أو لجنة التصويت. وهنا تكمن مسؤولية الدولة في دعم هذا القطاع وتزويده بالخبرات الهندسية خصوصاً لجدة التصنيع الزراعي.

يقين إنه لا يتوفر لدينا أية إحصائيات عن هذه القطاعات تسمح لنا بتحديد حاجياتها حاضراً ومستقبلاً، خصوصاً في ضوء الواقع الاقتصادي وحجم الدين العام وضعف القطاع الصناعي وعدم وجود أسواق خارجية له.

من هنا، يجب التركيز على تكبير حجم الاقتصاد، وزيادة البحث العلمي الصناعي، ومساعدة القطاع الصناعي خصوصاً صناعة التكنولوجيا المتقدمة أو بما يعرف بـ"اقتصاد المعرفة"، وهذا يحتاج إلى جهد كبير وخبرات فنية وتخطيطية عالية.

**ج - العالم العربي والعالم الثالث:**

إن الهجرة هي إحدى مجالات العمل الواسعة والمفيدة، خصوصاً إذا كانت أخلاقياً مهنيةً موقتاً يعزز الروابط ويتيح فرص العمل الجديدة أمام الكثيرين؛ وهذا ما شهدناه بأوساط صورة مع البلاد العربية وقسم من البلاد الأفريقية. وهذه التجارة يجب أن نوليها عناية خاصة ونخطط لها تخطيطاً سليماً ينسجم مع التطور الكبير الذي بلغته بلاد الاغتراب تلك.
وقد عرف هذا السوق الماضي ازدهارًا وفقرة هائلة امتصت على أثرها عدداً كبيراً من المهندسين اللبنانيين ولا يزال لغاية تاريخه مجالاً واسعاً نسبياً لعمل المهندسين اللبنانيين في شتى مجالات الاختصاصات.

بقي شيء هام لا بد أن نصارح أنفسنا به. إن لبنان الصغير بمساحة أرضه وعدد سكانه استطاع بطموج أهله أن يلعب دوراً هاماً في نهضة المنطقة. كثيراً حجمه الجغرافي والسكاني، ولكنه لا يستطيع أن يستمر في ذلك إذا لم يأخذ في الاعتبار الحقائق التالية:

إن الحصول على الثروات بطريقة السهلة والسريعة والعشوائية السابقة لم يعد ممكن، إن النجاح في المستقبل رهن بالجهد المبذول والمستوى والخبرة المناسبة، ويبقى أن المال ليس وحده المعيار الوحيد للنجاح.

فالعلم لم يعد وقفاً على أحد أو بلد أو منطقة. الجميع يتعلمون ويهينون كواحدهم للمستقبل. وإذا أراد لبنان الاستمرار في التوهج، وجب عليه التغيير بال نوعية والسبق. نسبي الآخرين ولكن نساعدهم ونتمثّل لهم الخبر والتقدم في الوقت نفسه. ويبقى المجال مفتوحاً أمام الطليعة، المهم أن تكون منها، وإذا تخلّى لبنان عن الطليعة وقع في الرتابة والسطحة وتصبح دوره بحجم أرضه وعدس سكانه. نأمل أن نبقى ونستمر في الطليعة وأن نعمل في إطار الوصول إلى اقتصاد مبني على عالم المعرفة والتكنولوجيا المتقدمة.

د - تفاعل البرامج التعليمية وسوق العمل:

تعتبر البرامج التعليمية إحدى العناصر الرئيسية للعملية التربوية، ينبغي تحديثها باستمرار وتطويرها لتساعد في تحقيق جودة التعليم من جهة ولتنطلق مع عالم العمل وتلبية حاجات المجتمع من جهة أخرى.

لقد عكست البرامج التعليمية وفي جميع الأزمنة، حالة المجتمع وأوضاعه الاقتصادية ومدى التقدم العلمي الحاصل على مستوى العصر. فمثلًا، مع بدء الثورة الصناعية جرى تحديد البرنامج التعليمية لتسير الانتاج والتطويرات الجديدة، وفي الستينات، عكست البرامج حالة الصراع على الفضاء والخيار البائدة بين الجبهات=l組مة المحددة والاتحاد السوفيتي وجاءت لتسير الانتاج والتفاعل في الرياضيات والفيزياء وغيرها من العلوم. ثمّ مع بداية القرن الواحد
والعشرون أجمع الاقتصاديون في الشأن التربوي في الجامعات والمدارس على ضرورة أن تتبي

برنامج التعليم التقدم الحاصل في تكنولوجيا المعلومات والاتصال، كما أن عقلية الاقتصاد
والحركة الاقتصادي للشركات الكبرى والصغيرة، وتقدم المجتمع على صعيد الإنتاج والاستهلاك،
وتتركز على قدرة الطالب على استنباط وتوليد المعرفة ويزعج ما يسمى اقتصاد المعرفة إلح
ضاعف من الجادة إلى أيادي عاملة ماهرة ومؤهلة إلى اختصاصيين جدد يتميزون بقدرة كبيرة
على استخدام التقنيات الجديدة والتفاعل معها.

من هنا، كان على التعليم العالي أن يباشر بتطوير مناهجه التعليمية، وأن ينتقل من-

نقل المعرفة إلى عملية استحداث المعرفة (تونسية مؤسس هافانا حول التعليم العالي
اليونسكو) وأن يتخذ موقفاً استباقياً إزاء عالم العمل عن طريق تحليل مجالات وأشكال العمل
الناشئة والتبني بها والاستعداد لها وأن يؤمن عملية التدريب والتأهيل المستمر للعاملين.

وفي الواقع الحالي للبرامج التعليمية، نلاحظ أنه لا يكفي أن تكون مناهج التعليم
العالي متطورة نتؤمن تعليماً جيداً وتحقيق جودة التعليم، فأغلب مؤسسات التعليم العالي
الجديدة في لبنان وفي العالم العربي تستحوذ برامجها من برامج مؤسسات تعليم عال عرفة
داخل لبنان وخارجها، بل أن بعضها يستنبط برامجه بشكل كلي أو جزئي عن برامج التعليم
الموجودة على شبكة الإنترنت أو تلك المتوافرة في دليل بعض الجامعات المعروفة، بل الأهم
من ذلك يكمن في توفير أساتذة كفؤين يمكنهم من تلقين هذه البرامج إلى الطلاب، وإلى قدرة
هؤلاء الأساتذة على توفير مستلزمات البرامج التعليمية من برامج التدريب وأعمال تطبيقية
مخبرية وتجهيزات مساعدة (mutex ووازن إيضاحية وغير ذلك) وطرق تقييم، وكيفية وضع
أسنلة مناسبة وإجراء امتحانات نزيهة وغير ذلك، جميعها أمور أساسية تتعلق بكفاءة الأساتذة
ومدى تعمقهم بالمعلومات بهم تدريسهم وهبهم في مجال التعليم. فالخبرة الأكاديمية
لالأستاذ وقدرته على التأهيل المستمر والبحث ومدى تفرغه لعملية التعليم هي من الأمور
المهمة المواكبة لعملية تطوير البرنامج.

14- تطوير البرامج التعليمية وغابتها:

إزاء الواقع الجديد الذي فرضه عالم العمل، وتلبية لتوصية اليونسكو في تحقيق موافقة
التعليم العالي، يجب تطوير برامج التعليم العالي بالإرترك على رسالة الجامعة (الكلية أو
المعهد) ومهامها لتزوي مطلبات عالم العمل والتقدم الحاصل في المجتمع وفقاً لقوى تقوم على:
1 - تحديد السياسات العامة للبرامج التعليمية:

مثلًا، تحديد التوجهات العامة للبرامج التعليمية كما يلي:

1 - أن تؤهل المتخرج على القدرة على مواجهة المشاكل وحلها.
2 - أن تكون نظرية أو تطبيقية، علمية وعملية... تعزز حاجات السوق والمجتمع.
3 - أن تؤهل المتخرج للحصول على المعرفة المتعددة المصادر والجوانب المختلفة.
4 - أن تسمح للطالب في المساهمة في عملية الإفتراض والإبداع.
5 - أن تسمح للطالب بمتابعة تعليمه وتأهيله طوال حياته.
6 - أن تزود الطالب بالإحساس بالمسؤولية، والشخصية المنوية المستقلة، وتمي فيه قدرة العمل مع آخرين كفريق عمل.
7 - أن تكون مرنة بحيث يتم تعديلها بسهولة ويسر وأن تكون تكاملية في الاتجاهين مع التعليم العالي والتعليم العام، وتسهم بما يسمى بالحركة الأكاديمية.

2 - تحديد السياسات الخاصة للمواد التعليمية:

وهي عبارة عن التوصيات والمعايير التي يجب أن تخضع لها كل مادة تعليمية، مثلًا:

1 - أن تكون المادة نظرية، تطبيقية أو عملية أو نسبة معينة من ذلك.
2 - أن تتكامل عمليًا مع المواد الأخرى في الأعلى أو في الأسفل، أو ألقاها مع المواد في نفس المرحلة.
3 - أن تقدم للطالب مؤهلات إضافية وتساعده على ابتكار معارف جديدة، وتروده بالخبرات اللازمة.
4 - أن تتفاوت مع التطور الحالي في كل موضوع لكل مادة.
5 - أن تلبية حاجة سوق العمل إليها، فتكسب الطالب أحدث ما توصلت إليه التقنيات الجديدة.
6 - إلخ.

3 - تحديد الأهداف الكبرى والصغرى للبرامج التعليمية:

وهي عبارة عن مجموعة الأهداف التعليمية العامة التي ينبغي أن يوفرها المناهج التعليمي في كل حقل وفي كل مرحلة، والأهداف الخاصة لكل مادة، يلي ذلك:

- تحديد البرنامج الزمني التدريس للأهداف.

4 - تحديد الحقول التعليمية:
عبارة عن الحقول أو المجالات المعرفية التي تنتمي إليها المجموعات الإنسانية من المعارف والمهارات التي ينبغي تزويدها للطالب في كل مرحلة أو فصل وفقًا للأهداف الموضوعة.

5 - تحديد البرنامج الزمني التسلسلي للأهداف، وجميع الأهداف المتصلة مع بعضها في وحدات تعليمية مع تحديد المدة الأزمة لتعليم البرنامج: عدد الحصص، مدة الحصة، عدد الأسابيع.

6 - تحديد وحدات التعليم.

7 - تحديد الدروس والангحص والنشاطات التعليمية وطرق التقييم والوصول إلى الأهداف.

8 - تحديد عدد الأجردة وتوزيعها على المقررات والفصول والسنوات، بما فيها الأرصدة التطبيقية والنظرية.

15 - ضمان جودة التعليم العالمي الهندسي:

نظراً لتنوع النظم الأكاديمية وتتنوع الاختصاصات ومستويات التعليم والهيئات الأساسية والبيئة الأكاديمية. وتتفاوت سياسة الأونيسكو من جعل التعليم العالي في متناول الجميع وتسهيل الحركات الأكاديمية والحريات والاستقلالية للجامعات، أصبح مفهوم تحقق الجودة في التعليم أساسياً، يؤكد عليه المنظمة الدولية لضمان مؤهلات المخرجين وتوزيعهم بال المعارف والمهارات اللازمة.

وقد تناول "دونالد إيكونغ" مفهوم ضمان الجودة معرفاً به على الشكل التالي: "كل السياسات والنظم والعمليات، تؤجر نحو ضمان المحافظة على جودة منتجات التعليم المقدمة من المؤسسة وتحسينها، ونظام ضمان الجودة هو وسيلة تستخدمها المؤسسة لتؤكد نفسها وللآخرين إن الظروف قد تقلب كي يبلغ الطلاب المستويات القياسية التي حددها المؤسسة لنفسها".

ولا يمكن فصل الجودة عن "الملاءمة"، فديمقراطية التعليم وجعله متاحًا للجميع يفترض التفاعل مع سوق العمل وضخ كوادر مؤهلة قادرة على المناقشة والمسمى في وجه المتغيرات
تشمل الأمور الاقتصادية التي تواجهها الدول، وتتأثر العولمة وانفتاح الدول، لتجعل من ضمان الجودة هما رئيسيًّا لكل مؤسسة ترى من واجباتها تقديم أفضل المعارف وتزويد الطلاب بالمهارات اللازمة لمجأرة العصر.

ولضمان الجودة ينبغي على مؤسسات التعليم العالي أن تعمل على:

- ضمان جودة مستوى العاملين والأساتذة، فالعاملين في مؤسسات التعليم العالي وأساتذتها، يجب أن يتمتعوا بمهارات ومستويات رفيعة تجعلهم قادرين على مواجهة مشاكل سوق العمل، والبحث العلمي والتطور الذاتي، إضافة إلى تمتعهم بمتطلبات وقيم أخلاقية رفيعة.

- إلى جانب مهارات العاملين من أساتذة وموظفي، يجب على المؤسسات أن تؤمن مكانة إجتماعية ومالية لاذقة للمؤسسات، ليسوها للبحث العلمي وإعطاء كل ما يعرفه من مهارات إلى تلامذتهم. كما يجب وضع حافز وبني تشجع الباحثين على العمل متظاهرين ضمن فرق مُستخدمة الاختصاصات تعتني بمشاريع بحثية، تدرس الموضوع من جوانب سِتٌ، وتحاول على جميع مطلوبين المتطلب وقيم البشري.

- ويجب على مؤسسات التعليم العالي أن تعالج مشكلة الحراك الأكاديمي وتفرض شروطاً ومعايرة مشبعة (إمتحانات، إعتراف، معايير وغيرها ...) للانشغال إلى التعليم، مع الحرص على جعل التعليم متاحاً للجميع، ضمن مقدرات ومؤهلات كل شخص.

- كما يجب على المؤسسات وبواسطة الأساتذة، أن تعلم على تحديد مناهجها لجعلها تلتزام مع التطورات التكنولوجية المعاصرة ومع احتياجات المجتمع وسوق العمل. وهذا يعني أن جودة البرامج والمناهج تعتبر جزءاً لا يتجزء من جودة العاملين والمدرسين في التعليم العالي، وهذه الجودة تركز على جودة الأهداف الموضوعة في التعليم والتي يجب أن تقترب جودة الأساليب التربوية المرزتزة على أحد ما توصلت إليها التكنولوجيات المعاصرة. وفي إطار البروز المتزايد للطابع الدولي للبرامج، يتعين على التعليم العالي أن يعيد النظر في أنماط تنظيم برامجه، لا بصورة منعزلة، بل في علاقته مع المؤسسات الأخرى ومع مراعاة الإفصاح المتزايد على عملية التدريس مدى الحياة.

وتربط موضوع الجودة بشكل كبير بمستوى جودة الطلاب ومدى تأهيلهم في المراحل الثانوية، وهنا يجب التأكيد على تعديل وتوسيع المناهج التربوية في المراحل الثانوية بما يلتزم مع
الاختصاصات الجديدة في التعليم العالي ومطلبات العصر الجديد، مع التشديد على التشاور المستمر بين مراحل التعليم ما قبل الجامعي والتعليم الجامعي.

كما أن جودة التعليم يرتبط على جودة مستوى البنية الأساسية والبيئة الداخلية والخارجية للتعليم العالي، أن جودة التدريس والبحث يفترض توفير بيئة أساسية مادية كافية وتجهيزات ومواصلات، ومشاريع تحفيز المشاريع، وطالما كان التفاعل كبيراً مع العالم المعمل طالما توفرت الظروف للخلق والإبداع وتخرج جامعيين مزودين بمهارات واسعة. وما لا شك فيه أن البناء الخارجي للجامعة له دور نفسي على العامين داخله، حيث يشعر الجميع بانتمائهم إلى مؤسسة قوية وفاعلة لا ينقصها التجهيزات والتكنولوجيات الحديثة.

يبقى أن ضمان الجودة يرتبط على تنظيم عملية التقييم والتصحيح، وضع شروط ومعايير واضحة ومحددة للتأهيل المسبق والمستمر والدائم، من مراجعة النتائج والبحث عن أسباب الخلل القائم بهدف تحسين الأنشطة والنتائج والقيام بالعمليات تقييم ذاتي للمؤسسات التعليمية تحدد مواقع الخلل في الأداء والصعوبات التي تعترضه.

كما تفترض جودة التعليم العلمي المحافظة على الاستقلال الذاتي للمؤسسات التعليمية والمسؤولية الذاتية، والمعنى للأستاذة والإدارة والعاملين فيها، والخضوع للمسألة بهدف تحسين الأداء.

وبالرغم من أهمية ضمان "الجودة" فإن آلية تحقيقها تبقى شكلية ونظرية إلى حد بعيد ومن الصعب الالتفاعل منها خصوصاً في غياب الهيئات الرقابية المستقلة سياسياً وأكاديمياً، وفي غياب هيئات الاعتماد المشهود لها بنزاهتها واستقلالها دولياً (كالهيئة الأمريكية CTI، والفرنسية ECPD وغيرها).

كما أن موضوع إدارة التعليم العالي وإبعاده عن مفهوم الاستثمار وإيجاد آلية للتنقيم الذاتي والخارجي هي من الأمور التي يجب وضع حلول لها في إطار تحسين الجودة ورفع مستوى الأداء؛ والامتناع عن "إتباع سياسة جذب الطلاب وإغراقهم".

من هنا، يجب إحداث نظام وطني لإدارة الجودة بالتعاون مع الهيئات الدولية المشهود لها والتي تنظر في عناصر الجودة الرئيسية والمتصلة بـ الإدارة الجامعية، تمويل
التعليم، الخطة الدراسية والبرامج، أنظمة القبول والترقيع، محاسبة الهيئة التعليمية وتحسين أدائها، تأمين البيئة الجيدة لتعزيز البحث العلمي وتثبيته، تحقيق جودة البرامج التعليمية وربطها ببحاجات السوق، تأمين مستوى عالٍ من المختبرات والتجهيزات والمكتبات، وغير ذلك من الأمور.

من هنا فأن كل عنصر من عناصر الجودة يحتاج إلى دراسة وإلى آليّة لتحسينه وتطويره وإلى خبرات تربوية وإدارية طويلة.

وفي هذا الإطار يعتبر "التمويل" أساسياً، حيث بدأت تعاني منه مؤسسات التعليم العالي خصوصاً بعد تقلص الميزانيات الحكومية المخصصة للفترة من جهة وإرتفاع كلفته من جهة أخرى، مما جعل التعليم الهندسي يعاني من مشكلة جبن طلاب كفاء ذو قدرات عالية (مثلما كلفة طالب هندي في الجامعة الأمريكية في بيروت حوالي 16 ألف دولار، بينما تعاني الجامعة اللبنانية من ضعف الميزانية الحكومية المخصصة فقط للرواتب والأجور ...). وهذا ما دفع بعض المؤسسات الجديّة عن البحث عن الطلاب في إطار إعلانات ودعائيّة، لجذب الطلاب مع ما يترافق ذلك من تخفيف الشروط الواجب على الطلاب الحصول عليها للانضمام إلى التعليم الهندسي وغيره. وفي موضوع الأساتذة، فإن عملية اختيار الأساتذة وتطوير مؤهلاتهم وفاءهم، والتحقق من جودة مُخرجاتهم وأهليتهم في العملية التعليمية، هي إلى حد بعيد صعبة ومهمة في أن معاً، كما أن تلقين الأعمال التطبيقية والخبرية على أيدي أساتذة مهارة يعتبر في غاية الأهمية، مع ما يترافق ذلك من وضع آليّة جديدة للتقييم وإختبار للمعرفة والمؤهلات النظرية والتطبيقية وكيفية إختبار الأسئلة الامتحانات وطرق التدريس والثقة هي من الأمور التي يجب العمل عليها.

ومما لا شك فيه أن البرامج التعليمية وللبحث العلمي الدور الأساسي في تحسين جودة التعليم وتأمين التأهيل المستمر للأساتذة وطلاب معاً، وفي ربط التعليم بالمجتمع وسوق العمل.

- تطوير البحث العلمي ينطلق لتتوسيع حجم الاقتصاد وفتح أفاق جديدة في مجال سوق العمل.
البحث العلمي عبارة عن "الأعمال الإبداعية" التي تركز على المعارف المختلفة.

ويمكن تصنيف البحوث العلمية بشكل عام، كما يلي:

1 - بحوث ودراسات استراتيجية: بحوث سياسية، حقوقية، اقتصادية يستفاد منها في مراكز القرار وإدارات الدولة والحكومة والمؤسسات الاقتصادية... إلخ.

2 - بحوث نظرية في الأدب والآداب والفنون: بحوث في الأدب، اللغة، الشعر، الموسيقى، إلخ، وليس لها تطبيقات عملية ولا تخضع لمعايير الجودة الاقتصادية.

3 - بحوث علمية تطبيقية: مثلاً: بحوث في الطب والهندسة والتكنولوجيا إلخ.

4 - بحوث نظرية علمية في العلوم البحثية: رياضيات، فيزياء، كيمياء لا تجد لها تطبيقات مباشرة بل يستفاد منها في مجالات أخرى.

5 - إلخ.

هذه البحوث تشكل وحدة متكاملة تساهم جميعها في رفع المستوى الفني والإبداعي للمواطن بحيث يكون للموسيقى والأدب والفنون دوراً مبايناً لدور البحوث التكنولوجية والعلمية وغيرها.

وسنعرض لواقع البحث العلمي وكيفية تطويره من خلال بعض المؤشرات الاقتصادية والإحصائية.

أ - بيئة البحث العلمي:

1. البحث العلمي، يجب إيجاد بيئة بحثية ملائمة تقوم على مجموعة من الركائز.

أهميتها:

1. وجود الباحث وراحته، وحريته وتكافؤه الذاتي، واعتبار البحث رسالة وليس هدفاً مادياً: ينتشر الباحثون اللبنانيون والعرب في مراكز البحوث المتقدمة خارج بلدانهم، ويبرأ الكثيرون منهم مراكز مقدمة فيها، ولو نظرنا إلى المختبرات الواقعة في جامعات الدول المتقدمة (فرنسا، بريطانيا، الولايات المتحدة وغيرها) لوجدنا أن عدد الباحثين الأجانب (لبنانيون، عرب، آسيويون، أفارقة...) يفوق الباحثين من أصل البلد، ليس من أجل الحصول على درجة علمية عالية فقط (دكتوراه أو غيرها) بل كباحثين متخصصين داخل هذه المختبرات. فالباحث موجود، ومدعي خارج وطنه، يجب إيجاد الحوافز الضرورية لعودة هذه الأدمغة إلى بلدانهم ومنها لبنان.

2 - بيئة البحث العلمي:

1. البحث العلمي، يجب إيجاد بيئة بحثية ملائمة تقوم على مجموعة من الركائز.

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وفي المقابل يغلب على البحث داخل الجامعات العربية طابع البحوث النظرية (آداب، إنسانيات) يقوم بها الباحثون بهدف الحصول على ترقيات أكاديمية وليس ضمن خطة بحثية إمنانية تهدف إلى تطوير اقتصاديات البلد ومراكز الإنتاج فيه.

كما يشكو الباحثون داخل الجامعات في لبنان وفي بعض الدول العربية من تغيبهم عن مراكز القرار الاقتصادي والسياسي وعدم استماعهم وطلب المشورة منهم في أي موضوع له علاقة بالقطاع العام أو الخاص على السواء.

ب - وجود خطة وطنية لتطوير البحث العلمي وتنشيطه:

من الملاحظ أنه لا توجد لدى أية دولة عربية ومنها لبنان، أية خطة وطنية لتنشيط البحث العلمي على غرار الدول المتقدمة. هذا خطة يجب أن تطالب الباحثين وحيرة الأدمغة، كما يجب أن تطالب وسائل تغذية البحث وتنشيطه وتزويدوها بالموارد والتجهيزات الفنية والتقنية والمشورة القانونية اللازمة، وفتح الأسواق أمام المنتجات الوطنية والتنسيق بين مراكز البحث العربية والدولية وجامعاتها.

وعلى سبيل المثال، نشير إلى خطة وطنية لتنشيط البحث العلمي والتطوير في إسرائيل، ووضعتها لجنة استشارية مؤلفة من 1300 باحث إسرائيلي في مجالات مختلفة، أعدت خطة عمل مؤلفة من 450 نموذجاً. من بنودها إعادة الباحثين اليهود والمهندسين المبدعين إلى إسرائيل، تعديل البرامج والمناهج لمدارس الجامعات وتوجيهها لتخصص في مصلحة الخطة (تنشيط تعليم الرياضيات والفيزياء والمعلوماتية وغير ذلك). إطلاق مشروع "المختبر الإلكتروني" الذي تقوم على دعوة كل من لديه فكرة إلى تشكيل فريق عمل لوضع فكرته موضع التنفيذ وتأمين المساعدات المالية والمشورة القانونية لإجراء البحوث والدراسات بهدف تطوير فكرته وتحويلها إلى سلعة صالحة للإنتاج ومن ثم تمويل دراسات الجدوى وتقديم المساعدة للمبادرات في عملية الإنتاج والتسويق إلخ.

أما في اليابان وماليزيا فهناك لكل خمس سنوات خطة بحثية.

3 - تمويل البحث العلمي:

المجال هو العصب الرئيسي للبحث العلمي. فلا بحث من دون تمويل، والتمويل يجب إعتباره استثماراً إيجابياً والتمويل يرتبط بالوضع الاقتصادي للبلد ومعدلات النمو فيه. أما مصادر التمويل فهي:
- حكومية:

من الملاحظ أن التمويل الحكومي للبحث العلمي يشكل نسبة ضئيلة جداً من التمويل العام للبحث في الدول المتقدمة، فهو لا يتجاوز 8-10% في اليابان والولايات المتحدة والسعود. و11.8% في إسرائيل، وأقل من 20% في ماليزيا وفي بعض الدول الصناعية الأوروبية.

بينما يشكل التمويل الحكومي للبحث العلمي والتعليم العالي حوالي 82% من إجمالي التمويل للبحوث في الدول العربية. وتبلغ قيمة التمويل الحكومي للبحوث في لبنان 7 مليارات ليرة (هيئة البحث العلمية وльцنة ليرة لبنانية هي ميزانية البحث في الجامعة اللبنانية.

ويبلغ إجمالي ما تتفقه الدول العربية (تمويل حكومي) على البحث العلمي 0.9 مليار دولار، وتصدر الكويت والإمارات العربية قائمة الدول العربية من حيث الإنفاق على البحوث، بينما تتفق إسرائيل لحدها حوالي 4 مليارات دولار (2 مليار دولار بحث مدني ومعدل 2 مليار دولار للبحث العسكري). كما تتفق اليابان 28 مليار دولار في السنة الواحدة حوالي 2.8% من دخلها القومي ((1995÷2000) أنتفقت اليابان 140 مليار دولار على الأبحاث العلمية). كما نلاحظ ضعف الإنفاق الحكومي على البحث العلمي داخل الجامعات في لبنان، فهو لا يزيد عن 2% من ميزانية التعليم العالي والباقي 98% رواتب وأجور في الجامعة اللبنانية. بينما في المقابل، تبلغ نسبة ما تتفقه الحكومة على البحث العلمي داخل الجامعات في إسرائيل حوالي 30.6 %، والإفوق الحكومي الباقي 69.4% يتم على عملية التعليم بعد ذاتها، من رواتب وأجور وصيانة مبان وتجهيزات وغير ذلك. (مع الإشارة إلى أن حجم الإنفاق الحكومي على التعليم العالي في إسرائيل يبلغ حدود 1650 مليون شاقل سنة 1998 و2000 مليون شاقل سنة 2002).

-قطاع الأعمال:

هو المحرز والممول الرئيسي للأبحاث داخل الدول المتقدمة، ويبلغ معدل مساهمته في تمويل البحث العلمي، حوالي 52.7% في إسرائيل والولايات المتحدة، 82% في اليابان و70% في ماليزيا، بينما تبلغ نسبة تمويل القطاع الخاص للبحوث العلمية في الدول العربية نسبة ضئيلة للغاية لا تتجاوز 3-8% في أغلب الدول العربية، وهي صفر في لبنان.
وتعتبر الصناعة الممول الأكبر للبحوث العلمية في الدول المتقدمة بنسبة تؤتي 52±70% من إجمالي التمويل، مما يشير إلى العلاقة الوثيقة بين الصناعة وقطاع الأعمال والبحوث العلمية إن لجنة الاستثمار في البحوث أو لجنة الأرباح التي يبنيها القطاع الخاص من وراء البحوث والتطوير.

فمثلًا، تبلغ قيمة الصادرات الصناعية في إسرائيل حوالي 90 مليار دولار، بينما تبلغ قيمة الصادرات في قطاع التكنولوجيا المتقدمة فقط، حوالي 8 مليارات دولار لسنة 1998. أما في مالزيا فإن نسبة 54% من إجمالي صادراتها هي صناعات تكنولوجيا عالية، ولا تكتفي بعض الدول بإنتاج مؤسستها المنتج، بل تقوم بعدد اتفاقيات تمويل وشراء أبحاث من جامعات في دول مختلفة (مثلًا: تسعى بعض الجامعات الفرنسية لجذب طلاب لبنانيين لدراسة الدكتوراه فيها وقد قام موفدون لزيارتنا لهذه الغاية، كما تقوم إسرائيل بعدد صحفات أبحاث مع جامعات دول أوروبا الشرقية وتحديداً بلغاريا، بولونيا، المجر مما إنعكس إيجاباً على تقدم جامعات تلك الدول).

<table>
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<tr>
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<th>الإنفاق على البحوث والتطوير % من إجمالي الناتج القومي</th>
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الجدول رقم 1: أ исполни تمويل البحوث والتطوير في بعض الدول.

* وتركز على البحوث في القطاعات العسكرية والتجارية المتقدمة وتقدر ب/piث بسالي redirection مصادرها المؤسسات اليهودية في العالم والولايات المتحدة مثالًا البحوث إنتاج صواريخ حديث...
يُستفاد من هذا الجدول أن تمويل البحث العلمي لا يزال في مستوى متدهني جداً مقارنةً بإسرائيل وماليزيا والدول المتقدمة بالرغم من الإمكانيات المالية للدول العربية، وهي تقع في أسفل سلم التمويل الملحوظ للأبحاث في الدول النامية الأخرى، كما نلاحظ أن التمويل الحكومي هو الغالب وأن مساهمة القطاع الخاص والصناعي ضئيلة جداً ولا يتجاوز 3%، وهذا ما يفسر ضعف الإنتاج الصناعي في الدول العربية.

جدول رقم 2: الإنفاق على البحث والتطوير في الدول المتقدمة:

<table>
<thead>
<tr>
<th>بلدان (بلدان عربية)</th>
<th>لبنان</th>
<th>إسرائيل</th>
<th>ماليزيا</th>
<th>اليابان</th>
<th>الولايات المتحدة</th>
<th>الاتحاد الأوروبي</th>
<th>السنة</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>% بحوت نظرية 90%</td>
<td>30</td>
<td>24</td>
<td>25.5</td>
<td>18.6</td>
<td>36.2</td>
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<td>لا يوجد</td>
<td>1</td>
<td>1.1</td>
<td>22.4</td>
<td>11.5</td>
<td>52.3</td>
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<tr>
<td>% غير محدد</td>
<td>70</td>
<td>75</td>
<td>73.4</td>
<td>59</td>
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</table>

جدول رقم 3: توزع وحدات البحث والتطوير في الدول الأوروبية حسب الميادين الرئيسية للاقتصاد والجهة المنفذة للعام 1996:

<table>
<thead>
<tr>
<th>الجهات المنفذة</th>
<th>الميدان الرئيسي</th>
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<tbody>
<tr>
<td>% من المجموع</td>
<td>الزراعة</td>
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<td>الجامعات</td>
<td>19</td>
</tr>
<tr>
<td>الحكومة</td>
<td>97</td>
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</tbody>
</table>

الميدان الرئيسي
من الملاحظ أن أغلب وحدات البحث في الدول العربية هي حكومية، وأن التمويل الأكبر هو للفضا الزراعي (تنفق الكثير من الأموال على تطوير الزراعة في دولة الخليج وليبيا)، وأن أغلب البحوث هي في الإنسانيات والعلوم الاجتماعية.

النشر والترجمة:

وفي موضوع النشر والترجمة، وبالرغم من أن عدد سكان الوطن العربي يبلغ بحدود 300 مليون نسمة، ووزعون على 22 دولة عربية، فقد بلغ عدد الإصدارات الجديدة حوالي 5600 عنواناً، تأليفًا وترجمةً، في جميع الدول العربية، ويباع من كل عنوان حوالي 5000 نسخة في أحسن الأحوال وفي جميع الأسواق العربية. وفي المقابل فإن الولايات المتحدة وحدها، طبعت مليوناً ومنحت ألف عنوان، كما طبع في أميركا الجنوبية ودول البحر الكاريبي حوالي 42 ألف عنوان (في تسعينات القرن الماضي).

وتشير الإحصائيات الصادرة عن منظمة اليونسكو العالمية عن موضوع في السنوات الخمس الأخيرة من القرن العشرين، أن العالم العربي كله قد أنتج أقل من كتاب واحد مترجم في السنة لكل مليون نسمة. في حين أنتجت إسبانيا وحدها ما يقارب 920 كتاباً، لكل مليون نسمة (على عكس ما كان سائداً في العصر العباسي إبان عهد الخليفة الأموم الذي اعتبر الترجمة وسيلة أساسية لنقل المعرفة إلى العالم الإسلامي).

وبالمقارنة مع إسرائيل، وبالإشارة إلى الإحصائيات الصادرة عن معرض الكتاب العبري لسنة 2004 (مدير عام اتحاد دور النشر الإسرائيلية أمنون بن شمونيل)، بلغ عدد زوار المعرض حوالي المليون إسرائيلي، وبلغ عدد الكتب المباعة حوالي 600 ألف كتاب أي ما نسبته 5% من إجمالي الكتب المباعة في الأسواق الإسرائيلية؛ وبشكل عام، يباع في إسرائيل حوالي 36 مليون كتاب سنوياً، منها 15 مليون كتاب مدرسي، بقيمة تبلغ حوالي 450 مليون دولار أمريكي. وتصدر إسرائيل سنوياً حوالي 4 آلاف عنوان جديد، ويبلغ معدل ما يقرأه المواطن الإسرائيلي حوالي 11 كتاباً في السنة (صحيفة مصاريف الإسرائيلية).
هذه المقالة تشير بشكل واضح إلى الخلل الكبير في الوطن العربي حيث الثقافة والمعرفة مهملة وغير مزعومة، والاهتمام الرسمي معدوم، لصالح بعض الثقافات الشعبية التافهة والتي تلعب الفضائيات العربية دوراً أساسيًا في نشر ثقافة اللهو والترفيه الهابط والمعيب في أكثر الأحيان بدلًا من التركيز على تاريخ وحضارة العالم العربي والإسلامي.

من هنا ندرك حجم المعاناة التي يعانيها المثقف العربي المنتظم، الذي لا يجد من يقدر له جهوده ولا حتى في أبسط الأحوال من يقرأ له فكره!!!

4 - تطوير عملية البحث العلمي في لبنان:

- اعتبارًا من خلال هذه المؤشرات أعلاه، وتطوير عملية البحث العلمي يجب:

- إجراء اتفاقيات بحث علمي مع المؤسسات البحثية المتقدمة في الخارج.

- إعداد قروض تمويل وبحث علمي مع جامعات ومؤسسات بحوث خارجية مما يؤمن ديناميكية في تطوير البحث العلمي.

- حث القطاع الخاص على التعاون الكلي والوقود لمؤسسات البحثية اللبنانية والجامعات وتأميم تمويل مناسب، وإعطاء ضرورة للإيجاد المحلي الذي يركز على التكنولوجيا والإنتاج الوطني.

- العمل على هيئة القطاع الخاص في عملية التعليم عن طريق السماح لأصحاب الاختصاص والخبرة والكفاءات بممارسة التعليم والتأهيل في مواد لها علاقة بالاختصاص خصوصاً في المواد المرتبطة بتقدم العلوم والتكنولوجيا وتقديم الحوافز القانونية والمالية لتفعيل هذه المشاركة.

- تأمين وسائل البحث العلمي ومقوماته وتأمين وسائل التدريب والتأهيل والتجربة المستمرة للسلاسل المطلوبة محلياً من القطاع الخاص والعام.

- تكيف برامج الدكتوراه في الجامعات وتوجيهها للقيام بأبحاث جديدة مندقة بالتعاون مع الجامعات العربية والعمل على ربطها بقطاع الأعمال.
زيادة الإنفاق الحكومي على البحث العلمي وربط المشاريع الحكومية والدراسات التي تحتاج إليها الدولة بالمؤسسات العلمية البحثية والجامعات، كمساهمة منها في تأمين مردود مالي إضافي.

- التعاون مع الدول العربية ومؤسسات البحث العلمية والعلمية فيما بينها ووضع خطة عامة لهذا التعاون.

- التعاون مع الدول المتقدمة لتمويل أبحاث لصالح قطاع الأعمال في هذه الدول.

- إلغاء

خاتمة:

إزاء هذا الواقع، هل من الممكن تطوير سوق العمل وتحسين الجودة وتطوير البحث العلمي في مؤسساتنا الجامعية؟ قد تكون الإجابة المباشرة على هذا السؤال صعبة ولكن ذلك لا يعني الأساتذة من البحث عن كل جديد في اختصاصاتهم (خصوصاً في المجالات العلمية والطبية والهندسية...) بهدف تطوير معارفهم وزيادة معارفهم لتقدم كل ما هو جديد للطلاب وللوصول إلى جودة البرامج التعليمية وتحقيق جودة التعليم، كما أنني لا أرى حرجاً بإعادة طرح موضوع الترخيص للمؤاهد والجامعات الجديدة على أساس تخصصي قابل للتوسع مستقبلاً. بحيث يكون لدينا مثالاً: معهد المعلوماتية، ومعهد للعلوم السياسية وغير ذلك وهذا ما قد يساعد في تحقيق جودة البرامج التعليمية، جودة التعليم، وتجميعاً للأدوات الفنية كمدخلًا لتطوير البحث العلمي.

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10 – جريدة النهار اللبنانية: مقالات ودراسات.
INSIGHTS ON RESPONDING TO GLOBALIZATION-DRIVEN CHANGES IN HIGHER EDUCATION IN DEVELOPING NATIONS

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Abstract

Globalization is not a new phenomenon but the contemporary term characterizes a far more complex system of international connectivity and commerce. People throughout history had transcended their communities in quest for domination, to seekeconomic opportunities, escapepolitical or religious oppressions and social injustice, flee war zones and natural disasters areas, satiate their cultural curiosities, and pursue educational aspirations. The Scriptures are full of accounts of related experiences. Regardless of the motives, interactions were mainly physical. The massive advances in information and communications technologies - the main engine of globalization - havemade the interactions of individuals, communities and cultures undertakings of scale and simplified the handling of matters and transactions with minimal physical migrations of people. Globalization had affected every facet of life. Forces of good and evil have tapped to its resources to leverage their prospects. Globalization has also widened the spectrum of knowledge attainment methods to include, at two extremes, the traditional model where earning a college degree requires physical presence, and a future model where one can earn a degree without setting a foot on campus. Between these two extremes lies an area of untapped possibilities for an established traditional university to venture into to maintain its future viability and advance its brand. The aim of this paper is to offer some insights on globalization of education in developed nations, Lebanon is the case in point, and to trigger discussion among key players to consider the impact of globalization on policy making related to all aspects of university life. The paper also makes a plea to institute in the developed nations to proactively participate and contribute to the global search for the attributes of the University of the Future and to fashion their authentic presence within the evolving spectrum of higher education.

Keywords: Globalization; university of the future, on-line learning, active participation, authentic model
1. Introduction

Naom Chomsky, and other renowned scholars, differentiate between two meanings of globalization: the “literal” meaning and the “doctrinal or technical” meaning. The literal meaning of globalization encompasses the economic, cultural, and political integration “that serves the interest of real people, flesh and blood.” In the doctrinal (technical) sense globalization is the means to advance the “neoliberal socioeconomic program,” dubbed as “anti-globalization,” aiming to achieve “international economic integration” carefully regulated “to ensure that the interests of the investors and financial institutions” are served and “full-spectrum dominance” is attained [1, 2].

According to the Nobel Laureate Joseph Stiglitz, Globalization encompasses many things: “international flow of ideas and knowledge, the sharing of cultures, global civil society, and the global environment movement” [3, 4]. Stiglitz believes that “Globalization has the potential to bring enormous benefits to those in both the developing and the developed world.” However, during his illustrious career as a Professor of Finance and Economics, as the Chairman of the Council of Economic Advisors under President Bill Clinton, and as a chief economist and senior vice president of the World Bank, he has accumulated “overwhelming evidence” that globalization “has failed to live up to this potential.” “The problem” Stiglitz states “is not in globalization itself but in the way globalization has been managed” and in the shaping of the political and economic processes by the “neoliberals [4]” to “generate profits for some at the expense of the many.” Naom Chomsky presents an account of how these “neoliberal” forces have managed to transform a nation like Haiti from “the richest colony in the world” to a desperately failed state that “may not be inhabitable in a few generations” [2].

The debate according to Stiglitz is, to a large extent, no longer “anti” or “pro” globalization. From an economic standpoint, the positive impact of globalization is exhibited by the many nations that have been integrated into the global economy and the awesome growth they have witnessed over sustained period of times [2, 4]. A more detailed account on the growth of “the rest” is offered by Fareed Zakaria in his book The Post-American World and the Rise of the Rest [5]. The landscape of human experience is also full of images showing the “darker side of globalization: recessions and depressions; environmental degradation and the stripping of Africa from its assets and natural resources, leaving it with a debt burden without its ability to pay [4].” Notwithstanding the voices on both sides of the globalization debate, globalization is a “key reality in the 21st century.” The “genie is out of the lamp” and the main players steering the globalization debate, or at least influencing it to advance a “desired” socioeconomic agenda will not abandon the cause any time soon. The gap between the “haves” and the “have nots” will continue to grow. Life for too many is lived on edge. Bill Clinton writes in a Time magazine article, “Talent and intelligence may be spread evenly across the planet, but opportunity is not” [6].

Overwhelming evidence points to education as key determinant of economic and social development in nations [7-9], and since globalization is “about knowledge economy
and technology”, a “central feature of development” therefore is to absorb new knowledge as it emerges and close the “knowledge gap” through education [4].

Education has been global throughout the human history. However, physical travel was necessary to seek knowledge in the past. Students (authors included) who travelled to study in America recall the “global” setting in a typical American University classroom: A mix - melting pot - of cultures, dreams, motives, languages, colors, and races sitting alongside using one medium of communication, the English language. And the Communications technologies (ICT) revolution came along. These two elements, English language and ICTs – have globalized the “American Classroom” to a point where if the online education platforms that are currently in development reach maturity, the University of the Future will have “no walls” and access to the “American Classroom” may no longer require physical travel. The impact will be enormous.

Being inevitable, globalization is influencing, and will continue to impact, all aspects of the education process: the learning medium, flow of information, standardization of curricula and tests, cultural experiences, mobility of talent or “brain circulation”, forever or life-long learning, quality standards, and cost of education. A major reason behind world renowned academic “centers and peripheries” extending their operations beyond their established boundaries is to search for talent [10]. “Brain circulation” to the beneficiary thereof, “brain drain” to the disadvantaged, is probably the most important ramification of global education on developing societies. The negative implications of brain drain on developed nations has ignited a debate, prompting leaders like Mahathir Mohamad, the former prime minister of Malaysia, to propose that developed nations benefiting from the migrating talents compensate the nations of origin for the lost opportunities of their investment [4]. Politics aside, the issue of brain drain is serious to warrant debate at the highest levels of the policy making chain including not just higher education institutes (HEIs) but other key players in the society to curb its uncertain impact on a nation.

2. The Changing Medium for Knowledge Attainment

Massive Open On-line Courses (MOOCs) and delivery platforms such as Coursera, Udacity, and edEx are experiments in higher education that have managed to expand the horizon of higher education debate, promising a revolution no one can fully fathom its outcomes yet. These elements are presented as alternatives to the traditional higher education “credentialing system”. Online courses are increasing in number and maturity rendering travel no longer necessary to seek knowledge. The American Council on Education, an association that advises college presidents in the US, had recently endorsed eight MOOCs for credit offered through Coursera [10,11]. Accordingly a student who passes any of these courses may receive credit toward a traditional degree without the student setting a foot on campus. The implication is that a student enrolled at University A could take a MOOC offered for credit by University B without having to pay University A any tuition and still receive credit for the course toward a degree from University A. Law makers in several US
states are discussing bills that require state universities to give credit to students who pass certain online courses including MOOCs. A major driver for the debate is financial and is gathering momentum.

The three important issues that proponents site for not embracing this approach are economics (tuition revenue), quality control (assessment of learning outcomes), and cheating. MOOCs potential in “disrupting” the revenue base of an institution is a major factor for not being fully embraced. The ramifications to HEIs in developing countries are huge, especially that the cost to pass a MOOC offered by a renowned institution may be far less than the tuition paid to the institution at home! Things will not change overnight though. Colorado State University – Global Campus has offered a three-credit MOOC through Udacity for $89, the cost of the required proctored exam (regular tuition $1050) [12]. The course has not attracted any student, yet. But the fact that the course was offered indicates a trend that will continue to evolve. The opinion of professors, even those who had taught MOOCs do not think that students should receive credits for on-line courses, even if they perform well in class. Apparently a schism exists on this issue between the academics on one side and administrators and lawmakers on the other. Only time will tell whose opinion will prevail. In the meantime, lots of activities are happening. The $89 course may be a real bargain. A better bargain still if efforts to give potential students credits for prior and experiential learning for free get traction!

Coursera, the Silicon Valley-based provider of massive open online courses, have concluded that the majority of MOOCs users have already attained a university degree. Accordingly focusing on MOOCs will not achieve the financial benefits Coursera aims to achieve. Consequently, Coursera is using its resources and experiences to support universities to build their own online courses for use in multiple campuses. Coursera has already signed agreements with many university systems in the US. The agreements detail the process of developing, adopting and administering “guided” courses, and the approach for revenue sharing and licensing of the courses to other institutes [13]. This approach may be a viable option to institutes in developing nations.

While neither MOOCs nor Coursera’s platform will be the panacea, it is helping widen the spectrum of the debate on the future of higher education. No one knows where the discussion will lead, but once a viable framework emerges, as it will, the landscape of university education and the attainment of knowledge will forever change. One thing is certain: Technology will be a very important part of the education process that cannot be ignored by policy makers.

3. University of the Future Global Campus

No one really knows what the University of the Future will look like but one thing for sure is that it will be different in many ways than its traditional counterpart. There are many experiments in progress and convergence to some new forms is only a matter of time. The cost of education is increasing so rapidly that prospective students are having difficulty in
affording the tuition. Accordingly universities have to find ways to deliver quality, complex knowledge in a flexible, affordable manner. This demands a new thinking.

3.1 Local Education – Global Reach

Many well-established universities in the US and Europe are forging a global outreach vision to cement a global preeminence in the 21st century. The rationale is “financial, brand and prestige, and scouting talent” at the undergraduate level to ease transfer to research institutes after graduation. This does not mean that established universities open up satellite campuses in distant parts of the world. Often time globalization outreach is fostered through programs offered on campus. A case in point is the Georgia Tech (GATech) approach articulated in its Strategic Vision[14] which is set on furthering the globalization of the educational experience at GATech with special emphasis on:

- “Enhancing the language component of our educational offering, increasing support for language and culture studies through various creative modalities;
- Consider the meaning of a Georgia Tech Global Village (or community), either physical (space) or virtual capable of inter-linking the various relevant faculty, student, international business, among others, communities in a proactive way; and
- Global leadership in innovative pedagogy and outreach which will further solidify the Institute’s global footprint”.

This model may suit the purpose of institutes like GATech who has built a brand and developed the capacities to cope with the changing times - pre-requisites that most universities in developing nations cannot claim to have.

3.2 No Walls University

New York University (NYU) is making headway of its concept of the global university without walls [10]. The University has already opened two degree-granting campuses in Abu Dhabi and Shanghai, and 11 Global Academic Centers around the world. The vision is to create “virtual network” of “co-equal” universities that form one ecosystem, a distributed university dubbed as Global Network University without a “central home campus”. The concept enables a student to start a course in one of the virtually networked universities and finish in another, or take different courses in different centers and eventually receive the same NYU degree. It is a matter of time that NYU-like concepts will emerge to cover the entire world. The opportunity is for the prepared and the experienced will change the world! Consider this: One of the winning teams of the 2012 Hult Global Case Challenge organized by Hult International Business School was a group of four students from Abu Dhabi campus of NYU - nationals of countries in conflict - one from India, one from Pakistan, one from China and one from Taiwan[6]!

A revolutionary idea for the future of higher education is offered by Salman Khan in his book *The One World School House: Education Reimagined*. Khan envisages an “unfettered, open-access online [higher] education” model in which students attain education at their own pace by tapping available on-line courses and attending seminars while working on internships and projects mentored by entrepreneurs, inventors, and
executives. Students may then get credit for the learning they have attained and “prove themselves” through assessment mechanism conducted by some internationally recognized body. According to Khan’s idea, traditional university role will be limited to teaching. Mr. Khan writes that “Existing campuses could move in this direction by de-emphasizing or eliminating lecture-based courses, having their students more engaged in research and co-ops in the broader world, and having more faculty with broad backgrounds who show a deep desire to mentor students” [15]. Readers may read the comments made on the book by prominent world figures (Al Gore, Bill Gates, Muhammed Yunus, Goerge Lucas, and many more) posted on the amazon.com book’s page to appreciate the importance of Khan’s revolutionary idea [16].

4. Globalization of Education and the Underdogs!

Educational institutions in developing nations, such as Lebanon, are witness to experiments that may have enormous implications, yet have little influence on their outcome and are definitely not prepared to deal with the challenges they will pose. Institutions may choose one of two options, wait for the dust to settle and embrace the surviving mode of delivering knowledge or participate in the effort to create a competitive platform. The problem with the former option is that the surviving modality may be too costly, especially to “resource-deprived institutions” in poor countries [17], or more importantly may change the game entirely to a point that renders institutes helpless to cope. The latter proactive option gives a chance to an institute to show its intellectual prowess and creative capacities that could possibly advance its brand instead of becoming a member of the “bewildered herd”.

Imagine a nation whose educational system is under development having to cope with competition from all around. Consider the following three important implications. (1) A nation’s institutes may be able to tap to the plethora of free information and resources, yet required cutting edge resources are not for free! (2) Standard curricula, if not carefully adapted may often neglects the needs of a nation to preserve its identity and improve certain conditions. (3) Well established institutes will be able to lure talents exacerbating the problem of brain drain. Many Universities are building collaboration with established institutes abroad. Everyone would agree that these institutes are not charitable organizations. They seek first and foremost to advance their interest. Established universities, well equipped with the tools of the trade, will be able to leverage these partnerships to their advantages. Why then most universities in Lebanon are more than eager to establish collaboration with foreign institutes regardless? The answer is simple, to claim an affiliation with a reputable institution abroad and use that in their marketing campaigns. Of course the collaborating professor and the student will benefit. The more important question though is: what is the impact of this collaboration on the development of nation?

The foregoing is not intended to make a case against individuals seeking collaboration, but to exhort officials to forge policies by which partnerships lead to mutual benefits. Here are some ideas:
1. Whatever collaborative projects undertaken, let them deal with problems that relate to the institute’s community or at least common to both;
2. If experimental work is conducted, let the partner institute(s) provide support to establish the infrastructure at the local institute to conduct at least some research locally;
3. The work should advance the local institute’s capacity in the related field.

These issues will not matter if the local institutes do not build itself to meet the competitive challenges. By that we mean the local universities must create the environment that lures and retains top local talents and provide them with the tools, time, space and reason to unlock their creative self and pursue their aspirations, and give them the security they need so that they lead sustained, stable lives. Classroom conditions and how students are taught need to change, practical experience and community outreach enhanced, connectivity and social space improved, and experience in citizenship is strengthened. More importantly the universities’ approach to harnessing talents has to change.

Institutes in developed nations have to be creative in how the talents of their faculty and students are used. It is time that the rigid faculty hiring and promotion systems change to give them a chance to venture and build their future enterprises! If a talented professor has an idea of a startup, why the university does not give him/her the space and time to develop that enterprise without of course compromising performance! Accordingly promotion requirements have to change, responsibilities modified, and expectations modulated. An institute cannot transform if change is one dimensional or focuses on a limited piece of the educational spectrum, transformational change is holistic. Why not allow the talented professor to teach his classes from a distance? If he/she has an enterprise and is willing to build the infrastructure that enable him/her to deliver lectures from his/her office or from anywhere in the world, why not? Why not allowing students to start working on a dream problem they are passionate about through their studies and receive credit for it? If the ultimate outcome of education is the impact it will have on a society, and if the mantra of education is creativity and innovation, then one can easily conclude that someone working on a problem he/she is passionate about without the time and space limitations will have a better chance of achieving a creative outcome that will influence his/her future and ultimately impact the society. Why not offer a course or two in the curricula where student(s) are free to choose their problem, find resources, and create something with very little interference from the system, only to offer support when sought? The cliché “think outside the box” is used to describe creativity. The authors pose this question: why not allow teachers and students to live outside the box in pursuing their creative work!

Administrators in the developing countries should cease the opportunity to chart a pathway toward a more certain future. The future for sure will never be the same and discussing matters and forming committees and councils to discuss the issues in a meaningful way is prudent. Who knows, ideas that are generated in an “obscure” institution may have a “butterfly effect” elsewhere! Technology may have “flattened the world” but the world will
always be a globe-like. This difference should be an incentive for all to participate in the discussion and creatively generate ideas that work for a given context. Instead of waiting for the MOOCs to mature and watch throngs of students seek “certified” and “accredited” knowledge form a distant provider and the revenue base shrinks, it is time that institutes in developing nations develop authentic platforms that provide knowledge while maintaining control of their destiny. The authors propose a strong collaboration between local institutes on creating a shared on-line platform that provide certified knowledge to students in a flexible manner. How the system ends up will be the subject of discussion among the various institutes that participate in the project. Forming a council to foment a process in that direction will be an excellent start. Educators may take a page from the experience of business: if globalization is no longer profitable embrace glocalization. The aforementioned proposal aims to forge a viable local educational platform with global reach. The authors do not claim to have all the answers but the point is to embark on a collective brain storming effort about ways that enable local institutes to use globalization to remain viable and beneficial to their nations, and the world! Only then globalization will not be a zero-sum gain.

5. A Personal Note

Globalization has taken excitement from life. In childhood, waiting for the mailman anticipating a letter from a distant relative or friend was a thrill, managing to make a telephone call was a luxury, watching a movie was a delight. Access brought about by the elements of globalization has taken the thrill of anticipation and instant gratification has overridden the prolonged satisfaction of a piece of good news.

All this nostalgic flirting though is meaningless to a new generation that was born in the mix of a fantastically changing world. They have no memories of a “past” to compare with. So it does not matter to them as much. So what is the fuss all about? It is about preserving a sustainable future! If we have no choice but to embrace all that what is being created somewhere, we risk reducing the options to our future generations, stay where you are and face uncertain future, or leave somewhere to have a life and fulfill their dreams and leave behind a talent-deprived land. The danger is that there will not be enough room in the land of dreams for all dreamers to go! What Education to do? Build authentic generation endowed with the social responsibility and citizenship, and the capacity to create, innovate and radiate!

The Mad Man parable in Khalil Gibran’s *The Wonderer* may provide some context to the foregoing [18]. The parable goes that a man meets a youth in the “garden of madhouse”. Sensing wisdom and sanity in the youth’s demeanor, the man, puzzled, asked him for the reasons that led him to the madhouse. The boy rejoined that everyone he knew, family member, friend, teacher wanted him to make choices as seen through their own life’s lens. “Each would have me but a reflection of his own face in a mirror.” To escape the insanity of the “outside” he sought refuge on the “inside” where he can be himself.
Globalization tends to force developed nations to follow paths that are not of their choosing, just like the loving associates of the boy.

6. Conclusion

The most important role of an educational institution, especially higher education one, is to farm dreams and endow their bearers with the tools to fulfill those dreams. Dreams are powerful assets of the human world. Like trees dreams need nurturing in an ecosystem that breeds commitment to advancing the human conditions. ICT is forcing HEIs to transform but the features of the future HEI are still on the drawing board although a huge effort is being made to drum up a viable form. Whatever emerges once the “brain” storm settles, it will not be a one size fits all and each institute or each “team” of institutes, as they refer to it in the airline business, will have to craft its niche and establish its footprints in a highly competitive playing field. Instead of trying to cope with the surely approaching changes that will not let up, HEIs in the developed world could take advantage of the available tools that flattened the world and be a beat in the lyrics of the future of higher education. In education, globalization will transcend prepared institutes beyond their traditional walls, but for the institutes watching on the sidelines it may be the force for shrinking boundaries.
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INFLUENCE OF GLOBALIZATION IN ENGINEERING EDUCATION IN PALESTINE

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Abstract

Currently, engineering programs are being globally reshaped to represent a move towards quality assurance in engineering education and the mutual recognition of engineering degrees internationally. This paper discusses the recent development of globalization of engineering education in order to give information on the changes needed to meet the labour market dynamic changes. Also, the needs for quality in engineering graduate programs at Palestinian tertiary education institutions are discussed.

Keywords Engineering Education, Globalization, Accreditation, Palestine, Labour market.

1. Introduction

Education is the primary driver of economic development around the world, and only through the spread of education in other parts of the world, will this help in alleviating the negative aspects of the global marketplace. Technological advances drive the process and reductions in the costs of international transactions. This will help in the spread of technology and ideas, and also in raising the share of trade in world production and increase the mobility of capita.

Therefore, technology advances whether in science or engineering education is a key driver to globalization. In fact, there is more need for engineering education, compared to other subjects,
to respond to the fast changing demands of the international labour markets. The qualifications of engineering graduates now and in the coming decades are different from those obtained by earlier generation of engineers.

The purpose of this paper is to report the influence of globalization of engineering education programs in Palestine and how to improve and develop the quality of those programs in order to meet the needs of the local and the regional labour markets.

1.1 Does globalization promote brain drain?

Brain drain definition in this section is limited to the departure of educated or professional people from one country, economic sector, or field for another, usually for better pay or living conditions. In many cases, the drain starts in early stages of the individual career either after the high school or the completion of the university technology degree.

However, in most Middle East countries domestic labour markets cannot fully absorb an increasing level of education labour force, migration is an important channel for resolving local market imbalances with potentially large benefits to the individuals and national level. Labour movement is particularly important for the Middle East region because one of the region's main characteristics is excess of labour in a subgroup of countries and excess of capital in another.

Furthermore, migration to the rich countries and other Arab countries is temporary, and as such does not lead to the permanent loss of educated people. Finally, in light of the high unemployment in the exporting countries, the opportunity cost of keeping university graduates at home is low. Thus, the brain drain problem is not so in intraregional migration in Middle East[1].

2. Globalization of Education

The United Kingdom’s Department for International Development [2] has defined globalization as the growing interdependence and interconnectedness of the modern world through increased flows of goods, services, capital, people and information. Globalization and mobility of students have brought important challenges to universities all over the world. In Europe, the Bologna process (see section 3.1) and the declaration of Lisbon goals are important drivers of change in tertiary education. The effects of these processes are seen outside of Europe, and the tools brought in to harmonize programs, provide quality control, and emphasize outcomes are being used widely in European countries as well as in the United State, Canada, Australia, and most recently in Latin America, East Asia and the Middle East [3]. In the next sections globalization of distance education and off shore campuses as well as virtual colleges will be discuss.
2.1 Distant education and globalization

One of the most recognized elements to advance globalization is the use of communication technologies, such as the Internet and mobile devices with the associated application widely used in various aspects of education. The dissemination of knowledge has been completely reshaped through the unlimited accessibility to information through search engines and on-line scientific journals. With instant communication and online libraries, new scientific discoveries are happening much faster than ever before.

The availability of high speed internet services enabled many engineering institution worldwide to develop distant learning based non-degree courses as the one offered by MIT (http://ocw.mit.edu/courses/index.htm). Distance education proved to be viable tool for the delivery of educational programs across international borders.

There are four major problems with Internet communication in education: the unequal access to the Internet internationally; the control of educational and research software by for-profit organizations in Western countries; the dominant use of English on the Internet which substantially increases the strength of Western academic powers such as the UK and the US; and the belief that the Internet accelerates the digital divide between rich and poor nations. Here, in Palestine, the four major problems do exist clearly and severely affect the engineering studies in such away it is not recognized as engineering area of studies.

2.2 Off-shore campuses and globalization

An alternative that provides engineering education opportunities in global terms is the growing trend in off-shore campuses. More than one million students will seek studies in higher educational institutes yearly. Imagine if 20% is geared towards studying engineering that is a strong economical driver to many engineering institutions to compete for. This staggering demand must be met. In addition, there is a strong appeal for Western education in most countries, most notably in the Middle East countries as UAE, Qatar and Egypt.

Waterbury [4] writes that there has been a failure by higher education institutions in the Middle East to provide proper education and training for its people, an ideal position for western universities to exploit. Most citizens of the Middle East are very familiar with American education system been the key driver that helped make the United States the economic and military superpower it is, but that it has produced the scientific, business, and educational leadership for many other countries. Unfortunately, such opportunity does not exist for Palestine population due to the political instability the region is undergoing.
2.3 Virtual colleges and globalization

Most recently, Global Engineering College (GEC), virtual campus concept is seen as innovative way to address demand for engineering education at large scale as studied by Hossiey [5]. Virtual campus is open to national and international students. The cultural and economic effects of globalization have created fundamental changes that are driving a new structure for engineering education worldwide.

The United States of America have realized that engineering students also require strong international skills to succeed in the global engineering workforce. Students graduating from an engineering program can expect to work at some point in their career, on teams with individuals from different cultural and linguistic backgrounds from various locations in different continents.

3. Globalization of Engineering Education
Challenges

Studying engineering in international global environment faces several challenging barriers to participants. Challenges such as: certification, curriculum, language barriers, semester timing, methods of delivery, performing hands-on exercises, reliability of on-line delivery tools and associated and virtual simulated labs, perceptions and marketing of the programs.

In fact, engineering education across the world is already broadly similar in many respects. Where two distinct types of engineering curricula are offered, one more theoretically oriented and the other more application oriented. In spite of this engineering students must be trained in line with the evolution of a more abstract and changing working environment. Decades of service in one single profession are no longer the norm. Therefore, students should be given the opportunity to develop other skills outside their field of study. To become innovators, young graduates should posses a range of soft skills as well as interdisciplinary knowledge. This could be encouraged by developing more flexible curricula allowing the students to explore real potentials.

3.1 Accreditation and Globalization

To meet the above challenges, The EU countries established what is now known as Bologna Process. The Bologna Process involves an inter-governmental initiative of more than 45 countries in Europe. The aim of this process is to set up throughout Europe a system of easily comparable degrees and to ensure suitability of accredited programs. In addition, Bologna's Process other objectives are: the promotion of the necessary European dimensions in higher education with regards to curricular development, inter-institutional cooperation, mobility schemes and integrated programs of study, and training and research.
Here, it is worth referring to website of the EU Bologna Process main recommendations that were established to encourage globalization of engineering education which can encourage Palestinian TEI’s to participate effectively and gain proper accreditation. (http://ec.europa.eu/education/policies/educ/bologna/bologna.pdf):

Also, the USA Accreditation Board for Engineering Education (ABET) now requires programs to graduate engineers with the ability to function in multidisciplinary teams and for broad education to understand the impact of engineering solutions in a global and social context (http://www.ABET.org).

4. Education in Palestine

Recently, Work Bank [6] reported that only 5% of Palestinians aged 24-32 have not obtained a formal degree. Compared to other countries in the Middle East and North Africa (MENA) Region for which data available, West Bank and Gaza have the highest adult literacy rate and the highest gender parity (0.94) in adult literacy.

The main objective of the Palestinian strategic plan for higher education is to move from the focusing on access to education towards quality of education for all. In order to achieve the required quality, dramatic changes are needed in the education system; this includes the development of soft skills such as learning to learn, team work, synthesis of information and critical thinking which are important for labour market involvement.

The Palestinian higher education system consists of 49 Tertiary Education Institutions (TEI’s), including both universities and colleges, supervised by the Ministry of Education and Higher Education. With regard to universities, the majority of them are said to be “public.” In Palestine, educational institutions are said to be “Public” because even though they are mainly private financed, they do receive limited funding from the government. Also, they are heavily regulated by the Ministry of Education and Higher Education (MOEHE).

In fact, the principal role of the MOEHE is to accredit the TEI’s and to supervise the sector. Higher education has largely been funded by external grants and tuition fees, with little central government support. Declining external support for university operating costs, however, have posed a significant challenge to higher education, necessitating increased fees and other adjustments. It is unclear how rising tuition fees might affect higher educational access by lower-income Palestinians in the absence of any comprehensive system of financial support for needy students.

4.1 Possibilities of research

High standards of research are vital component to the professional lives of faculty members and graduate students in a university setting. Globally speaking, engineering research advances the
state of engineering practice, provides valuable learning and experience to graduate students and generates needed revenue for teaching institutions. Besides, the traditional-supported research foundations and councils, the recent trend toward partnership with industry and government has provided additional sources of research funding.

Palestine’s universities are the “natural location for meaningful research, consistent with national objectives for Palestinian social and economic development. However, research and development, particularly in the social sciences, technology, and engineering remain weak, Abu-Lughod [7]. Quality and adequacy of teaching and research laboratories and workshops vary at different institutes. It has become more difficult for the public and non-profit institutes to hunt donor funds to sustain and upgrade those laboratories. In conclusion, the higher education institutes have a modest infrastructure for teaching but definitely not suitable for research except certain science and engineering fields.

4.2 Quality improvements projects

The Palestinian Government through ministry of Education and Higher Education (MOEHE) is implementing a Tertiary Education Project with the support of the Word Bank group and the European Union (EU). A major component of this Project is the creation and implementation of the Quality Improvement Fund (QIF). The main objective of the Quality Improvement Fund is to provide support to improve the quality of Palestinian tertiary in situations and programs in order that they are relevant to the labour market and economic development of Palestine made competitive with international standards and capable of developing income-generating programs. Although administered separately, the primary purpose of the QIF fund is to improve quality and relevance in tertiary education, and is therefore closely linked to the national accreditation process and the institutional self-evaluation initiative.

In Palestine, one of the triggers for the shift towards outcomes was that students are lacking the skills industry required. In the subsequent process, the MOHE together with Word Bank and industry stakeholders and representatives from profession were closely involved in the discussion of developing a new QIF project [6] entitled “Education to work Transition Project.” By engaging the business community early on in the design of the curriculum and in the teaching/learning process, and by making available on-the-job learning opportunities for students, the proposed project is expected to have an even stronger impact on the future employability of graduates since the graduates will bring with them not only theoretical know of their specialities but, perhaps more importantly, they will have acquired soft as well as hard workplace skills that cannot be taught in the classroom. Even though this project is still taking place, some achievements have been made. This indicates especially in engineering, that industry is central to the setting of educational goals.
5. Engineering Education in Palestine

Palestinian tertiary education institutions (TEI’s) endorse a priority shift towards quality and relevance of engineering education and training with the aim of graduating students who have skill and qualifications that are more responsive to the needs of a changing local and regional labour market which is set to become increasingly integrated into the world economy. Therefore, TEI’s should work with business and private sectors to encourage them to participate developing training programs and curricula for engineering programs at all levels as well as assessment and skill accreditation, and monitoring and evaluation. TEI’s also, upgrades facilities for engineering departments to provide relevant education and training to students are needed.

To increase the employability of engineering graduates in support of the Palestinian economy, the engineering programs should be more relevant to the diversified labour market needs, and by improving training programs for students and trainers as well as by introducing quality assurance mechanism.

5.1 Student enrolments and Accreditations

The composition of university subjects amongst Palestine tertiary education graduates is heavily skewed towards education, social sciences, business, and law. Less than 15% of graduates study sciences or engineering. The following table analyse the engineering student enrolments at Palestinian Universities. The data is drawn from the HOHE Statistical Yearbook from the 2009 [8]. In Table (1) the limited number of female students at the Bachelor level may be due to the constraints faced by young women to get into a paid job upon the graduations.

<table>
<thead>
<tr>
<th>#</th>
<th>TEIs</th>
<th>Enrolled Students</th>
<th>Graduated Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>Female</td>
</tr>
<tr>
<td>1</td>
<td>Al Azhar University - Gaza</td>
<td>268</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>Islamic University - Gaza</td>
<td>2389</td>
<td>773</td>
</tr>
<tr>
<td>3</td>
<td>Hebron University</td>
<td>102</td>
<td>71</td>
</tr>
<tr>
<td>4</td>
<td>Palestine Polytechnic University</td>
<td>1560</td>
<td>502</td>
</tr>
<tr>
<td>5</td>
<td>AlQuds University</td>
<td>675</td>
<td>214</td>
</tr>
<tr>
<td>6</td>
<td>Birzeit University</td>
<td>1479</td>
<td>482</td>
</tr>
<tr>
<td>7</td>
<td>Alnajah University</td>
<td>3549</td>
<td>1343</td>
</tr>
<tr>
<td>8</td>
<td>The Arab American University</td>
<td>279</td>
<td>65</td>
</tr>
<tr>
<td>9</td>
<td>Palestine Technical University-</td>
<td>587</td>
<td>214</td>
</tr>
<tr>
<td></td>
<td>Tulkarm Khadory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>University of Palestine</td>
<td>398</td>
<td>50</td>
</tr>
<tr>
<td>11</td>
<td>Palestinian Technology College-</td>
<td>27</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Deir Albalah</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>College of Science and Technology - Khan Younis</td>
<td>62</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11375</td>
<td>3824</td>
</tr>
</tbody>
</table>
Faculties of Engineering at Palestinian universities are actively involved in absorbing the impacts of the information and globalization age, characterised by the rapid pace of communication technology advancement. Thus, the Palestinian universities are not leading in their response to these changes but are merely responding and trying to cope. Exhaustion, stagnation and self-assurance are more relevant descriptions of many local universities than leadership, trend-setting, excellence and radiance.

The accreditation system in Palestine is centralised and managed by the Accreditation and Quality Assurance Commission (AQAC). The main services provided by the AQAC are consultancy and institutional review to ensure that their quality and standard meet international criteria. The current accreditation criteria for engineering programs at the Palestinian TEI’s are: 20-25% basic mathematics and science; 55-35% engineering fundamentals; 10-15% engineering electives and project work; 20-25 % multidisciplinary content. However, being provided any guidelines in terms of outcomes or the qualifications they need to achieve, the universities are ultimately responsible for their programs actual content.

**5.2 Curriculum Implementation**

The engineering profession has experienced substantial change over the past two decades. Combined and double degree programs combining the disciplines have become increasingly attractive to students. In Palestine, achieving diversity was one of the main goals of the process. However, the fact that in Palestine one common body is responsible for accrediting all engineering degrees can have a self-replicating tendency. It can be concluded for Palestine that the mere possibility to develop diversity through the definition of common outcome may not be sufficient to reach the desired diversity between programs.

Shanableh and Omar [9] summarized Skill desired in engineering programs includes the following:

- The ability to apply knowledge of basic science and engineering fundamentals as well as the ability to effectively communicate with engineers and non-engineers;
- Competence in an engineering discipline and in information technology;
- The ability to identify and formulate problems and solutions; as well as to work in multidisciplinary and multicultural teams;
- The ability to understand and consider the social, environmental and cultural responsibilities of professional engineering;
- Commitment to the professional ethical responsibilities of engineering practice; the principles of sustainable development; and commitment to the life-long process of learning.
These issues include ways of achieving diversity among engineering programs, means of enabling student and staff mobility, and the preparation of engineering students for professional practice through engineering education. Presently, explicit efforts are underway in the engineering program at most TEI's to meet the objectives that were described. Some of these efforts are the year-long senior design experience is broadening its formalized critical thinking and problem-solving instruction from an “open-ended solutions” approach to an “unstructured problems” approach. Also, efforts by the Career Planning and Placement Center have especially focused on professional development. In addition, a track within the engineering programs is being developed that incorporates courses from humanities and social sciences, business, and technical communications.

5.3 Industrial skill and entrepreneurship

It has been, generally, acknowledged that students are lacking the skills required in industry. In the subsequent process, industry stakeholders and representatives from the profession were closely involved in the discussion of ways to take engineering education into the future [10]. Within the discussion on the attaining a professional qualification at Bachelor level, industry stakeholders are calling for a currently no focus on professional practice. This is connected to the fact that there is no focus on students and their outcome in terms of their learning and desired attributes. Moreover, it is recognized that entrepreneurial skill and attitudes are absolutely needed by everyone. The social, financial and technological changes taking place in the world over the last decade constitute for all the higher education stakeholders crucial factors for the development of new policies to encourage entrepreneurship and innovation.

Thus, education and preparation for entrepreneurship should be encouraged in engineering education programs. This can be achieved by student centered teaching and learning, where students are the main players of their learning. In such an environment faculty members in higher engineering education need to become the promoters of entrepreneurial skills and the facilitators of development of such learning experiences.

5.4 Faculty member development

Engineering faculty members can influence thousands of other engineers in a lifetime of teaching, and thereby affecting their future careers more are than all their prospective employers. Engineering faculty members can leave their mark on the profession and society as a whole. This dynamic role involves the responsibility to teach well, to create enthusiasm and respect for the calling of engineering, and in the mean time to develop a sense of professionalism in students at all levels.

Faculty members should possess an appropriate balance between technical proficiency and teaching effectiveness. Practical technical experience in non-academic settings is also a valuable asset for potential educators. Effective use of communication skills is a critical qualification for successful teaching. Mobility of faculty members should be actively supported for the
acquisition of new skills and pedagogical competencies which are necessary for fulfilling new educational goals.

In addition, faculty members should also consider spending at least some sabbatical time gaining current, practical experience in private consulting, industry, or other engineering settings. An alternative method of gaining practical non-academic experience is to maintain a part-time connection with other groups or companies outside the university environment since teaching engineering is considered a form of professional practice.

Experienced faculty members should also take it upon themselves to mentor not only their students but also new faculty members. Engineering university staff should always maintain a vital and visible connection to their professional association. Needless to say that, an intimate familiarity with the “Code of Ethics” can help faculty members to maintain the highest ethical standards and allow them to act as role models for students. It is important to integrate the Code of Ethics into course work, where appropriate. This will help in to inculcate ethical thinking of the students.

6. Conclusion

The conclusion, therefore, is that global engineering course offering needs comprehensive curricular reform that will make international engineering education attractive to all levels of education. Such barriers do exist for Palestinian’s population seeking engineering degree from outside Palestine boundaries.

In line with emerging new needs and new professions, traditional teaching methods need to be changed and crossed in the engineering field and also, between engineering and other disciplines. Also, accreditation of non-traditional programs should be considered.

To maximize the return on their investment in education, Palestine and neighbouring countries need to rethink their emigration and labour mobilization policies. They could adopt transparent and predictable systems for licensing and supervising private recruitment agencies to combat recruitment malpractices.
References


MULTIDISCIPLINARY APPROACHES IN ENGINEERING EDUCATION FOR GLOBAL ENVIRONMENT: EARTHQUAKE ENGINEERING FROM MULTIDISCIPLINARY TO GLOBAL APPROACH.

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Abstract

Globalization has a great influence on the 21st century job market and professions, specifically regarding science and technology. The technical skills life cycle is becoming shorter and the mobility of technical specialists between countries is increasing. Engineering education is rapidly evolving and requires excellent technical expertise, taking both advantages of traditional and innovative approaches in education. The need to incorporate interdisciplinary knowledge into education becomes urgent, and moreover the complex global environment requires intercultural team work skills.

This article highlights the importance of multidisciplinary approaches leading to innovation in the global perception of engineering education. It focuses on the role of multidisciplinary approaches in earthquake engineering as a successful experience. Moreover the multidisciplinary earthquake engineering experience is taking the challenge of using global approaches in order to be capable of better solving universal issues.

Keywords: multidisciplinary approaches, globalization, earthquake engineering.
The world has become a small town. All can move and communicate easily with each other. Globalization represented as the global cultural, political, and economic integration is the fruit of communication, interconnection of people and businesses across the world. Thus solving the challenges of the globalization will need multidisciplinary, multicultural, multilingual efforts.

Creativity and innovation is not limited anymore to be the fruit of one science and discipline. The brightest and most innovative ideas are witnessed to be the fruit of multidisciplinary sciences. Leaders of the new world are required to have multidisciplinary education in order to envision a global solution for any encountered problem or challenged faced in a world that is getting more complex every day. Many universities and research institutions have already took the challenge of introducing multidisciplinary programs. The earthquake engineering science has gone a further step, already a multidisciplinary science, they are by now moving global in their visions and goals.

1.2. Globalization made the world flat.

Thomas Friedman [1] in his book «The world is flat » explains the ten forces that flattened the world and made it global. They are resumed as following: The first force was the fall of Berlin wall in 11/9/89, the second; was the Web went around and Netscape went public, the third was Work Flow Software, the forth was Uploading, the fifth was Outsourcing and Y2K, the sixth was Offshoring, the seventh was Supply – Chaining – Eating Sushi in Arkansas, the eight was Insourcing, the ninth was In – Forming- Google, Yahoo, MSN Web Search, the tenth was the Steroids – Digital, Mobile, Personal, and Virtual. Now that the world was flattened, many new challenges needed to be faced.

1.3. Global challenges.

Many lists of global challenges for the world in 2020 were prepared by many groups of scientists, engineers and mathematicians who made those inventions possible. Let us note the list prepared in the conference hosted by the Royal Society in London, the one by the National Academy of Engineering, and the one through the Millennium Project [2].

Many items of the three lists were similar, proving that those challenges were global, but the remaining issue was how to solve these challenges. The most trustworthy solution would result from the combined work of scientists, engineers, mathematicians and technologist all over the world; which is a multidisciplinary and global approach to the problem. Therefore the engineering education institutions are advised to work on implementing multidisciplinary and interdisciplinary programs and to promote the discussions between cultures. They are encouraged to focus on becoming the best research institutions, as they are usually designed to
operate, through focusing on intellectual growth and team work between different disciplines and cultures instead of focusing on the personal growth of each.

The paper is organized as follows: part two presents the programs and institutions that took the multidisciplinary challenge, part three presents the earthquake engineering from multidisciplinary to global experience, and part four concludes.

2. Many programs and institutions took the multidisciplinary challenge.

Many engineering sciences were not possible without the progress of multidisciplinary approaches. Therefore new programs or methods were proposed and tested to verify the effectiveness of the multidisciplinary and intercultural curriculum. Among those let’s note the following remarkable attempts.

A leading step of a multidisciplinary summer school established in an industrial setting, the site of Bang & Olufsen in Denmark [3]. This successful application to the European ERASMUS Intensive Programme aimed to overcome difficulties faced when students work in multidisciplinary, intercultural teams in the globalized world. Students from six different European universities aimed to develop innovative concepts and products with a strong industrial perspective(s), they were encouraged to «exhibit soft skills like communication, interpersonal, and social skills, time planning, creativity, initiative and reflection»

The Chalmers University of Technology, a research university with a long history in engineering education, has its mission statement «Chalmers shall be an outward – looking university of technology with a global appeal that conducts internationally recognized education and research linked to a professional innovation process». It proposes a multi – disciplinary, multi – lingual engineering program for education writing development: an in – depth collaboration in mechanical and civil engineering, providing programs in both Swedish and English [4].

Recently the Colorado school of Mines proposed a Multidisciplinary Laboratory course, replacing the laboratory course in electrical circuit, fluid mechanics and stress analysis [5]. The systems experiments required from the students to practice higher level of thinking, moving beyond the basics theory verification. It encourage students to reorganize knowledge and discover the connection among concepts in several courses helping the students understand relationships among science, engineering science and engineering design.

The University of Canterbury has embedded design projects into its new Mechatronics multidisciplinary program, which has proved to reinforce students’ systems thinking, hand – on abilities, and cross – course linkage.
The Pennsylvania State University offers multidisciplinary engineering degree, in an attempt to follow the National Academy of Engineering recommendations. *It incorporates advanced coursework in electrical, chemical and computer engineering, as well as engineering design to produce innovative engineers specialized in systems design and integration. Since the design of large systems (ships, aircrafts...) and complex systems require the knowledge of several engineering disciplines to complete successful design.*

The Purdue University’s College of Engineering has created a Multidisciplinary Engineering (MDE) program in order to provide an engineering education that meets contemporary demands [6].

### 3. The earthquake engineering from multidisciplinary to global experience: An example to follow in engineering education.

It wasn’t until engineers (civil, structural, mechanical, aeronautical and geotechnical) shook hands with architects, urban planners, earth scientists (geologists, geophysicists, seismologists), computer scientists, information technologist, public officials, and social scientists (decision makers and risk managers), that real progress appeared in creating what we call now earthquake engineering. Earthquake Engineering, from its young conception in the 50s, has moved forward with giant accelerated steps. Moreover this progress is propagating back to be applied in each one of the fields independently from the earthquake engineering background that it was originally designed to improve. It aimed to reduce seismic risk worldwide by promoting international cooperation of practitioners and researchers, as noted in [7]: «Earthquake science is a global science, indifferent to political or physical boundaries, as evidenced by the Great Indian Ocean Earthquake and Tsunami of 2004, which caused life loss and destruction in a dozen nations. It can therefore best be practiced through effective international cooperation.»

The brightest ideas in earthquake engineering were the fruit of multidisciplinary work, noting among many the remote sensing technologies, smart materials, self-centering rocking braced-frame spine systems, hybrid testing.

The theoretical concept of its most innovative approach the Performance Based Earthquake Engineering is a multidisciplinary approach which deals with a specific structure defined by its design and location. It embodies four main disciplines, the hazard analysis provided by the seismologist, the structural analysis and the damage analysis both provided by civil and geotechnical engineers, then the decision analysis provided by decision making experts and we might recommend the fifth part which is the risk management analysis that would help implementing the strategy in the real society provided by risk managers.
Many attempts to move forward from multidisciplinary to globalized concept were concretized, in 1984, the Concept of the International Decade for Natural Disaster Reduction (IDNDR), was proposed by the US Academy of Sciences, the Decade program started in 1990. In 1992 the International Association for Earthquake Engineering (IAEE), created the World Seismic Safety Initiative (WSSI) to be strongly involved with the IDNDR, [7].

Moreover the success of the multidisciplinary earthquake engineering approaches encouraged to deal with all hazards in a similar way. The multidisciplinary earthquake engineering was assisted by many educational and research centers, we note here under few among many.

3.1. The Multidisciplinary Center for Earthquake Engineering Research MCEER successful experience.

The first national center for earthquake engineering research in United States was established by the National Science Foundation at the University States of New York University at Buffalo, in 1986. It evolved to a Multidisciplinary Center for Earthquake Engineering Research, MCEER, in 1998. The MCEER’s educational activities aim among others to «develop future leaders in earthquake engineering/hazard mitigation», offering multidisciplinary education.

As expressed by the own words of Michel Bruno, the Director of MCEER from 2003 – 2008: «One thing is certain – making our society more resilient to disasters requires a concerted effort and the marshalling of talents across a wide range of disciplines».

The successful experience of the Center led to its expansion to address the technical and socio – economic impact of a variety of hazards, on critical infrastructures, facilities, and society following the 11th of September 2011 terrorist event, due to similarities between the emergency response of earthquake and terrorist events. Many studies for earthquake engineering were adapted to a variety of hazards like: Computer algorithm modeling progressive collapse of buildings, earthquake design details, seismic isolated structures, seismic jacketing technology, steel plates shear walls, remote sensing technologies.

The program educational objectives of the civil engineering curriculum at the University of Buffalo are: Technical engineering competence, Communication and interpersonal skills, Ethics and professionalism, Continuing education, Awareness of contemporary issues.

The department of civil, structural and environmental engineering offers graduate degrees with many concentrations. Looking in detailing to the concentration in structural and earthquake engineering, the courses offered are mainly in earthquake engineering mostly related to structural engineering, except for the earthquake engineering course and one elective course in seismology.
Even the multidisciplinary research is very encouraged and a main concern in the earthquake center the curriculum did not reflect all the possibilities that could be offered specifically in the earthquake engineering educational program.

3.2. The European Earthquake Engineering Research Center.

In Europe a similar path was taken in the PAVIA Risk Center, where several organizations with various areas of expertise work with a common goal, dealing better with different types of risk. Among its institutions: The EUCENTER, European Center for Training and Research in Earthquake Engineering, it has the scope of promoting, supporting and sustaining research and education in the field of seismic risk mitigation. The GEM, Global Earthquake Model, aims to assess earthquake risk anywhere in the world. The UME Graduate School helps understanding and managing extremes, it offers an interdisciplinary program that focuses on Disaster risk assessment, Extreme situation management, and engineering for risk mitigation. One of the offered Master degrees is the MEEES program, an Erasmus Mundus Masters’ Course that aims to provide higher-level education in the field of Earthquake Engineering and Engineering Seismology. Students are allowed to follow courses in two different Universities in Europe from the ones participating to the Erasmus Mundus program, benefiting immediately from a multilingual and multicultural environment. The Pavia Masters program offers a broader multidisciplinary involvement and includes a variety of courses in geotechnical engineering, structural engineering and seismology.

3.3. The University of Illinois at Urbana Champaign, UIUC, moving forward from multidisciplinary to global.

A notable effort, covering both education and research, is achieved by the Civil and Environmental Engineering Department at the University of Illinois at Urbana Champaign, UIUC. In education, the Department has established interdisciplinary primary and secondary fields of study in three thrusts, namely (1) sustainable and resilient infrastructure systems - SRIS, (2) nexus of energy, water and the environment - EWES, and (3) societal risk management – SRM. These thrusts are also reflected in the graduate Masters as well as PhD programs. With a statutory international trip for each thrust, referred to the Global Leaders in Civil and Environmental Engineering, the thrusts are also employed to energize international collaboration. Finally, The Department has established 8 international hosting agreements with leading international universities whereby senior students join Illinois for their final undergraduate year, and stay over for a one-year non-thesis professional Matsers degree at Illinois. The latter program, referred to as Global 3+2, is very well attended and is currently hosting a substantial number of students from the 8 partner universities. Below, emphasis is placed on one of the UIUC features of the research program; the global multidisciplinary alliance recently established in earthquake engineering.
The hybrid testing has lately experienced the global challenge; an experiment could be run in multi-site all around the world, benefiting from each particular one [8].

Moreover, the Network for Earthquake Engineering Simulation NEESgrid is delivering the Multi-site simulation test, MOST, to connect three sites: the National Center for Supercomputing Applications NCSA, the MUST–SIM at the UOIU, and the University of Colorado at Boulder. The goal is to link earthquake researchers across the United States, with leading edge computing resources and research equipment, allowing researchers to collaborate on experiments and share resources, an experience that can be extended to link researchers all over the world.

Consequence-based Risk Management (CRM) Framework, enables the execution of loss assessment in order to reducing the assessed losses to an acceptable level. A Software MAEviz was introduced as a tool to coordinate planning and event mitigation, response, and recovery. It was chosen, as a platform to assess earthquake losses for many countries United States of America, Turkey, China, and Austria. Once again UIUC has chosen to take the global challenge aided by the NCSA, at the time being MAEviz software, is being developed into the global software «mHARP», Multi Hazard Assessment, Response, and Planning. Many partners from different countries are involved: United States of America, United Kingdom, Austria, New Zealand, China, South Korea, United Kingdom, Lebanon and Trinidad and Tobago.

The university of Illinois does not have a specific earthquake engineering concentration in the curriculum, nevertheless the structural engineering program and geotechnical engineering program contain earthquake engineering courses as part of the multidisciplinary learning and students are very involved through their master projects and PhDs degree in the multidisciplinary global learning in the research center and are actively participating to the multidisciplinary globalized research.

3.4. Recommendations.

As seen in the presented three educational institutions, the curriculum in the Earthquake Engineering Masters’ degree is in general getting a more multidisciplinary aspect including a broader range of courses.

Nevertheless a greater effort can be made in introducing more disciplines. The social sciences in the curriculum as decision analysis and risk management which are very essential in the program need to be introduced more effectively because they solve several fundamental issues in earthquake engineering (e.g. the issue of strengthening the great percentage of existing buildings, the application of the performance based earthquake engineering methodology, and the earthquake loss estimations procedure which purpose is to link engineering to the decision making process).
Proposing multilingual programs could be interesting, since earthquake engineers have the mission to solve universal problems, as the one caused by the earthquake itself, they need to be sent in field missions after the occurrence of an earthquake and work in a multicultural environment, thus mastering an additional language could offer a great help. This could be achieved through the establishment of several cooperation between engineering departments of several universities form different countries and different cultures, which opens the chance to students to achieve one semester of the curriculum in a different cultural environment.

Joint courses between engineering department and other departments (sciences, business, etc...) or to be involved in pursuing one or two electives in other departments than the engineering should be encouraged. Joint laboratory courses are interesting to establish. Interdepartmental Master Graduation Projects should be promoted. This exposure can easily help students to achieve innovation either in their research or technical, actual or future professions.

The interesting experience of the «multidisciplinary engineering summer school in an industrial setting» [3], encourage to apply the concept instead of the summer training that engineering students achieve during the summer.

In order to achieve that, many issues needs to be solved as the need to train the faculty members to be able to handle global and multidisciplinary vision and curriculum, in order to offer the best to the students. Moreover the need to balance multidisciplinary engineering with fundamentals must be accomplished.

4. Conclusion

The world is becoming smaller, more dynamic and competitive. Hence it is very challenging for the engineering education establishments, who prepare future leaders and engineers, to follow the rhythm of the extremely fast and global development. The future engineer’s generations will be dealing with global issues and addressing sophisticated, multidisciplinary and multicultural problems. They need to have capabilities to link topics of different subjects and disciplines, in order to propose the most suitable solutions. Engineering educational institutions needs to find the balance between engineering subjects and social sciences, accounting for the dynamic changes in technology, pedagogy and importance of long life learning [9]. Many institutions already have included multidisciplinary multilingual educational programs. The multidisciplinary Earthquake engineering successful experience has started more than fifty years ago, and was reflected through multidisciplinary educational programs. Once again Earthquake engineering are taking the lead and moving forward to deal with global issues, lifting up the geographic boundaries.
Acknowledgement

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References


Accreditation and Excellence in Architectural Education

Faculty of Architectural Engineering, BAU, As an Example

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Accreditation, Definition:

Educational accreditation is a type of quality assurance process under which services and operations of educational institutions or programs are evaluated by an external body to determine if applicable standards are met. If standards are met, accredited status is granted by the agency.

RIBA accreditation

Acquiring the RIBA accreditation was a major milestone in the path of the faculty of Architectural Engineering in Beirut Arab University. The process itself presented countless advantages regarding the documentation prepared for the visit, which managed to organize and file all course documents (Course outlines, Specifications...Etc.). This led to a continuous follow-
up in all Faculty-related documents as well as amendments, both curricular and non-curricular; in order to better meet the RIBA Accreditation requirements.

The validation criteria have helped on re-organizing the curricula in terms of order, so that different courses are taught in sequence, both vertically and horizontally.

On the other hand, the faculty has always surpassed other faculties of architecture by teaching subjects relevant to the engineering field which serve as a good background to the modern practice of Architecture. This aims at teaching students the relevance between Architecture as an Art and Architecture as a science and the need to combine them into both Functional and Aesthetical requirements.

The RIBA accreditation has led to a high raise in the educational standards of the faculty, which has always maintained its respectable reputation among other Faculties of Architecture, both in Lebanon & the Middle East. Following the RIBA general criteria, amendments have been made to the educational process, regarding the curriculum as well as preparing students more adequately into the whole concept of becoming an Architect, in terms of presentation & marketing skills, communication, & critical thinking, never disregarding the actual educational knowledge of theories and histories. The aim is to create an Independent and confident Architect, capable of self-expression and equipped with communication skills and critical thinking.

Excellence- as a definition- is a talent or quality which is unusually good and so surpasses ordinary standards. It is also an aimed-for standard of performance.

In order to achieve excellence, the Faculty of Architecture in Beirut Arab University has always strived to provide advanced learning environments which would eventually lead to the production of eligible Architects who are able to compete and excel in real life practice, and not only theoretically.

Education is undergoing constant changes under the effects of globalisation. Driven by technology and communication, developments are shaping children, the future citizens of the world into ‘global citizens’, intelligent people with a broad range of skills and knowledge to apply to a competitive, information based society. The future of countries often lies within their ability to compete in a global market where industrial based economies are giving way to knowledge based industries.
Thus, Education is becoming a lifelong learning and training process, therefore developing transferable skills and knowledge that can be applied to competitive markets. Education is becoming more invaluable to individuals.

In today's environment, education provides individuals with a better chance of employment, which in turn leads to a better lifestyle, power and status.

Consistent with the master plan of Beirut Arab University, the Faculty of Architectural Engineering has always been committed to delivering a professional architectural education while providing an educational atmosphere that respects individualism and diversity through fostering the development of articulated, creative and rational design & problem-solving process; thus aiming into reaching an Excellent standard of Education.

The Faculty of Architectural Engineering takes the responsibility of educating architects and planners who would practice and excel in their career in a responsive manner, thus being responsible to the society, culture and the environment, while advancing architectural knowledge through research and critical thinking as well as using all attained knowledge to benefit local, regional and global communities. The courses offered in the faculty are relevant to modern professional practice by covering recent and contemporary architectural theories.

Globalization and Excellence in education have always been part of the mission of the Faculty. Achieving this goal incurred some modifications on all aspects of the educational process, mainly through abiding to international educational standards. Visiting professors and External Examiners are summoned each year from different schools of Architecture from around the world in order to introduce students to various intellectual methods of International Architecture. Students then are given the freedom to define their future path as prospective Architects, nevertheless taking into consideration their acquired knowledge throughout the 5 years of Architectural Education.
“HAND-BRAIN ALLIANCE”

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Abstract

Shanghai Jiao Tong University (SJTU) is one of the top five universities in China; its students are generally excellent with high IQ. However, students majoring in civil engineering in SJTU tend to be uninterested in their major, which results in a lowered quality of undergraduate education. To improve the situation many efforts have been made, such as to move the education from teacher-centered to students-centered, from knowledge transfer-centered to capacity building-centered and from classroom-centered to outside-classroom. Up to date, the students’ learning condition has been improved obviously. Students become more interested in civil engineering and their teams have won six championships successively in the National Structural Design Competition. It is found that the most important in the education improvement is to make engineering education programs more welcoming. The key point is to make students’ “Hand-Brain Alliance” to explore students’ potential.

1.Raise a problem

Since 80s of the last century the steady economic growth of China has been commonly recognized in the world. Until 2010 the gross domestic product (GDP) of China has been reached second one. Following the process of industrialization and urbanization, China has become a largest construction field in the world. Under the developing background, however, young men in China are not very interesting in engineering specialities, especially in traditional specialities.

As an example, in civil engineering department at Shanghai Jiaotong University (SJTU), a considerable proportion of students are complaining about that, the civil engineering is not their original choice, they actually are passively arranged in civil engineering department,
which means that they like some other specialities, since their grades are lower, they could not have more choices.

It is clear that the annual financial support for education from the central government of China is increasing; various education promotion programs and students’ creation plans are presented continuously. In the last century, since the financial problem many works could not be done, but now, the financial condition has been improved a lots, what has been done is still questionable. From the Global Competitiveness Report 2012-2013 of the World Economic Forum, about 81% under-graduated students from engineering schools in US can be competent for works immediately, but in China the relative percentage is only 10%.

Some student presents the following definition of examination on web set: “What is the examination in university? It is not a test on IQ, it is a test of physiological limit and EQ, the ability of collecting relative information, the ability of showing bosh, the ability of self-studying, the ability of quick recitation, the spying ability, the mental carrying capacity on bogus contents, and how much money to copy a great lots of examination papers.

Please take look at a typical student distribution in classroom (Fig.1) which is given by students. There are some particular areas for sleeping, for game players, for unsatisfied students, ambitious students and overdue students. It is really questionable how many students in class are listening to their teacher seriously?

![Fig.1 Typical student distribution in classroom](image)

In China you may hear “to build a creative educational system to train qualified students to
meet the needs of the country” everywhere, which means that most people have recognized the importance of creation for the country, but it seems that there are many slogans without essential improvement in engineering education. Where is the sticking point?

2. Analyse the problem

In China, it is often neglected that there is a very inherent concept, which is the engineering is always connected with dry and monotonous works. If the word “Civil Engineering” is translated to Chinese directly, which means “Land and Timber” engineering, some people treat it as yokels’ job (Fig.2). Some students think that in civil engineering only calculation and drawing are needed. They do not understand the excellence and sapience of civil engineering during human settlement in the world. The problem is not from students but from the civil engineering education.

![Fig.2 Some people in China treat civil engineering as yokels’ job](image)

It has been lasted for long time that the theoretical training is overestimated, teaching in classroom is the most important. Most teachers have been accustomed to teach theory in classroom. They aspire to systematic and complete theory but forget that the reality is primary. In fact, engineering has two constraints from both nature and society, the theory must be connected with practice in engineering, the individuality and synthesis must be emphasized. In the new century with Information explosion and technical globalization the traditional education mode has been impacted seriously, the curriculum is expanding rapidly and the practical training programs are atrophying, the situation is getting more worse.

3. Solve the problem

The innovation of engineering education in China is a very wide and complex plan, many works should be done. From authors’ view and experience, three key points have been taken for more than ten years, which can be presented as follows. (1) From teacher-centered education to students-centered education, the transition process should be done in class by every effort from teachers. (2) From knowledge transfer-centered education to capacity building-centered education, the transition from indoctrinization to heuristic approach, from school to society, from student learning to life-long learning should be done in school as
quick as possible. (3) From classroom-centered education to outside-classroom education, the awareness on “All genuine knowledge originates in direct experience…” [1] and the principle of “creation must be proven by practice”[2] should be emphasized.

3.1 To improve and rearrange the education system and to make “the first classroom” more abundant

3.1.1 Pay more attention to mobilizing students’ interest in speciality. The students’ interest is the first of first things to ensure the education purpose and the improved result.

Since 2002 a course “Introduction of Civil Engineering” has been provided by Prof. Xi-la Liu at SJTU, in which many examples are shown to convince students to take civil engineering as their life-long job. A complete triangle knowledge structure including practice-theory-computation and three knowledge levels including analysis-system-society are mentioned. The requirements on capacities and quality are also presented. This course, as an engine, excites students’ interest (Fig.3).

3.1.2 Increase courses on systematical thinking, such as “Conceptual Design of Structures”, and emphasize a mode “thinking in global and doing from local”

Since 1998, SJTU was the first school to provide a synthetical course “Conceptual Design of Structures”, and the instructor is a chartered engineer. In this course more contents are related to synthetically decision making. It is emphasized that the element analysis should be based on structural consideration and the structural stiffness should be a mainline in structural design. The awareness of “thinking in global and doing from local” has been raised for students.

3.1.3 Move the education from classroom-centered education to outside-classroom, change “writing home works” to be “doing home works”
Since 2005, Dr. Xiao Bing Song added more practical training in the course “Fundamental of Reinforced Concrete”. The students have to finish each step independently in the test, which starts from concrete mix proportion design, reinforcement colligation, setting formwork, stirring, casting, and curing to each step on setting specimens, sticking strain gages, setting sensors, loading and finally to write the test report. Every student gets involved and gains a lot (Fig.4).

Since 2006, on the “Fundamental of Reinforced Concrete” class the students have used gypsum and wire to model reinforced concrete specimen and finished failure test on class for demonstration. Several student groups can be organized to start a competition. From the failure of specimens students can have visual and vivid observation and strong perceptual knowledge (Fig.5).

3.1.4 Across the boundaries between different courses

Since 2008 Dr. Xiao Bing Song and Dr. Wen Bing Fang have provided a joined course “Architectural Design”. It emphasizes the combination and penetration between architectural and structural fields. The connections between technology and aesthetics is so-called “Longitudinal and Transverse Connection” in SJTU.

In 2010, the students from both civil engineering department and architectural department can take a same course, which was welcoming and attractive for students. In an International “Tower of Babel” Design Competition hosted by the Union of Seven engineering Schools, a joint student team from civil engineering department and architectural department of SJTU won “the Best Construction Award” (Fig.6).
3.2 To expand “the second classroom”: to emphasize the awareness of practical education, to find the bearer of practical education, and to reduce the trace of practical education

Since 2002, when the first Structural Design Competition at SJTU was held successfully, ten years passed. During the past ten years, SJTU hosted ten competitions and the student teams from SJTU were invited to attend eight competitions and to host one competition in south-eastern China. Besides SJTU student team attended six National Structural Design Competitions. They have won 17 national or regional awards, which is so-called the best team in China (Fig.7).

The most important is not only the awards, but should be what the students really obtained in understanding and sentiment during the competitions. One of the students, Mr. Xin-Rao Chen, who was the winner of the first class award in the first National Structural Design Competition, wrote that “…hard working on it in five days, enjoying it in five minutes, loading it in five seconds, and collapse in 0.5 second….. It is our whole life in these days, in which it is full of sweat and hardship, setback and rough, especially choice, expectance and happiness.
3.3 The teachers must have rich experience to guide students.

The practical training for many young teachers is not enough; they come from a school gate and go to another school gate. When the content of a textbook is very practical some problem may happen. In China, no matter in engineering school or in science school, during interviewing new applicants may have to answer the educational background and published papers; it is hardly to show the practical experience. In the department of civil engineering at SJTU, the practical experience of faculty members is needed, and to have a registered engineer license is getting more important. This license requirement for promotion should be the same as publishing papers, which is a important step to improve faculty quality in civil engineering.

The authors, Dr. Song and Prof. Liu, have won awards from the Ministry of Education and the Ministry of Construction for several times, they also won the National Outstanding Design Award in China and the China Award from the Institute of Structural Engineers (IStructE) in UK. They not only have the National Registered Engineer Licenses (first class) but also have the Chartered Engineer Licenses. The teaching group of structural engineering in the Department of Civil Engineering at SJTU, among 25 faculty members there are 10 Chartered engineers and 6 National Registered engineers.

3.4 To build an creative atelier of structures as a platform for creative activities of students

In the atelier the research on structural engineering including geotechnics, transportation, building structure, and bridge structure can be done. At present, it gives strong support to attending various scientific and technical competitions, such as the structural design competitions between universities in Asia, the National Design Competition in China, and so on. Some students’ branches on civil engineering are very active in the atelier. The atelier area is around 250 meter square, and some loading facility, small vibrometer, high-speed camera, and laser cutting machine are equipped in. The atelier opens seven days a week, students can work on modeling, loading and evaluating inside. (Fig.8 and Fig.9).

Fig.8 Instructors in the creative atelier of structures
4. Education Results

Considering the characteristics of engineering education some positive results can be obtained by ten years’ hard work, it can be shown as follows.

4.1 Attractive education is the most favorite for students

In SJTU, the topics for competition are always changing to keep interesting, such as “Fishing” in 2009, “Cutting out” in 2011 (Fig.11), and “Crossing the barrier” in 2012 (Fig.12).

It seems that “interesting” is the best teacher, “to muster the student interesting” is the origin of education, which is also the most favorite for students. Prof. Xi-la Liu, Dr.
Xiao-Bing Song and Dr. Wen-Bing Fan were elected as “the most favorite teacher” by SJTU students (Fig.13).

![Prof. Xi-la Liu Dr. Xiao-Bing Song Dr. Wen-Bing Fan](image)

**Fig.13 The most favorite teachers in SJTU**

4.2 The awareness on “All genuine knowledge originates in direct experience…” [1] should be strengthened and the principle of “creation must be proven by practice” [2] should be emphasized.

To educate students to understand the importance of “working by hand” is not easy, which seems a common sense for students in high school and is not suitable for university students. In fact it is lagging indeed. No matter how beautiful the theory is, no matter how clever the designed scheme is, they must be proven by practice. During doing the students can not only integrate the learnt knowledge, but can also be excited in specialty (Fig. 14).

![Happy learning from doing](image)

**Fig.14 Happy learning from doing**

4.3 Considering the characteristics of civil engineering and architecture, to combine the technical and Aesthetic education to create SJTU style

Mr. Huan Cheng Jiang, an academician of Engineering Academy in China, said that “the reasonable structure presents an architectural beauty”. Another academician of Science Academy in China, Mr. Kang Qi said that “it is impossible that an architect becomes an artist completely, architect should be a combination of engineering technology with art.
In SJTU the department of civil engineering and the architectural department are in same school, there are many traditional exchange channels between two departments. The faculty members from both departments have clear consciousness on how to keep the cooperation, which is an advantage of SJTU.

![Image of structural design competition on new topics](image)

Fig. 15 Structural design competition on new topics

4.4 Following engineers’ requirements to build students’ capacity

On class, the principle of “Teach one, Home work two and Examination three” will use to give students necessary training, by which students may have capacity on self-learning and long-live learning. The adoptability of students is the first requirement in capacity building, which had been recognized in wind generation (2008) and disaster prevention of mudslides (2012) (Fig. 15)

5. Conclusion

Under the developing background, young men in China are not very interesting in engineering specialities, especially in traditional specialities. Based on over ten years’ effort made at SJTU it is found that the most important in the education improvement is to make engineering education programs more welcoming. The key point is to make students’ “Hand-Brain Alliance” to explore students’ potential.

This is a very precious time to review what a great Chinese educator, Mr. Xing-Zhi Tao (1891—1946), said. He mentioned to us that “The common fault in Chinese education is to teach brainworkers without using hands and to teach manual workers without using brains, and therefore neither of them can do anything.” He also mentioned that “The only countermeasure is to make hand-brain alliance, which can bring both hands and brains with incredibly great power.”[3]
References

INCORPORATING COMMUNICATION SKILLS IN ENGINEERING EDUCATION: THE CASE OF LEBANON

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Abstract

After globalization and the rapid advancement of technology, the nature of engineering work has dramatically changed to involve more teamwork and communication across multidisciplinary teams that are often geographically distant. Researchers and employers have agreed that the 21st century engineer must have a set of required skills that were not emphasized in the past. Most universities, including those in developing countries, have started to incorporate various general education and non-technical courses in their programs as recommended by accreditation bodies and research in order to graduate well-rounded engineers ready for working in a 21st century business environment. However, a main question remains to be whether engineering students really understand the importance of such courses and the reason why they need to gain the associated skills. In this study, a sample of undergraduate engineering students in a developing country was surveyed to determine their perceptions about the importance of various soft skills including communication skills and how well their universities have equipped them with these skills. Moreover, the students were surveyed regarding their perceptions about industry expectations and the factors that contribute to recruitment and promotion of engineers. The results were used to assess the role of universities and to recommend further improvements in this area.

Keywords: engineering education, soft skills, communication skills, student perceptions
1. Introduction

Globalization is a concept that engineers must not only understand but also incorporate into their everyday business and professional lives. Globalization has changed the way engineers work while mandating their communication with diverse people from various backgrounds, cultures, and languages. In addition to the importance of communication in conducting global business, good communication skills are a requirement for successful leadership [5]. Until now, it is widely acknowledged that the main strengths of engineers lie within their technological skills and their main weaknesses are associated with their management and communication skills. This is mainly because engineering education exposes engineers to little or no ‘soft’ training needed in the global professional community [3].

By examining the required engineering skills and attributes for engineering graduates by various accrediting institutions and countries (USA, UK, EU, AUS, and Japan), it was shown that many of the common employability skills for engineers constitute of non-technical skills. Some of the main non-technical skills required by engineers are communication skills, teamwork, lifelong learning, professionalism, and decision-making skills [12]. In addition, based on interviews conducted with professional engineers in supervisory rules, it was shown that most recent graduate engineers start their entry-level positions as junior members operating in teams. The interviewed professionals reported that graduates with little previous teamwork experience face problems in their first jobs [4]. Other research studies assure this finding and emphasize the importance of functioning well in a team-based environment as a success factor for new engineer hires. Moreover, the teams that engineers need to work with today do not consist solely of other engineers and technical people. Companies are continuously developing their team structures to become more product-oriented and involve personnel from marketing, engineering, manufacturing, etc. This raises a need of not just teamwork ability but more specifically multi-disciplinary teamwork and communication [1]. As an attempt to prepare their students to become “global engineers”, Japanese engineering schools found that there is a need for curricular change even in Japan’s tightly regulated academic world [2]. Having been the leaders for decades of many technologies the Japanese, like the Americans and others, have started relying on other countries in several stages of the manufacturing of their products such as the famous Toyota cars. To retain a competitive edge and keep their engineers in the lead, Japanese engineering schools realized the importance of teaching students how to succeed in cross-cultural teams. That meant focusing on communication skills, leadership skills, the ability to work in teams, as well as oversees management [2].

It was shown more than a decade ago that communication skills for engineers were highly valued from the industry perspective and somehow from the academic perspective
but not from the students’ perspective [8]. Communication skills include oral communication with managers and peers, presentation skills, business writing skills, and cross-cultural communication abilities. All of these areas can be tackled at the undergraduate level if well incorporated in the courses offered by the engineering programs [9]. Graduating effective communicators does not mean offering a required course on communication in engineering schools but instead it entails incorporating the communication component in all courses by working on class projects, class teams, and oral and writing reports [5].

2. Problem Statement

Engineering employers highlight the importance of gaining communication, teamwork, management, and other soft skills in the engineering programs as these skills are believed to be major ingredients of success for the graduate engineer in his/her entry-level job. For this purpose, the Accreditation Board of Engineering and Technology (ABET) recently updated its engineering accreditation criteria to include a set of professional or “soft” skills in addition to the traditional technical or “hard” skills that aid students to become better prepared to face the challenges of the real business world. In spite of the efforts to align their curricula with the new ABET requirements, engineering programs still by large mainly emphasize the technical skills while paying insufficient attention to the non-technical skills. This paper investigates the extent to which universities have started incorporating the essential soft skills required by the industry through examining the degree of exposure and understanding of these skills by senior undergraduate students in prominent engineering programs in Lebanon. Special emphasis is paid to communication and teamwork skills.

3. Methodology

Based on the literature review and the objectives of the study, an electronic questionnaire was carefully constructed by a team of researchers at the Engineering Management Program at the American University of Beirut. Since this study aimed to capture a general picture of how well engineering programs in Lebanon are exposing their students to soft skills, several universities were contacted and invited to participate in the survey. Four prominent universities in Lebanon participated in the survey and distributed it electronically to their students. These universities were the American University of Beirut (AUB), Lebanese American University (LAU), Beirut Arab University (BAU), and Notre Dame University (NDU). Two of these universities have been accredited by ABET for
their undergraduate engineering programs. Moreover, all of the participating universities offer general education courses and required electives on engineering management and ethics. The survey was sent out to the senior engineering students (last two years of degree) of the four universities totaling to slightly more than 2,000 students. The survey was kept open and continuous reminders were sent to students for a period of around 4 months i.e. equivalent to one semester. The total number of responses was 306 yielding a response rate of approximately 15%. After collecting all responses and closing the survey, the respondents were distributed as follows: AUB – 66.2%; LAU – 14.4%; BAU – 11.9%; NDU – 7.4%.

4. Results

In this section, the results pertaining to five questions from the afore-mentioned survey will be presented and analyzed. All five questions were directly related to communication and teamwork skills to suit the objective of this study.

The first question in the above-mentioned survey that is of interest to this study is a question pertaining to the perceptions of undergraduate engineering students of the engineering profession and practicing engineers in the workplace. The answer choices involved a rating on a 5-point Likert scale of the truthfulness of nine statements. As shown in Figure 1, all statements received a rating greater than 3.5 except for one statement pertaining to the communication skills of engineers. Students strongly believed that employers and society respect engineers. They also confidently believed that engineers can shift easily from technical to management positions, can perform well in teams, and enjoy an interesting and satisfying work. Moreover, students on average believed that engineers have an important decision-making role in their organizations and often get good promotions and would ultimately assume a high level position in their career. In relation to that, the majority of students also believed that engineers make good managers. However, there was a wide dispersion in students’ views of whether engineers receive adequate compensation and salaries as this statement received a lower rating than all other statements of average rating above 3.5. Finally, students gave an average rating of less than 3.5 for the truthfulness of engineers being good communicators. This result has an important implication as it shows that even engineering students who will become engineering practitioners in a year or two do not believe that engineers in the workplace have good communication skills.
In order to determine whether students truly understand the importance of various soft skills in getting them recruited after graduation to their entry-level positions, they were asked to rate the importance of a variety of employability factors from a 1 to 5 Likert scale. Two out of the twelve presented factors pertained to communication and teamwork skills. Interestingly and as shown in Table 1, the ability of performing well on teams received the 3rd highest rating by students. Moreover, communication skills, whether oral or written, also received a significant rating of 3.9.

<table>
<thead>
<tr>
<th>Importance of engineers’ recruitment factors</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education (Reputation of Degree &amp; University)</td>
<td>4.43</td>
</tr>
<tr>
<td>Motivation &amp; need for achievement</td>
<td>4.23</td>
</tr>
<tr>
<td><strong>Teamwork &amp; leadership skills</strong></td>
<td><strong>4.22</strong></td>
</tr>
<tr>
<td>Relevance of education with applied position</td>
<td>4.05</td>
</tr>
<tr>
<td>Creativity &amp; optimism</td>
<td>3.96</td>
</tr>
<tr>
<td><strong>Communication &amp; writing skills</strong></td>
<td><strong>3.90</strong></td>
</tr>
<tr>
<td>Internship(s)</td>
<td>3.83</td>
</tr>
<tr>
<td>Connections</td>
<td>3.81</td>
</tr>
<tr>
<td>Cumulative Average (GPA)</td>
<td>3.72</td>
</tr>
<tr>
<td>Risk-taking propensity</td>
<td>3.57</td>
</tr>
<tr>
<td>Extracurricular activities</td>
<td>3.30</td>
</tr>
<tr>
<td>Gender &amp; physical appearance</td>
<td>2.79</td>
</tr>
</tbody>
</table>

Table 1: Engineering students’ perceptions of the importance of employability skills from the employer’s perspective
As the inclusion of non-technical courses is still fairly new to engineering education, it was important to survey students about the importance of enrolling in these courses. What is more important is use the students’ perceptions regarding these courses to infer the importance they give to learning the embedded skills in them. The courses are list in a descending average rating order in Table 2. Risk Management received the highest mean rating from students. This is a very interesting result because Risk Management is not a required course in the participating engineering schools. However, it seems that engineering students have grasped the importance of understanding risk and evaluating it in engineering practice based on what they know from the industry. Focusing on communication skills, it can be seen that students gave a high rating to the Technical Writing course, which is a mandatory course for all engineering majors in the participating universities. However, this course that embeds the skills of written communication showed up towards the bottom of the list indicating that although students believe in its importance, they tend to prioritize other soft skills such as project management and ethical decision making.

<table>
<thead>
<tr>
<th>Importance of Course/Skill</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Management</td>
<td>4.20</td>
</tr>
<tr>
<td>Project (or construction) management</td>
<td>4.17</td>
</tr>
<tr>
<td>Decision analysis</td>
<td>4.13</td>
</tr>
<tr>
<td>Sustainable development</td>
<td>4.10</td>
</tr>
<tr>
<td>Contemporary technological issues</td>
<td>4.01</td>
</tr>
<tr>
<td>Engineering economy</td>
<td>3.99</td>
</tr>
<tr>
<td>Engineering ethics</td>
<td>3.93</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>3.89</td>
</tr>
<tr>
<td>Technical writing</td>
<td>3.83</td>
</tr>
<tr>
<td>Management Theory</td>
<td>3.81</td>
</tr>
<tr>
<td>Basic accounting/finance</td>
<td>3.38</td>
</tr>
<tr>
<td>Basic marketing</td>
<td>3.27</td>
</tr>
</tbody>
</table>

*Table 2: Students’ perceptions of the importance of non-technical courses and the embedded soft skills in their engineering education*

In general, the surveyed engineering students had a good understanding of the factors affecting the promotion of engineers and could significantly rate all eleven factors that were listed in the questionnaire. Table 3 shows the factors that were presented to students
with a descending rating. Interestingly, the communication factor came third in the list. A vast majority of students believed that having good oral communication and presentation skills is highly important for engineers to be promoted in their organizations.

<table>
<thead>
<tr>
<th>Factors affecting engineers’ promotion</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being innovative and creative in finding solutions to technical problems</td>
<td>4.41</td>
</tr>
<tr>
<td>Showing strong abilities on supervising/managing others</td>
<td>4.34</td>
</tr>
<tr>
<td><strong>Having good oral communication and presentation skills</strong></td>
<td><strong>4.26</strong></td>
</tr>
<tr>
<td>Having a broad view of problems and seeing the big picture of the organization</td>
<td>4.18</td>
</tr>
<tr>
<td>Engaging in self-development and continuous learning involving technical knowledge</td>
<td>4.17</td>
</tr>
<tr>
<td>Having strong ethical conduct and behavior</td>
<td>4.14</td>
</tr>
<tr>
<td>Recognizing &amp; exploiting business development opportunities within the organization</td>
<td>4.12</td>
</tr>
<tr>
<td>Being on good terms with supervisors/top managers</td>
<td>4.07</td>
</tr>
<tr>
<td>Being helpful and supportive with colleagues</td>
<td>3.91</td>
</tr>
<tr>
<td>Practicing extended work involvement (e.g. working long hours, taking projects home)</td>
<td>3.89</td>
</tr>
<tr>
<td>Being customer-oriented</td>
<td>3.77</td>
</tr>
</tbody>
</table>

*Table 3: Students’ perceptions of the importance of promotion factors for engineers in the workplace*

It seems that students have a proper understanding of the importance of soft skills and the need to gain them during their education. To determine whether Lebanon’s top engineering programs are adequately equipping their future engineers with these skills, the 306 surveyed students were asked about their opinions of how well their universities have prepared them for performing ten different tasks pertaining to various soft skills. Of interest to us are teamwork and communication skills. As shown in Table 4, students believed that they were well prepared to work effectively in a team, and a little less prepared to write a technical report. However, when asked about the oral communication skills, students tended to agree to a lesser degree that they were well prepared to conduct oral presentations in front of an audience. According to the significant rating mean of 3.5 used in this study, the average rating of the oral communication skills was not significant. This means that there is a loophole in how engineering schools in Lebanon are dealing with enforcing oral communication skills and how they are being embedded in the curriculum.
### Table 4: Engineering students’ perceptions of their preparedness from their universities to do certain tasks

<table>
<thead>
<tr>
<th>Perception of university preparedness</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying and assessing engineering problems within realistic constraints such as economic, environmental, social, and safety factors</td>
<td>4.02</td>
</tr>
<tr>
<td>Leading a small team</td>
<td>3.95</td>
</tr>
<tr>
<td><strong>Working effectively in a team</strong></td>
<td><strong>3.90</strong></td>
</tr>
<tr>
<td>Dealing with people from different cultures and backgrounds</td>
<td>3.78</td>
</tr>
<tr>
<td><strong>Writing a technical report</strong></td>
<td><strong>3.71</strong></td>
</tr>
<tr>
<td>Performing research on emerging technologies and learning new techniques on your own</td>
<td>3.69</td>
</tr>
<tr>
<td>Recognizing &amp; transforming opportunities for developing new technologies</td>
<td>3.62</td>
</tr>
<tr>
<td><strong>Conducting an oral presentation in front of an audience</strong></td>
<td><strong>3.41</strong></td>
</tr>
<tr>
<td>Dealing with an ethical dilemma</td>
<td>3.4</td>
</tr>
<tr>
<td>Evaluating potential risks and dealing with uncertainty</td>
<td>3.18</td>
</tr>
</tbody>
</table>

**5. Conclusion**

By comparing the survey’s results with similar previous literature, it can be inferred that students have raised considerable awareness of the importance of soft skills in their engineering education. Also, universities have finally started to seriously tackle the needs of the industry and pay more consideration to the set of non-technical skills required for succeeding in the workplace. Although students in Lebanon do appreciate the soft skills that are taught at the undergraduate level, the conducted survey showed that they emphasize on teamwork and written communication skills more than oral communication skills. This implies that there is an additional effort required from engineering schools to pay more attention to this area and enforce it throughout the curriculum. Ultimately, the industry does not only require good Communicators in writing but also good oral communicators who can deal with the employers, peers, suppliers, customers, and others.
References


Acknowledgments

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Abstract

The issue of compatibility between the learning outcomes of the higher education system and the requirements of economic and social development and the needs of the market is one of the most important issues of development in any of the countries, and because the higher education is an essential source of human resource development. Universities are trying to focus on the quality of education, through the use of systems and means of modern education, including the quality assurance to highlight the efficiency to the national and international needs and requirements. As the Islamic University of Lebanon, is always working on upgrading academic and scientific developments in order to incorporate them into study programs, and seeking to assure the
compatibility between the learning outcomes and goals to meet the needs of the community, as well as looking to find out the problems of its graduates in the various practical sectors, so by communicating with them and with related companies and also with the market.

The purpose of this study was to evaluate the learning outcomes of the educational process for graduates of Surveying Engineering Department in the faculty of Engineering at the Islamic University of Lebanon, in order to identify the suitability of the learning outputs of this section with the requirements of development and the needs of the Lebanese and Arab market. To achieve this goal, a statistical approach has been used as a direct scientific way in accordance with the nature of this study. This study was based on the Department of Surveying Engineering graduates at the Islamic University of Lebanon since the academic year 2002 until 2011, where a direct contact is done with the possible number of the graduates of this Section (69 out of 116 graduates) to collect the needed information for the survey.

The analysis of the data showed many important points: Despite the availability of employment opportunities in the Lebanese and Arab market for the graduates of this section, but the learning outcomes does not completely fit with the nature of the work of graduates, and some courses may need to improve, and it is advisable to develop some theoretical and practical courses related to the new market requirements.

At the end of this study some recommendations that are related to the market are provided in order to increase in general the competitiveness of Surveying Engineering graduates, and also to improve the compatibility between what is provided by the Department of Surveying Engineering at the Islamic University in Lebanon and the needs of the market.

الكلمات المفتاحية: ضمان الجودة، البرامج التعليمية، المخرجات، التنمية، سوق العمل، الخريجين.
المقديمة

شهد التعليم العالي في لبنان خلال العقود الماضية تطورات تنموية هائلة، إن كان على صعيد الزيادة في اعداد الجامعات والمتطلبات التعليمية والمصرّدة، وبناءً على زيادة الارتفاع والمصرّدة، وأيضاً إلى التطور الحاصل في التعليم العالي في لبنان، إلا أن الاهتمام بمشاريع نظام التعليم العالي والمتطلبات المتطلبة، لم يظهر إلا خلال السنوات العشر الأخيرة. لقد تم ارتكاب الجامعات من خلال ورش العمل والمؤتمرات التي كانت تقوم مؤسسات التعليم العالي اللبنانية بدعم وتوجيه من مديرية التعليم العالي في وزارة التربية الوطنية وبعض المؤسسات العلمية والترفيهية الدولية [1]، وذلك بهدف تحقيق درجات الملاءمة بين ما تقدمه مؤسسات التعليم العالي في لبنان ومع متطلبات التنمية المستدامة واحتياجات سوق العمل، حيث قام بعض الجامعات بإفتتاح بعض التخصصات الجديدة المتصلة بسوق العمل مثل تخصصات صناعية بيدنية وطبية وغيرها. وتشمل قبل الطلاب في بعض الاحصائيات، أو بعض الأقسام القائمة، وذلك لضمان تعويض احتياجات السوق.

إن التعليم العالي وسوق العمل عضوان متلازمان متراابطان لا بد من التوفيق بينهما، وذلك لتحقيق الشراكة بين البرامج العلمية والتخصصات التي تقدمها مؤسسات التعليم العالي واحتياجات سوق العمل الحالية والمستقبلية [10]. يؤدي عدم التوازن بينهما إلى خسارة الإمكانات المالية التي تصرفها في تمويل تخصصات وبرامج ترتبط بالخطط الموضوعة للتطوير وتدريب الطلاب الشابية وبدعم توجهها إلى المهن المتصلة.

وإلى فإن توازن التخصصات التعليمية مع متطلبات التنمية الوطنية واحتياجات السوق، تعتمد بالدرجة الأولى على دراسة تحليل الوضع الراهن لتعليم العالي ونوع التدريس بين ما يعزز هذا النظام وما يتيحه سوق العمل، وبالتالي العمل على وضع برامج وسياسات تنمية تعامل على حد حجات السوق من الخريجين وتنمية متطلبات الاستثمار الذي يساهم في التنمية الوطنية المستدامة [3].

أهداف الدراسة

هادف هذه الدراسة إلى تحليل وتقديم مخرجات العملية التعليمية لخريجي قسم هندسة المساواة في كلية الهندسة في الجامعة الإسلامية في لبنان خلال السنوات العشر الماضية، وذلك من خلال الدراسة المهنية والبحث والتوافق مع خريجي هذا القسم من أجل التعرف على مدى استجابة وانخراط خريجي قسم هندسة المساواة بسوق العمل اللبناني والعبري والخروج بتصاميم واقتراحات تعمل على تحقيق درجات الملاءمة بين ما يتمدده هذا القسم ومتطلبات التنمية واحتياجات سوق العمل من جهة أخرى.

اسئلة الدراسة [2] [7]

يمكن تلخيص مشكلة الدراسة في الإجابة على السؤال الأساسي التالي:

ما مدى مواجهة مخرجات العملية التعليمية لخريجي قسم هندسة المساواة بمتطلبات التنمية الوطنية واحتياجات سوق العمل؟

والإجابة عن هذا السؤال على أولاً الإجابة على مجموعة من الأسئلة وهي:

أولاً: أي وماهي نوعية عمل خريجي قسم هندسة المساواة الحالية؟

ثانياً: ما هي الفترة الزمنية التي استغرقها الخريج للحصول على العمل؟

ثالثاً: تدفق نوعية الأعمال التي عمل بها منذ خروجه وغاية الآن.

رابعاً: تقييم خريجي القسم للقرارات النظرية والإيديولوجية التي درسوا.

خامساً: ما هي المقررات على متطلبات الديانة في عمليتهم لاحقاً؟

سادساً: كيف يمكن بشكل عام تطور قسم هندسة المساواة في لبنان مع متطلبات التنمية، وبالتالي مع سوق العمل؟

هندسة المساواة في الجامعات اللبنانية [12]

تعتبر دراسة هندسة المساواة في المجالات الهندسية الحديثة التي بدأت الجامعات اللبنانية الاهتمام بها في الأونة الأخيرة.

فالأخص الحفاظ عليه جزءاً من ضمن مصطلحات الهندسة الحالية، وما زال هذا الاهتمام وانتشاره في نفاذة المهندسين في بيروت يدخل في نطاق اختصاص الفرع الأول. المهندسين المدنيين الاستشاريين.

1. جدول رقم (1): تطور أعداد الطلاب المخريجين في قسم هندسة الساحة في الجامعة الإسلامية في لبنان

<table>
<thead>
<tr>
<th>العام الدراسي</th>
<th>عدد الخريجين</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>1999-1998</td>
</tr>
<tr>
<td>-</td>
<td>2000-1999</td>
</tr>
<tr>
<td>-</td>
<td>2001-2000</td>
</tr>
<tr>
<td>-</td>
<td>2002-2001</td>
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<td>2</td>
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<td>14</td>
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</tr>
<tr>
<td>11</td>
<td>2009-2008</td>
</tr>
<tr>
<td>14</td>
<td>2010-2009</td>
</tr>
<tr>
<td>8</td>
<td>2011-2010</td>
</tr>
<tr>
<td>المجموع العام</td>
<td>116 خريجاً</td>
</tr>
</tbody>
</table>

وفي العام 2005 بدأت الجامعة اللبنانية الدولية بتدريس هذا الاختصاص وقد تخرج من هذا القسم لغاية العام 2011 خمسة طلاب.

اما عن اعداد قسم هندسة الساحة في الجامعة الإسلامية في لبنان فإنه قد قطع خطواتًا كبيرة في تدريب وخططه الأكاديمية وتشغله العلمية والبحثية، وباستخدام مجال تطوير مخترعاته وربطها بمطلوباتها السوقية، وذلك بهدف تحسين درجات التوافق بين ما يقدمه هذا القسم من كورس علمي تجارب مع متطلبات التنمية الوطنية واحتياجات السوق اللبناني والعربي. وقد واجب هذا التطور في القسم تطورًا متسارعًا، باعداد الطلاب المتخرجين بهذا القسم، حيث ان نسبة النمو زادت سنة بعد سنة إلى أن وصلت في العام 2011 حوالي 40% مقارنة مع العام 2010.

5. منهجية الدراسة

من أجل تحقيق هدف هذه الدراسة المتصلة في تحليل وتقييم مخرجات العملية التعليمية لخريجي قسم هندسة الساحة في الجامعة الإسلامية في لبنان، ومن أجل التعرف على أراء الخريجين في البرنامج التعليميennifer العائدة للقسم، وقد توقفت هذه البرامج مع متطلبات السوق، فقد تم التواصل مع الخريجين لمعرفة أراءهم حول الأمور التي سبق ذكرها.

ان قسم هندسة الساحة في الجامعة الإسلامية في لبنان يتمتع بخبرة لا تسبق نظيرًا وفيرة وكفاءة كوارد ودوبخريجية الذي يعمل قسم كبير منهم في الدول العربية في شركات هندسة متخصصة في البناء والمساحة في النشاط العربي، والقسم الآخر يعمل في لبنان في شركات متخصصة بالطرق والمساحة، وفي مجال التعليم، وفوقًا منهم من يتابع دراسات عاليا في اختصاصه، وقد تم الحصول على إمكانية التواصل مع 69 خريجاً من أصل 116 موجودون في لبنان وفي الخارج خلال سنوات التخرج 2002 ولغاية 2011. والجدول أدناه يبين توزيع مكان ونوعية عمل الخريجين:

<table>
<thead>
<tr>
<th>المجمع العام</th>
<th>مجال عمل الخريج</th>
<th>مكان العمل</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>لا يعمل</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>يعمل في آخر</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>في التدريس أو</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>أثر الدراسة</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>في مشروعات</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>إنهاء المهام</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>والطرق</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>في أعمال الساحة</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>والطرق</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>في أعمال الساحة</td>
<td>داخل لبنان</td>
</tr>
<tr>
<td></td>
<td>والطرق</td>
<td>داخل لبنان</td>
</tr>
</tbody>
</table>
في هذه الدراسة تم استخدام استمارة كأداة لتحقيق هدف الدراسة وقد تم إعداد الاستمارة المطروحة سابقاً في ثلاثة محاور رئيسية، وفي كل محاور أدرج عدد من الفقرات وذلك لتسهيل دراسة العمل الإحصائي:

- المحور الأول: يسأل عن طبيعة عمل الخريج والفترة الزمنية التي استغرقتها للحصول على عمله الحالي.
- المحور الثاني: درجة ملاءمة مخرجات القسم لمطبعة عمل الخريج ودرجة الاستفادة من المقررات التي درسها.
- المحور الثالث: التوصيات التي يمكن أن تعمل على تطوير قسم هندسة المساحة ليتلاند مع متطلبات التنمية وسوق العمل.

6. نتائج الدراسة

6.1 المحور الأول

يوضح الجدول رقم (3) نوع عمل خريجي قسم هندسة المساحة والفترة الزمنية التي استغرقتها لحصوله على عمله الحالي، حيث تشير الدراسة إلى أنه حوالي 84% من خريجي القسم يعمل في القطاع الخاص وآن (83%) من الخريجين وجدوا عملهم في أقل من سنة بعد خروجهم.

<table>
<thead>
<tr>
<th>الجهات بالرقمية</th>
<th>العدد الداخلي</th>
<th>النسبة المئوية</th>
</tr>
</thead>
<tbody>
<tr>
<td>القطاع الخاص:</td>
<td>51</td>
<td>74%</td>
</tr>
<tr>
<td>شركات</td>
<td>7</td>
<td>10%</td>
</tr>
<tr>
<td>مكتب</td>
<td>8</td>
<td>12%</td>
</tr>
<tr>
<td>حكومي:</td>
<td>3</td>
<td>4%</td>
</tr>
<tr>
<td>اخر:</td>
<td>69</td>
<td>100%</td>
</tr>
<tr>
<td>إجمالي:</td>
<td>69</td>
<td>100%</td>
</tr>
</tbody>
</table>

الفترة الزمنية لحصول الخريج على عمله الحالي

<table>
<thead>
<tr>
<th>الفترة الزمنية</th>
<th>العدد الداخلي</th>
<th>النسبة المئوية</th>
</tr>
</thead>
<tbody>
<tr>
<td>أقل من سنة</td>
<td>57</td>
<td>83%</td>
</tr>
<tr>
<td>من سنة إلى ستين</td>
<td>10</td>
<td>15%</td>
</tr>
<tr>
<td>أكثر من ستين</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>إجمالي:</td>
<td>69</td>
<td>100%</td>
</tr>
</tbody>
</table>

6.2 المحور الثاني

جدول رقم (2): مكان ونوع عمل خريجي قسم هندسة المساحة في الجامعة الإسلامية في لبنان
خصوص هذا المحور قياس:
- درجة ملاءمة مخرجات الفصل لطبيعة عمل الخريج
- تقييم الخريجين للمقررات التي درسوا ودرجة الاستفادة منها.

بوغض الجدول رقم (4) 4 درجة ملاءمة مخرجات الفصل لطبيعة عمل الخريج، حيث اشار (43) من الخريجين ان ملاءمة مخرجات الفصل لطبيعة عملهم الحالي كانت جيدة جدا، وان (22) يعتبرونها جيدة ومتلائمة مع طبيعة عملهم، وان (4) يرونها متوسطة، الأمر الذي كنا تقريبا نتوقف قبل الشرع في هذه الدراسة.

<table>
<thead>
<tr>
<th>الملاحظات</th>
<th>نسبة المنوية</th>
<th>عدد الخريجين</th>
<th>درجة ملاءمة مخرجات الفصل لطبيعة عمل الخريج</th>
</tr>
</thead>
<tbody>
<tr>
<td>لم يذكر الخريجون في استبيانهم مقررات غير مرغوبة للتدريب</td>
<td>63</td>
<td>43</td>
<td>جيدة جدا</td>
</tr>
<tr>
<td>غير مرغوبة للتدريب</td>
<td>32</td>
<td>22</td>
<td>جيدة</td>
</tr>
<tr>
<td>لم يذكر الخريجون في استبيانهم مقررات غير مرغوبة للتدريب</td>
<td>5</td>
<td>4</td>
<td>وسط</td>
</tr>
<tr>
<td>وسط</td>
<td>100</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>اجمالي</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

جدول رقم (4): ملاءمة مخرجات الفصل لطبيعة عمل الخريج.

بوغض الجدول رقم (5) 5 درجة الفائدة التي حصل عليها خريج الفصل من المقررات الدراسية النظرية والعملية في مجال عمله، حيث اشار (75%) من الخريجين ان الاستفادة من المقررات النظرية كانت جيدة جدا، وان (20%) يرونها جيدة، وان (5%) فقط يرونها متوسطة. أما عن المقررات العملية التطبيقية فكانت الاستفادة منها (83%) بدرجة جيدة جدا، وان (15%) يرونها بدرجة جيدة، وان (2%) من الخريجين يرون الاستفادة من المقرارات التطبيقية في مجال عملهم كانت بدرجة وسط.

<table>
<thead>
<tr>
<th>الملاحظات</th>
<th>درجة الاستفادة المتوسطة بين المقررات</th>
<th>المقررات الدراسة</th>
</tr>
</thead>
<tbody>
<tr>
<td>في الاستبانات لم يذكر الخريجون اياً من المقررات غير المطلوبة أو ضعيفة</td>
<td>جيدة جدا</td>
<td>المقررات النظرية:</td>
</tr>
<tr>
<td></td>
<td>%100</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>في الاستبانات لم يذكر الخريجون اياً من المقررات غير المطلوبة أو ضعيفة</td>
<td>وسط</td>
<td>المقررات العملية والتطبيقية:</td>
</tr>
<tr>
<td></td>
<td>%100</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

جدول رقم (5): تقييم خريجي الفصل للمقررات الدراسية النظرية والعملية ودرجة الاستفادة منها في مجال العمل.

المحور الثالث: 6.3

التصويبات التي يمكن ان تعمل على تطوير قسم هندسة المساحة لينتظم مع متطلبات التنمية وسوق العمل:

- التوصيبات التي يمكن ان تعمل على تطوير قسم هندسة المساحة لينتظم مع متطلبات التنمية وسوق العمل:
  - توصيبات الخريجين وإراءهم حول كيفية تطوير الفصل ومخرجاته لتنظم مع متطلبات واحتياجات سوق العمل حيث افصنت الأراء إلى نوعين: الأول: اقتراحات تصب في تحسين وتطوير البرنامج التعليمي، والثاني: اتخاذ بعض التدابير والقيام ببعض النشاطات التي تعود بالفائدة إلى الفصل.
الخلاصة والتوصيات

لقد عرض وناقش هذا البحث نتائج الدراسة الميدانية الخاصة بتقييم مخرجات قسم هندسة المساحة في الجامعة الإسلامية في لبنان خلال السنوات التسع الماضية وذلك من أجل التعرف على مدى تطابق مخرجات هذا القسم مع متطلبات التنمية واحتياجات سوق العمل، ومن ثم محاولة الخروج بتوصيات تعمل على تحسين درجات الملاءمة بين ما يقدمه هذا القسم واحتياجات السوق من جهة، وزيادة الميزة التنافسية لخريجي هندسة المساحة مع زملائهم في الجامعات الأخرى من جهة ثانية.

وقد عكست النتائج عددًا من النقاط المهمة والتي يجب الوفاء عنها ومحاولة إيجاد الأفكار لتفعيلها بشكل عملي للارتقاء بالعملية التعليمية إلى مستوى جيد، وذلك من خلال إعادة النظر في محتوى بعض المقررات التي تدرس أو ادخال مقررات جديدة إلى المناهج الدراسية (نظري وتطبيقي)، كذلك دعوة الشركات الهندسية والمؤسسات الحكومية ذات الصلة بمهمة المساحة للمشاركة في العملية التعليمية، وكذلك اتخاذ بعض التدابير والنشاطات التي تعمل على تفعيل العلاقة مع الخريجين وتواصلهم مع جامعاتهم الأم، وذلك لمعرفة ما يطلبه سوق العمل باستمرار من اشغال متقدمة في الاختصاص، والتقنيات الحديثة والبرامج المعلوماتية الجديدة المطلوبة استنادًا إلى التطور التكنولوجي الحاصل في المجالات العلمية والاقتصادية.
<table>
<thead>
<tr>
<th>ملاحظات</th>
<th>النسبة المئوية</th>
<th>عدد الخريجين</th>
<th>اقتراحات وآراء الخريجين</th>
</tr>
</thead>
<tbody>
<tr>
<td>تم تسجيل التوصيات التي حازت فقط على خمسين بالمئة وما فوق</td>
<td>75%</td>
<td>52</td>
<td>في مجال البرنامج التدريسي: التوسع والاهتمام أكثر في مقرر الطرق</td>
</tr>
<tr>
<td>خلق مقرر التصوير الجوي الرقمي</td>
<td>52%</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>خلق مقرر جديد يساعد خريج على كيفية التواصل مع الشركات وسوق العمل أو ما يعرف</td>
<td>67%</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>تدريس اللغة الإنجليزية كلغة أساسية</td>
<td>65%</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>إدخال البرامج المعلوماتية التخصصية الحديثة إلى البرنامج التعليمي</td>
<td>52%</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>تدريس مقررات في الهندسة المدنية مثل إدارة المياه، الإنشاءات، تكنولوجيا البناء...</td>
<td>78%</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>زيادة تدريس مقررات في الهندسة المدنية مثل إدارة المياه، الإنشاءات، تكنولوجيا البناء...</td>
<td>58%</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>التواصل بشكل مستمر مع الخريجين والتأكيد على أهمية الاجتماع السنوي الذي يعقد متمété الصيفي للطلاب</td>
<td>51%</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>المتابعة والاهتمام أكثر بالتدريب الصيفي للطلاب</td>
<td>60%</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>التأكيد على أهمية إجراء ندوات تخصصية أو مؤتمرات علمية ومعارض للمشاريع النهائية بين الجامعات</td>
<td>56%</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

جدول رقم (6) بين توصيات وآراء الخريجين في تطوير قسم هندسة المساحة في الجامعة الإسلامية في لبنان

المراجع
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اصدرات المركز التربوي للبحوث والانماء (2004)، التطور التربوي في لبنان مطلع القرن الحادي والعشرين، بيروت.
EXTRACURRICULAR SERVICE PROJECTS PREPARE ENGINEERING STUDENTS FOR REAL WORLD PROBLEMS

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Abstract

The number of engineering students participating in university-based international service projects has increased greatly in the past decade, reflecting evolutionary changes of what it means to be an engineering professional. While both curricular and extracurricular programs exist at many institutions, at Harvard University, international service projects have yet to become a formalized part of the engineering curriculum. These international projects provide experiences that align closely with the ABET Learning Outcomes and attributes of NAE’s The Engineer of 2020, which themselves share many commonalities. The Harvard University chapter of Engineers Without Borders – USA is an extracurricular student group that operates with faculty supervision, but is not currently part of the curriculum. Yet, the experiences that students obtain throughout the participation in Engineers Without Borders, as well as other engineering service learning organizations, can meet ABET Learning Outcomes and the foster the desirable attributes of The Engineer of 2020.

Keywords: engineers without borders, ABET, student outcomes, service learning, international, extracurricular, the engineer of 2020
1. Introduction

Extracurricular service learning projects, implemented through organizations such as Engineers Without Borders, Engineers for a Sustainable World, and other programs, have seen large increases in student interest and participation over the past decade. Simultaneously, there have been major evolutionary changes in what is required of an engineering professional. The introduction of these programs has changed engineering curricula through senior design courses at a number of academic institutions, which meet ABET accreditation requirements and foster the desirable attributes of The Engineer of 2020. Additionally, Project Based Service Learning and other hands-on learning methods have been shown to positively impact other outcomes, including increases in student self-confidence, self-efficacy, and self-esteem. The Harvard University chapter of Engineers Without Borders – USA (HUEWB) is an extracurricular student group that is not formally integrated into the engineering curriculum, though programs like these can still meet many of the ABET Learning Outcomes and foster the attributes of The Engineer of 2020. This article describes the interconnected nature of ABET’s Learning Outcomes and The Engineer of 2020, and demonstrates how Engineers Without Borders projects, specifically those conducted by Harvard University’s chapter, can meet these educational metrics for its own students.

2. Desirable Characteristics of Engineering Graduates

2.1 ABET Student Learning Outcomes

ABET, formerly the Accreditation Board for Engineering and Technology, is an organization that accredits baccalaureate and masters-level engineering, engineering technology, computing, and applied science programs in the United States and 23 other countries internationally. The ABET process is focused on what is learned rather than what is taught, as well as a methodology and process for continuous institutional and programmatic improvement. For an engineering program to attain accreditation, it must meet at least eight general criteria, and many programs have shown an increased focus on effectively meeting the Criteria 3: Student Outcomes, which are:

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multidisciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a
global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for
engineering practice

2.2 The Engineer of 2020

The learning outcomes that ABET uses to qualify programs for accreditation were modeled after Engineering Criteria 2000[10], which was published in 1997. Since then, several other engineering focused organizations have published their own characteristics of what makes a competent, employable, and successful engineer. In 2004, the National Academy of Engineering published The Engineer of 2020, which detailed the envisioned attributes of an engineer in 2020. In condensed form, engineers in 2020 will:[6]

1. possess strong analytical skills
2. exhibit practical ingenuity and creativity
3. communicate effectively orally, visually, and in writing while using modern virtual communication tools
4. understand and practice business, management, and leadership skills
5. possess high ethical standards and exhibit professionalism within their profession
6. demonstrate dynamism, agility, resilience, and flexibility
7. practice lifelong learning

2.3 Connecting ABET and The Engineer of 2020

While there are many different methods to map ABET Student Outcomes onto The Attributes of the Engineer of 2020, Polok et al. have generated a reduced set of these points that share the most commonality.[3] Here, ABET Outcomes 3a, b, e, i, j, and k are omitted, as many engineering programs have either been successful at achieving these learning outcomes or they do not represent a fundamental change between traditional notions of the engineering profession and The Engineer of 2020. Figure 1 describes Polok et al.’s list, which has been subsequently modified to include a mapping from ABET Student Outcomes to the attributes of The Engineer of 2020.
By examining the mapping described in Figure 1, it can be seen how ABET Learning Outcomes coincide with The Engineer of 2020 attributes in a number of ways. ABET 3c describes how graduates should be able to design a system, component, or process to meet realistic constraints. The ability of an engineer to create this design should be directly related to the quality of his or her analytical skills. Ingenuity and creativity play an even more prominent role in engineering design when the product to be designed is new, innovative, or completely “outside the box”. The presence of additional constraints, which may not normally be encountered, only increases the necessity for ingenuity and creativity within a given design, and reflects the agility, resilience, and flexibility of the designer.

ABET 3d describes the ability to function on multidisciplinary teams. We believe that to be a competent member of a multidisciplinary team, each individual member must be highly proficient in his/her own discipline, which implies that the team members possess strong analytical skills. Multidisciplinary teams are becoming commonplace within the engineering profession as the variety and magnitude of societal problems, like those being addressed by the Millennium Development Goals and The National Academy of Engineering’s Grand Challenges, are increasingly being solved through engineering solutions. These large societal problems require collective ingenuity and creativity that can only be addressed by diverse teams. The success and profitability of businesses will rely on the ability of their employees to not only be
functional parts of multidisciplinary teams, but also to manage and lead these teams. Similar connections can be made between ABET 3f, g, and h to the attributes of the Engineer of 2020.

3. Engineers Without Borders - USA

Engineers Without Borders – USA (EWB-USA) was founded in 2002 by Professor Bernard Amadei of the University of Colorado at Boulder as a means to connect developing communities with infrastructure needs to engineering students who are able to design solutions to those needs.[11] Since that time, EWB-USA has grown to over 12,000 students, faculty, and professionals in over 250 chapters working on over 350 projects in over 45 countries.[12] EWB-USA engages its members though community-driven infrastructure projects where chapters partner with a served community, typically for at least five years. This multi-year commitment to a community is referred to as a program. EWB-USA programs allow for a holistic and integrated approach to community-based development and tend to consist of multiple infrastructure projects as well as assessment, education, monitoring, and evaluation of these projects. By managing these projects programmatically, the effects of multiple projects can be collectively monitored to determine the impact on the overall quality of life in the served community. For example, an improved sanitation system may have a measurable impact on water quality either independent of or in conjunction with an improved potable water supply.

Within each EWB-USA program, chapters implement individual projects that address a specific community infrastructure need, including: water supply, structures, sanitation, energy, agriculture, civil works, and information systems.[13] While every project is technical in nature, each project must incorporate non-technical aspects, such as cultural, social, environmental, and economic considerations in order to be sustainable long after the relationship between the chapter and the community has concluded.

3.1 EWB-USA Project Process

EWB-USA projects generally follow a five-step process: project selection, assessment, design, implementation, and monitoring and evaluation. The project process is cyclical in that many elements of a given project inform subsequent projects within a partner community. Selection of an EWB-USA project is motivated by the needs of a specific partner community as well as the technical competency of the EWB-USA chapter. Once a specific project is selected, members from EWB-USA, with assistance from community members and in-country partners, must acquire all data necessary to perform an engineering design, including identifying and determining the appropriateness of multiple engineering solutions. Using the data gathered in the field, the engineering design is developed in the United States, typically at the chapter’s university campus. Throughout the design process, community and in-country partner feedback is solicited repeatedly to ensure that the final product meets not only the community’s technical
needs, but is also acceptable within the local culture and can be maintained solely by the community for many years.

The final, collaborative engineering design is then reviewed by the Technical Advisory Committee (TAC), which is a group of practicing engineers that review the facility design and documentation to determine if the design is appropriate and meets applicable U.S. or other international standards. Upon approval from the TAC, the chapter can make plans to construct the project with the partner community. After the conclusion of construction and for some time after, the chapter, with the assistance of the community members and in-country partners, will monitor the effectiveness of the facility as well as its operation and maintenance to determine if modifications to the design are necessary to meet the desired outcomes. Additionally, this will inform the chapter and the community of how to determine and proceed with future projects. At all points in the project process, engineering students must work with a professional mentor who has practical engineering experience in the relevant project field. Frequently, chapters have more than one professional mentor to achieve expertise across the technical areas within a given project.

### 3.2 HUEWB Tireo Abajo Water Filtration Project

In 2007, the Harvard University chapter was contacted by physicians from the St. Jerome’s Parish Constanza Mission to aid in the reduction of water-borne illness present in the community of Tireo Abajo, Dominican Republic. Members of HUEWB diagnosed the existing water system in Tireo Abajo to find a non-functional community-scale slow sand water filtration plant and contaminated distribution piping, while the groundwater source was relatively free of contaminants.

Over the next two years, HUEWB began to pursue two different options to address water-borne illness in Tireo Abajo: rehabilitation of the water filtration plant and designing a groundwater well which could be easily replicated at the household scale for those families who do not have access to the municipal water system. Rehabilitation of the water filtration plant would require collaboration with and consent of the local government water agency. After two years of little progress with the municipal government, this solution was abandoned, as it would not have been a viable short-term solution to water-borne illness. During the same time, HUEWB had made significant progress on family-sized groundwater wells with a functional prototype demonstrated in-country. Upon examining this solution further, the technical skills required to implement and maintain these well systems were beyond the capability of most members of the community, which raised the question of the long-term sustainability of family-sized wells.

As a result, the project team was forced to radically rethink the approach to providing clean water in Tireo Abajo. Since working with the local government for a community-scale solution would not be possible in the short term, the team needed to develop a point-of-use based
filtration system that was inexpensive and could be easily maintained by households with few technical skills. After some initial research, several feasible possibilities arose for water treatment at the household scale: ceramic filters, solar disinfection, bio-sand filters, and chlorine. After exploring the various options within the project team and with the community, ceramic filters were selected, as they are inexpensive, long lasting, locally produced, and can be implemented on an individual household basis. This solution dovetailed well with existing practices because many households use standing water storage tanks, and any attempt to implement a clean water solution must either ask these households to renounce the convenience of these tanks, or else intervene between the “tanks and the tap”.

In spring of 2010, HUEWB tested the feasibility of ceramic water filters for use in households in Tireo Abajo. Ten ceramic filters were purchased from AguaPure, a local ceramic filter factory, and were tested in five public and five private locations. The results from community residents were very positive, demonstrating the high potential impact of point-of-use ceramic filters. To facilitate greater adoption, HUEWB developed a microfinance model for a sustainable non-profit entity to sell the ceramic water filters in Tireo Abajo. HUEWB donated an initial capital investment to purchase filters from AguaPure. The filters were sold with an installment plan that would make it sustainable for the non-profit to purchase more filters. Two specific community members enabled the success, Rosana Duran, the neighborhood council president who was in charge of the finances for the group, and Dr. Saif Haider, a local physician, who stored unsold filters in the clinic where he was employed. Both individuals promoted the filter program and as of January 2013, 24 families were using the ceramic water filters and reported a reduced incidence of water-borne illnesses.

Throughout the partnership with Tireo Abajo, HUEWB was focused on strong community relations to enable the success of the ceramic filter project. Chapter members gave multiple, well-attended presentations about the water quality testing and their results. A school program was developed where middle school students educated community members on water quality and sanitary practices as part of their class. The community formed a health advisory committee, comprised of ten members, which allowed the chapter to remain more in touch with the community as a whole, even when not physically present. Furthermore, the team worked with Dr. Haider to collect health metrics related to water-borne illness not only within Tireo Abajo, but also in the surrounding communities.

3.3 HUEWB Pinalito Water Supply Project

Following the work in Tireo Abajo, HUEWB became involved with the neighboring community of Pinalito during a trip in 2012, during which the travel team learned that the community water well and pump were not operational. The community knew of the chapter’s involvement in Tireo Abajo through an in-country partner involved in the ceramic filter project and requested help from the chapter. During January 2013, HUEWB members traveled again to Pinalitoto determine the cause of the pump/well failure through extensive pump and recharge
testing of the existing well. In addition to these tests, the chapter performed water quality tests at several water sources used by the community, land-surveyed the community and surrounding area, met with community members as a group and with individual families, and began an education program in the local elementary school to teach children about clean water and hand washing(Figure 2). All of these tasks were necessary to develop a working rapport with the community members, determine the history of water usage and water-borne illness, and develop a holistic approach to water safety and security within Pinalito, as opposed to designing a purely technical solution.

Figure 2: Education program implemented in three elementary schools in the Tireo region in January 2013. (Left) A student uses a water sample from a local source to test for bacterial contamination. (Right) Five students examine the results of bacterial tests from four local water sources.

Using the data collected in January of 2013, chapter members spent the spring semester of 2013 determining a path forward for the community of Pinalito. Using results from the well tests as well as knowledge from a local drilling professional, it was determined that the well was unlikely to be repaired due to improper installation of the screened area by the original contractor. Based on this result and an analysis of the topographic and water quality data collected in the field, many alternative water sources were discounted due to either their water quality or the inefficiency of transporting water from the source to the community. The resulting solution to Pinalito’s water supply would be a new well, which would be properly designed to meet the community’s water needs. To prevent another failed well, this new well would be installed by a drilling professional who has extensive experience with wells in the area and would be unwilling to jeopardize the quality of the well and its groundwater in an attempt to cut costs. For the remainder of the semester, the project team designed a new well within the capabilities of the Dominican drilling professional, which will be added to an existing concrete water storage tank and the minimal distribution piping that currently exists in Pinalito. The complete design that will be constructed includes a new well with appropriate foundation and
protection measures, a submersible pump with control electronics, a control loop connected to float switches in the water tank for automatic pump switching, a structure to provide environmental protection of the electrical elements, a piping network to connect the pump to the existing 3000 gallon concrete storage tank, and subsequent connections to several communal access points, which will be constructed in multiple phases. This design will include complete water system operation and maintenance manuals as well as a sustainability plan to be produced both in English and Spanish. Before construction begins, the design, operation, maintenance, and sustainability plans will be presented to the community for their feedback, revisions, and approval. Currently, the community of Pinalito and HUEWB plan for the well to be drilled during the summer of 2013.

4. Connecting Service Projects to Learning Outcomes and Attributes

As extracurricular international service projects are examined, such as those developed by students at the Harvard School of Engineering and Applied Sciences, various elements of these projects can easily be identified as meeting both ABET Learning Outcomes as well as encouraging the attributes of The Engineer of 2020. Most fundamentally, these projects typically address a community need, usually in the form of infrastructure. Students that participate in these projects not only have to design a facility (ABET 3c, Eng2020 1) that is acceptable by U.S. or other international standards (ABET 3f, Eng2020 5), but this facility must also be able to be constructed on location with materials that are locally available (ABET 3h), greatly reducing the portfolio of pre-made designs that could be used in the U.S. Within the Dominican Republic, HUEWB students only implement designs where the materials can be sourced locally (Eng2020 6). This was one of the motivating factors for selecting the clay pot water filter as opposed to using other “high-tech” methods that could not be sourced locally. This required the project team to look “outside the box” of solutions typically used in the U.S. to technologies that are commonplace in less developed parts of the world (Eng2020 2).

The clay pot filters were selected not only by the project team, but in collaboration with the community of Tireo Abajo and the in-country partners, which created a diverse group of stakeholders collaborating on this project (ABET 3d). The students on the project team are pursuing varied academic concentrations, which range from engineering sciences to evolutionary biology and social anthropology. In addition, the academic and cultural backgrounds of the community members and in-country partners were diverse, including several Dominican community members with little education past middle school as well as a local university-trained physician who is originally from Pakistan. Without this multifaceted group of stakeholders actively participating on a multidisciplinary team throughout the multi-year relationship, an ineffective, culturally appropriate solution that was also sustainable economically, socially, and environmentally in the long term would not have been possible (ABET 3f).
Further, HUEWB projects are wholly student-led, with some technical oversight given by faculty, professional mentors, and the national organization, EWB-USA. As a result, the students are the project managers and need to effectively foster community relations, determine in-country logistics, and raise funds necessary to achieve their goals (Eng2020 4). This mandates professional communication skills, both written and oral, not only to communicate with the project team in the Boston area, but also to work with other supporters and like-minded groups in the U.S. as well as project partners in the Dominican Republic, most of whom do not speak English (ABET 3g, Eng2020 3). To be successful in these international extracurricular service projects, students and practicing engineers need to already possess or have the ability to learn the skills and attributes enumerated in the ABET Learning Outcomes and The Engineer of 2020.

5. Conclusion

Extracurricular service projects at many academic institutions, including ones at Harvard University, demonstrate that they fulfill ABET Learning Outcomes and encourage desirable attributes of The Engineer of 2020. Although the method in which these traits are learned is not institutionally formalized, as is the case with HUEWB students, the traits are evident within those individuals who participate in Engineers Without Borders or similar programs.

Engineering is a profession that utilizes both natural and man-made resources from the world around us for the advancement of society. The students who work on international service projects throughout their educational training will have the experience of working on teams with diverse groups of people throughout the world, and will be leaders in projects that have a direct positive impact on human life even before they graduate and enter the workplace.

Acknowledgments

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References


UNIVERSITY – INDUSTRY COLABORATION IN ENGINEERING EDUCATION AGAINST GLOBALIZATION

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Abstract

There is intense public interest in the role of universities as a source of science-based innovations. These innovations are the cause of rapid industrial growth and creation of new high technology products. This review is in university – industry linkage in innovation, interaction and the nature of innovation pursued. Universities are collaborating with industry over hundred years, but the rise of a global knowledge economy has intensified the need for strategic partnerships that goes beyond the traditional funding of discrete research projects.

Keywords: innovation, globalization, industry – university collaboration

1. Introduction

The globalization theory has faced a huge controversy and has been subject to many discussions all over the world. While many opposed it as a new form of imperialism, others see in it a way to control more efficiently the world recourses such as labor and natural recourses. The idea of outsourcing (moving of industry and business to other countries that have cheap labor or cheap power), made a big threat for many industries who found themselves producing the same commodity at a much higher cost than their global competitors. Many of them went out of business while others used innovation and new methods to rise and stand high in the global market.

Their main weapons were optimization of production and manufacturing, heavily depending on engineering solutions and large cooperation with universities and academic societies in the field of research and development as well as preparation of market ready engineers and specialists.

Universities on their behalf developed new customized specialties especially in engineering field satisfying the need of the market, instead of graduating future unemployed
brains that most probably will emigrate. What make a huge economical lost to the state and organizations that financed their studies.

2. University–Industry cooperation between theory and reality

What can disturb such a win – win cooperation?
For long time, the business world believed that “universities do not graduate hardworking specialists”, this idea has collapsed when old fashion business found the need of knowledge and innovation to keep their businesses running. However many problems faced the new trend and slowed the large scale cooperation with universities, especially in engineering field.

2.1 Issues facing academic society:

old and non-dynamic study programs that cannot catch with new technologies and trends in the global market, for example construction companies use new technologies and new materials while some universities are still teaching their students (future engineers) old methods and obsolete materials.

One aspect of university – business cooperation in engineering field can be noticed when a private company finance the expenses of a perspective student and orient his scientific research to form a ready member of this company when he finishes studies, or when company proposes and finances a thesis to conduct a research required for future development and at the same time guarantee a dedicated expert in the field of their interest.

University–industry collaboration is typically associated with companies that are looking for unique innovative solutions such as improving a product or reducing production costs, in order to create a prototype of a new product and sell it effectively. The main obstacles facing industry-university cooperation are unclear university and business cooperation mechanism and insufficient communication between both parties. The government may as well encourage scientific and business collaboration using some financial instruments and mechanisms, for example: in Lithuania, the budget of university (governmental with independent authority) is formed using mechanisms that rely on the number of students, additionally the government increases the university budget with the same sum of contracts and investments agreements made with private sector. As an example how university – private sector cooperation can increase the university budget income especially in engineering study, we can see (Fig. 1) how KTU budget income is decomposed for 2012[1].
University and private companies open together some application laboratories where students learn modern knowledge and technologies as well as perform practical tasks; researchers are engaged in research with business professionals to find solutions for existing problems. The most significant scientific and practical research results will be presented in scientific publications, and become accessible to public, or can be classified, depending on its nature.

2.2 Training
Training is one of the most clear aspects of cooperation between universities and industries, where we can see students do their practical training in private industries and have a taste of the real practical world with all its bitterness and opportunities, while industry personnel are sent back to universities to refresh their knowledge and get familiar with newest trends in the technology. Such cooperation enhance and boost the efforts in R&D where scientists became more involved with the need of the market, therefore, their researches are oriented more and more into useful solutions and products, having in mind all technological and financial aspect of existing industries. On the other hand, we should not forget that universities play an important role in the qualification of industry specialist and open for them a new spectrum of solutions to their old and existing issues. This fresh approach into innovation helps industry stay on the top of competitions and provide them with new methods to optimize their costs and capabilities.

The industry currently finances mostly post graduate and doctoral students, while we can see that “if there is a lack of highly qualified personnel to support businesses, the correlation remains the same, as businesses need people to grow. It is important to recognize that innovation can also be generated by under graduate students with dedicated scholarships and support that is differentiated from the existing post graduate programs.”[2]

2.3 Open innovation to survive globalization
To reduce costs and win the competition, industry invested in automation, mechanization as well as IT and digitization, relying more on the machines. However, it was not enough and they started to look for new methods and other approach, open innovation shows us the need to add more.
So while most companies try to concentrate their resources into specific market niches, open innovation field matures. The ability to create engaged communities and to divide it into specific groups, benefits open innovation customers, solvers, platforms and ultimately, consumers living in actual communities in the real world [3].

Open innovation concept gives some examples from companies that adopted this model, combining internal R&D with external capabilities from universities, fresh minds, experts, and creating ecosystems of innovation around their technologies. The fig. 2 depicts several ways where technology can enter into your development pipeline or how you can produce new technologies that are not core of your business. Most companies have an internal technology base where they own several core competencies. Enhancing internal technology capabilities forms a major part of company’s development portfolio. On the other hand, the acquiring of technology can be done using joint development partnerships, and licensing agreements. Another method is to develop new products using new technology, to enter a new market, what can expand your revenue base. The key aspect of fig. 2 is that the boundary of the corporation is porous and it allows technology to come in and out.

**Benefit of collaboration between university and industry**
- Higher possibility to recruit researchers and students
- Make local community more attractive for industry
- University benefits from access to laboratories, devices, projects and latest technology
  - Development and training of workforce
  - The usage of licensed scientific equipment

**Why should industry work with universities?**
- Provide access to intellectual capital
- Usage of specialized equipment
• Universities can be a source of new intellectual property (IP) that can result in wealth creation

Companies may demand help from university’s researchers who are working on studies related to some products and its development, seeking expert consultation. One of the main tasks of university is to ensure the high quality of courses, which depends on the qualifications of the teaching staff, IT facilities, and modern laboratory equipment. To achieve such a goal and to obtain well-trained highly skilled professionals, university invites private company’s specialists to give lectures to students, as well as to participate in graduate thesis defense and its practical part development. Industrial companies usually welcome students for practice, and invite university instructors and researchers for internships in companies [5].

Another challenge universities are facing is the transfer of knowledge [6]. Just close cooperation between students, universities and companies will make possible to achieve goals; good professional training and corporate prosperity. Integration and career mission of directorate in co-operation to be a connecting link. By concluded long-term university faculties and departments of co-operation agreements with the ministries, departments, enterprises, using advanced technology, modern production organization and management techniques, faculty students undertake an apprenticeship, prepare the finishing touches. Such cooperation accelerates the integration of graduates into the labor market, the less there is for young professionals-unemployed.

3. **Initiating and sustaining cooperation between university - industry**

University alumni are now managing large companies, creating their own business and occupying essential posts in public institutions; so they are able to see what knowledge or skills are most lacking in the labor market. The university community and university graduates meetings shall discuss the most recent issues in order to improve the education quality and graduate employment.

In many countries the university alumni contribute in the development of university. Thus it makes sense to say that one of the most important goals is to maintain closer ties between alumni and university, in other words, to receive consistently their feedback. Who else if not alumnus working in current industry, business, construction companies and public authorities can best assess university preparation for professional activities, and make a description of the pros and cons? Achieving this objective may be realized via several ways like giving lectures to students, offering thesis topics, inviting students into practice in their companies and participating in meetings-discussions with students, where the highlighted features of their profession and career opportunities and proposals will help the university leadership in its curricula preparation.
4. How university supports mechanical construction engineering and industry.

When industry can’t afford research centers but in the same time, it is willing to compete with other industries, university research centers can be their best solution. These centers are full with highly qualified engineers and scientists and they enjoy latest computerized solutions for simulation and calculation as well as newest equipments. For example a food industry can work together with different research centers in chemical science to enhance recipes and tests it. University research center can help doing all kinds of ecological influence studies of some project that are required by governmental institutions, without having an ecology expert. This will reduce the project cost.

Usually young scientists take longer time in their researches; however their results are outstanding with good quality.

The one thing that is always present in university is high technologically equipped laboratories, most of the time, these laboratories are not busy, and so as result of cooperation between industry and university, manufactures get to test their prototypes and finished products in these laboratories. These experiments will be a very good opportunity for young engineers and scientists to have an idea about the application of their knowledge and they could use some result in their own researches and thesis. For example, mechanical and material laboratory in KTU and designers from machinery plant “ASTRA” AB conducted many experiments to test some metallic construction prototypes when calculation can be so complicated or not conclusive to ensure the safety and effectiveness of some proposed solutions.

![Figure 3 Metal legs: a) filled with PU foam before deformation b) filled with PU foam after deformation](image)

One of the latest test was to check the difference between hollow legs of a tank made of sheet metal and the same metal leg filled with PU foam (Polyurethane foam) the result was impressive the leg filled with PU foam was able to withstand 17% higher load than hollow leg (fig. 3). These results were achieved respecting all scientific procedures accepted by standard requirements. This particular experiment resulted directly in profit around 8000USD for one project and will be used in further projects [7,8].

On the other side, many master degree students defend their master thesis based on such cooperation. Research centers can give even more impressive results using theoretical calculation and computerized simulation such as final element modeling using such programs like ANSYS Workbench, Solid Works etc. It can be more economically efficient
to do these calculations at the university then hiring specialists and buy expensive software that will not be used efficiently.

In 2005 “Machinery plant ASTRA” AB received an order for large stainless steel tanks for one company in Sweden with condition, that tanks will be manufactured at “ASTRA” workshops and transported to client site to Sweden to avoid building it on site with high presence of flammable materials (oil). These tanks where around 6 m in diameter and 12 m height.

One of main issue was the manipulation of tank from vertical position (how it’s build) to horizontal position for transportation, because of thin walls of tank. The company asked an engineer with long experience in metal construction to estimate the need of reinforcement necessary to avoid the collapse during these manipulations; according his rough calculation, he indicated that each tank (8pcs.) will need 3 stiffening rings, made of carbon steel to be mounted on each tank’s body to ensure the safety of the tank. When calculating the cost of these proposed constructions, it was clear that each tank will cost additionally around 8000 USD, and as these constructions have to be mounted on the tank during transportation to the client, so at least 4 batches must be made (transportation planned: 4 tanks each time). This huge cost pushed the responsible to order finite element calculation (fig. 4) at the university with cost of 1000 USD hoping to find a cheaper solution. After a very detailed calculations and computer simulations the university report proposed very simple and cheap instructions: where and how to lift the tank at specific angles and they decided that the body of the tank will be safe and will not collapse (fig. 5).

![Figure 4 Tanks finite element model grid](image)
By trusting science and computer technology the company had a huge economy of 31000USD in this project and proved the high accuracy of finite element simulation which is used more often in further projects [9, 10].

This cooperation helped “ASTRA” win the title of “Innovative Company of the year in Lithuania” as well as formed a respectable image in the field of metal working and construction in Western Europe.

This certifies that university can provide industry with solutions that make high economy of projects’ budgets and satisfy the need of innovation-hungry market. This model of
cooperation is working successfully for many decades and it formed a large gate for academic society into the world of industry and business. It help to better educate students and make them market ready. On the other side the benefit of industry is obvious: better economy and the possibility to compete in an international market.

The university driven innovation is so crucial for many industries (laser, chemical, food, telecommunication, electronics, IT and other process industries) in their way to compete under globalization condition where their competitors are not their neighboring companies, but any other company in the world. It became leverage against low cost labor markets and generated higher added value products.

5. **Conclusions**

Universities are discovering new and more effective forms of cooperation with business. It is important for most scientists to teach students how to work with companies, and to transfer new technologies into the production of new products. Therefore, one of the main goals of universities shall be entrepreneurship culture education.

Under globalization rules, industrial and engineering companies success depends on strong scientific and research co-operation with universities. While few years ago the university was the most co-initiator of the agreements with companies, manufacturers today are interested in the long run - the new technologies needed to develop skilled workers, not only theoretical but also practical in terms of well-trained professionals.

In fact current market conditions under globalization, make it harder to HR managers to find highly qualified young specialists. Through meetings with students, faculties and heads of departments, employers have a great opportunity to invite students to practice not only in their companies, but also to develop specific projectsthese. Thus companies are growing their future workers by themselves from the university benches.
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One of the EU’s greatest achievements has been to enable its citizens to move freely around Europe. There is freedom of capital, transit and goods. However, when European workers move to another Member State, they sometimes find it difficult to enter a regulated profession because the academic qualifications that they have gained in another Member State are not always recognised in the same way. Recognition of academic qualifications is essential for both personal and professional reasons. It also represents added value for the economy and European education, benefiting the whole of the EU by encouraging investment and intra-Community trade. This factor is even more important now that the European economy needs to be revitalised.

One may argue that the main function of qualifications (certificates, diplomas) is to make individual knowledge, skills and competences visible and transparent, to communicate their social and professional relevance and their potential fields of application. Comparable to money in the economic system, standardised qualification is a common medium of communication across the education and qualification systems. Categorising qualifications makes it easier to communicate individual knowledge, skills and competences and to transfer this understanding beyond the context of personal interaction. Sometimes, but by far not always, qualifications can come with certain entitlements, e.g. being the prerequisite for accessing certain domains of activity, such as further education or regulated professions. In some European countries like Greece, Portugal, Spain and Italy the profession of engineer is regulated. In many others it is partly regulated or not regulated at all. However, in discussing the recognition of foreign qualifications (or of informally acquired knowledge, skills and competencies) it is essential to distinguish between formal (or: legally binding) vs. social recognition. Formal recognition is performed by institutions of the education and qualification system (e.g. education institutions, professional authorities), while social recognition is performed by other actors (e.g. employers in the labour market). Frequently the formal recognition by authorities is just a means to the end of social recognition, but it is no guaranty for success.

Focusing just on formal recognition by education institutions or authorities, it is crucial to distinguish between different forms of validation and recognition. Validation can be understood as a “confirmation by a competent body that learning outcomes (knowledge, skills and/or competences) acquired by an individual in a formal, non-formal or informal setting have been assessed against predefined criteria and are compliant with the requirements of a validation standard” (Cedefop 2008: 199). Even if the term validation can be in principle used for all three learning settings, it should only be used for a form of validation in which
learning outcomes have predominantly been acquired in non-formal or informal settings. As a result, we can distinguish three forms of dealing with informally acquired knowledge, skills and competences. The first form is formal validation that leads to qualifications, which are equivalent to those of the formal education system, e.g. formal school leaving certificates, which can be acquired via ‘second chance’ education programs. Summative validation leads to certificates outside the formal education system, e.g. the European Computer Driving Licence, or ISO-certificates for professional skills like welding. The third form of dealing with informally acquired learning outcomes is formative documentation of knowledge, skills and competences (e.g. via portfolios and individual descriptions) without measuring them against thresholds.

In contrast, the formal recognition of (foreign) qualifications can be understood as the “recognition by one or more countries or organisations of qualifications (certificates, diplomas or titles) awarded in (or by) one or more other countries or other organisations” (Cedefop 2008: 130). Again, we can distinguish three forms of dealing with foreign qualifications. The most traditional form is the recognition of equivalence, granting the foreign certificate the same entitlements as a domestic qualification. The recognition of equivalence can be done either via detailed comparisons of curricula or merely as administrative acts that are based on intergovernmental agreements. The recognition for further education or training does not lead to independent qualifications. Rather, foreign certificates are recognised to gain access to further education or training programs and/or to substitute for parts of these programs. Contrary to these two types, the assessment of an individual’s foreign qualification by a public authority is an expert judgement or recommendation, which does not necessarily have a domestic qualification as a counterpart.

**Forms of validation and recognition**

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<td>Recognition of equivalence</td>
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<td>Recognition for further education or training</td>
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<td><strong>Validation of Knowledge, Skills, Competencies</strong></td>
<td>Formal validation (qualification within NQF)</td>
<td>Formative documentation (individual documentation, description)</td>
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Comparing these six forms of validation and recognition, one has to bear in mind that they can be distinguished by their different consequences. The majority carry the status of legally binding or administrative decisions, which tend to go hand in hand with certain entitlements (e.g. the right to hold a specific degree, or the right to access a regulated occupation). However, there also exist forms of validation and recognition, which are non-binding legally, but can still be helpful in communicating the personal knowledge, skills and competences.

I. European regulations to support the mobility of qualifications

The distinction between ‘legally binding’ and ‘legally non-binding’ does not only apply to forms of validation and recognition at the national level, but also to international or European initiatives to promote the geographic mobility of qualifications and competencies. Regulations on recognition, like the Lisbon Recognition Convention concerning higher education qualifications or the Professional Qualifications Directive 2005/36/EG, are legally binding documents, which carry clear obligations for nation states to establish ‘exchange rates’, thereby extending the reach of many qualifications beyond national borders to all countries covered by these regulations. In contrast, other political initiatives may either have the character of voluntary cooperations between countries, which may be based on political agreements on broadly defined goals, guidelines and benchmarks, but without legal sanctions, e.g. harmonisation of national qualification systems in the Bologna Process or the Copenhagen Process, or non-binding recommendations, e.g. for the development of National Qualification Frameworks, based on the QF-EHEA or the EQF, or the introduction of transparency instruments, e.g. Europass or the European Professional Card.

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II. Regulations on recognition

1. Lisbon Recognition Convention

The Convention on the Recognition of Qualifications concerning Higher Education in the European Region, better known as the Lisbon Recognition Convention, was signed during a diplomatic conference jointly organized by the Council of Europe and by Unesco in 1997. The convention replaces a range of older intergovernmental agreements on the equivalence of qualifications giving access to higher education, of higher education qualifications and of periods of study, which date back to the 1950s and 1960s. It was ratified by 45 (of 47) member states of the Council of Europe as well as by 8 non-member states. With respect to higher education qualifications, each country has to recognize the qualifications conferred to in another country, unless substantial differences can be identified suggesting non-equivalence, thereby putting the burden of proof on the relevant body rather than the applicant. In some countries this principle is regarded as recognition by default, which in most cases does not require any further administrative activity. In addition, the convention distinguishes between the recognition of qualifications (which sometimes can be denied) and the general right to a written assessment of the individual qualifications.


In 2005, the European Parliament and the Council decided on the Professional Qualifications Directive (2005/36/EG). This directive replaces 15 subject specific directives, which date back to the 1960s, and unites their content in one common body of legislation. The directive deals with regulated professions and defines four types of recognition:
• **Declaration of temporary provision of professional services:**
  Citizens of EU or EEA countries, which are entitled to practice a regulated profession in their country of origin and which plan to pursue this in another country on a temporary and occasional basis, may do so if they inform the competent authority in the host Member State in a written declaration.

• **General system for the recognition of evidence of training:**
  This form of recognition is based on the case-to-case comparison of the evidence of foreign training with domestic requirements for the respective regulated profession. If differences in level, content and scope for the respective qualifications are essential, compensation measures can become necessary to achieve recognition.

• **Recognition of professional experience:**
  For some regulated professions, the documented professional experience can be sufficient proof to achieve professional qualification.

• **Recognition on the basis of coordination of minimum training conditions:**
  This form of recognition applies to seven professions only (medical doctor, dentist, veterinarian, midwife, qualified nurse, pharmacist and architect). Based on a comprehensive list of qualifications from different EU-MS, which are seen to have harmonized minimum training conditions, equivalence can automatically be recognized.

It is crucial for our understanding that the Professional Qualifications Directive only deals with the transfer of professional qualifications within the EU/EEA area. It applies solely to regulated professions (not to all occupational activities), and only to qualifications from EU/EEA Member States (not to qualifications from Non-EU/EEA countries). All professions, which are regulated in the individual Member States, have to be listed in the Regulated Professions Database\(^1\) of the EU. A regulated profession is an occupational activity, for which a specific qualification is a legal or regulatory requirement (Cedefop 2008: 154). However, most professions/occupations are not regulated and do not ask for legal entitlements. Therefore regulated professions seem to be the minority in most countries, both with respect to the share of professions/occupations, but also with respect to their share in the national labour market. For all the other professions/occupations, qualification categories are useful tools to communicate knowledge, skills and competencies, but they are no legal prerequisite for a job. The proposal for a revised Directive has been examined by the co-legislators (EU Parliament, EU Commission and EU Council) and a political agreement has been reached at the end of June 2013. The major innovation of this proposal is the creation of a European Professional Card, which will be introduced for the interested professions and will significantly simplify recognition procedures. It will be based on the systematic use of the Internal Market Information (IMI) system and on the enhanced cooperation between the home and host Member States. FEANI is considering to propose the profession of “engineer” to the Commission for this European Professional Card.

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\(^1\) [http://ec.europa.eu/internal_market/qualifications/regprof/](http://ec.europa.eu/internal_market/qualifications/regprof/)
Another important element of the modernization of qualifications recognition is the introduction of a new system of automatic recognition based on a common set of knowledge, skills and competences. “Common training frameworks” could be developed for the interested professions and the qualifications obtained under such a framework would be automatically recognized in other Member States, without the need for any compensation measures.

III. Harmonization of education and qualification systems

1. Bologna Process

Having been triggered by the Sorbonne Declaration in 1998 and officially launched by the Bologna Declaration in 1999, the Bologna Process is based on the agreement of ministers of education from (currently) 47 European countries. An important part of the Bologna Process is the sequence of biannual meetings of the ministers, which are accompanied by experts and representatives from higher education. These meetings do not only reflect on past achievements, but also on the further development of the agenda of the Bologna Process. The overall mission is the foundation of the European Area of Higher Education (EAHE) which promotes mobility, employability and competitiveness across Europe. The most important instruments are the harmonisation of the degree structure (Bachelor/Master/PhD), joint principles for quality assurance and measurements to facilitate the recognition of qualifications and/or of periods of study. The European Credit Transfer System (ECTS) has been introduced to measure the workload of study units, the diploma supplement as an obligatory document to describe the content of individual study and learning outcomes.

2. Copenhagen Process

Following the example of the Bologna Process, the European Ministers of Vocational Education and Training together with the European Commission initiated the Copenhagen Process by signing the respective Declaration in 2002. Currently all 27 EU-MS as well as 6 non-member states participate in the Copenhagen Process which is also characterised by biannual conferences. Major topics of this initiative are the strengthening of the European dimension in vocational education and training, cooperation in quality assurance, increasing transparency and information, as well as recognition of competencies and qualifications. Results of the Copenhagen Process are: EUROPASS as a single framework for integrating various information tools; the European Qualification Framework EQF, joint principles for the identification of learning outcomes, which have been acquired in non-formal or informal settings; a joint reference framework for European Quality Assurance in Vocational Education and Training (EQAVET); and the European Credit system for Vocational Education and Training (ECVET), which aims at facilitating the validation, recognition and accumulation of work-related skills, knowledge and competences.
IV. Qualification frameworks

1. QF-EHEA (Qualification Framework of the European Higher Education Area)

As part of the Bologna Process, the concept for the Qualification Framework of the European Higher Education Area (QF-EHEA) was adopted during the Bergen Conference of European Ministers Responsible for Higher Education (2005). The QF-EHEA only deals with tertiary education and distinguishes three levels (or cycles) of qualifications: Bachelor, Master and PhD. To distinguish these different levels of qualifications, the QF-EHEA does not rely on traditional forms of input-driven descriptions (e.g. content, curricula), but it proposes a shift to output-driven forms of descriptions, focusing on learning outcomes. For this purpose, the QF-EHEA distinguishes learning outcomes, including competences, according to five descriptors: demonstrated knowledge and understanding, the ability to apply knowledge and understanding, the ability of informed judgements, communication and learning skills.

2. EQF (European Qualification Framework)

In 2008, three years after the introduction of the QF-EHEA, the European Parliament and the Council published their recommendation on the establishment of the European Qualifications Framework (EQF) for lifelong learning. In contrast to the QF-EHEA, the EQF comprises all levels of the formal education system, from primary education up to higher education, and distinguishes eight different levels of reference. Similar to the QF-EHEA, the EQF introduces a strong focus on learning outcomes, but uses only three descriptors, namely knowledge (theoretical and factual knowledge), skills (cognitive and practical abilities, like the application of methods, materials and tools), and competences (responsibility and autonomy).

3. NQF (National Qualification Frameworks)

Both the QF-EHEA and the EQF are concepts, which need to be recognised and implemented by integrating them in the National Qualification Frameworks (NQFs). So far, only a few countries have implemented NQFs (e.g. Ireland, Malta, UK and France). It has to be mentioned as well that the EQF is intended to be a mere classification system for existing qualifications, while the QF-EHEA is closely linked to the Bologna Process with the intention to harmonize the architecture of higher education degrees.

V. Other transparency instruments

1. Europass

Decision 2241/2004/EC of the European Parliament and the Council introduced Europass as the single Community framework for the transparency of qualifications and competences. Europass is constructed as a portfolio of different documents and existing instruments, including:
the Curriculum Vitae that helps individuals to present their skills and qualifications

- the Language Passport, a self-assessment tool for language skills and qualifications

- the Europass Mobility, which records skills acquired in other European countries

- the Certificate Supplement, which describes the national standards of specific vocational education and training certificates

- the Diploma Supplement, which explains what knowledge and skills have been acquired by the holder of a specific higher education degree.

While the first two documents are completed by the individual, the later three are issued by education and training authorities.

2. European Professional Card

Based on an evaluation of the Professional Qualifications Directive, the European Commission has recently revised the Directive with the aim of modernising it. It proposes the introduction of a European professional card as an instrument of faster recognition of qualifications in regulated professions. This card is to make use of the Internal Market Information system (IMI), an electronic tool designed to improve the cooperation between administrators of Member States. While currently the receiving Member State is responsible for the verification of the migrant’s professional qualification and documents, the introduction of a European professional card would shift this responsibility to the competent authority in the Member State of departure, which could issue the card on request. The receiving Member State would only have to verify the validity of the card itself. The European Commission launched a steering group on the professional card, which led to case studies being undertaken in seven different professions. FEANI, as the European professional organisation for Engineers participated in this group. The EC, DG Internal Market and Services are committed to promote the convergence in regulated professions by fostering the direct interaction between professional authorities across national borders.

VI. Institutional Infrastructures

1. ENIC-NARIC network

The ENIC and the NARIC network have similar functions, but different roots. The ENIC network (European Network of National Information Centres on academic recognition and mobility) was founded by the Council of Europe and UNESCO to implement the Lisbon Recognition Convention. National information centres are set up by national authorities of
states which are members of the European Cultural Convention or of the Unesco Europe Region. The network of National Academic Recognition Information Centres (NARIC) was created on initiative of the European Commission in 1984. All member countries of the European Union, the European Economic Area and Turkey have designated national centres.

In most countries a NARIC is at the same time an ENIC, however in some countries there only exist ENICs. The two networks collaborate closely and adopted a Joint ENIC-NARIC Charta in 2004. The national centres are the responsibility of their nation states. This means that the size and specific competence of national centres can vary. Generally speaking, ENIC-NARIC centres will provide authoritative advice and information concerning academic recognition of diplomas and periods of study undertaken in other countries and will provide guidance for the routes to take and the national institutions responsible for academic recognition (mainly higher education institutions). Differences can be observed in other areas of recognition (e.g. relative to advice on the recognition of school certificates, on vocational education and training, on professional qualifications) and to advice given to other sectors of the public administration (e.g. Public Employment Services), apart from informing the individual applicant.

2. National contact points for the Professional Qualifications Directive

Following article 57 of the Professional Qualifications Directive (2005/36/EG) each Member State had to designate national contact points, which are responsible for providing citizens or contact points of other Member states with information concerning the recognition of professional qualifications as well as assistance to citizens in realizing their rights. National contact points are also responsible for supervising and editing the entries of regulated professions of their countries in the Regulated Professions Database of the EU\(^2\). Similar to ENIC-NARIC, national contact points do not take decisions on the recognition themselves, but lead the way to the respective professional authorities.

3. EQF National Coordination Points

One element of the Recommendation on the establishment of the European Qualifications Framework was the advice to designate national coordination points, which are linked to the structures of the Member States. The tasks of the national coordination points (European Parliament & Council 2008: 3) should include:

- Referencing levels of qualifications within the national qualification system to the EQF
- Ensuring transparency in referencing national qualifications levels to the EQF to facilitate comparisons
- Providing guidance to stakeholders on how national qualifications relate to the EQF through the NQF

\(^2\) The list of national contact points can be taken from this database, under the following link: http://ec.europa.eu/internal_market/qualifications/contact/national_contact_points_en.htm
• Promoting the participation of all relevant stakeholders.

Even if not all Member States have established their NQFs yet, national coordination points exist already and play a crucial role in developing NQFs.

4. EURES network

EURES is a co-operation network between the European Commission and the Public Employment Services of Member States of the European Economic Area. EURES provides information, advice and recruitment/placement services to workers and employers who wish to make use of the principle of free movement of persons. EURES maintains the European Job Mobility Portal3 and a human network of more than 850 EURES advisers, which are located in Public Employment Services across Europe. EURES plays a particularly important role in cross-border regions. Currently there exist 20 EURES cross-border partnerships. These are regions with significant levels of cross-border commuting, where EURES helps to overcome administrative, legal or fiscal obstacles to mobility.

In the EU many efforts are ongoing to discuss governance and quality education and to reflect on the best strategies to address the educational challenges facing Europe. The European Union has placed education at the heart of its efforts to put the EU back on the road to economic recovery. Youth unemployment is at an all-time high, with more than one out of five out of work. At the same time, employers are trying hard to fill over 2 million vacancies for high-skilled jobs. Our educational systems need to better match the instruction imparted with the needs of the labor market: the skills being taught and the skills being sought. The European Union has no power to enact binding legislation in this field. But it does have a crucial role in supporting Member States to carry out the reforms needed to modernize schools and universities and to equip students with these skills. That is why the EU strategy for the future, Europe 2020, includes a double target in education, reflecting the aim both to widen skills and to raise their level: by 2020, fewer than 10% of young people should be leaving school early, with few or no qualifications and 40% of young people should be completing higher education. The Commission has been closely monitoring the efforts made by the Member States to improve their education systems. Still, the road ahead is far from having cleared.

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The importance of teaching, supporting learning, designing, and evaluating in Higher Education

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Abstract

Teaching and learning in Higher Education are facing new challenges nowadays. New techniques have emerged for the welfare of the student’s learning. Moreover, design and evaluation are main keys in the teaching / learning process and play an important role in shaping professional practice. Different theories of learning have also evolved and for all cases, the student is the centre and the teacher must adapt his teaching to the student’s needs.

Keywords: Higher Education, Teaching and Learning, Design, Evaluation

1. Introduction

For the development of students and faculties, a new framework for engineering education is established. This framework is wide and comprises many topics. In this paper, we will be discussing teaching and supporting learning in Higher Education (HE) as well as the design and evaluation for learning and teaching. Nowadays, learning is becoming or has the daring intention to become a life learning experience for students who will become citizens of this changing world. Effective learning appears to be the key now. According to Phil Race, there are seven factors underpinning successful learning: learning by doing, wanting to learn, making sense, learning from feedback etc… Different theories of learning have evolved; we can find behaviourist theories, cognitive theories, constructivist theories, and humanist theories as well as many other approaches to teaching and learning. Whatever it may be, it appears
that the student must be the centre and the teachers must adapt their teaching to the students’ needs. Behaviourist theories claim “that language is a set of habits that can be acquired by means of conditioning”. Cognitive theories consider “learning as an internal mental process” and the educator “structures content of learning activities to focus on building intelligence”. The purpose of Constructivist theories in education is “to become creative and innovative through analysis and synthesis of prior experience to create new knowledge”. The educator’s role is “to mentor the learner”. Humanist theories are “a paradigm that emerged in the 1960s, they focus on the human freedom, dignity, and potential. This is in contrast to the behaviourist notion of operant conditioning”. Humanists also believe that it is necessary to study the person as a whole, especially as an individual grows and develops.

2. Teaching and supporting learning in Higher Education

2.1 The teacher’s development through Action Learning

In distance learning courses, students are lonely learners in comparison to students who are accompanied by their teachers and their peers. In HE teaching experience, many students appear to learn more effectively if they have the opportunity to discuss and debate their learning with peers. It appears to give them more confidence and helps to highlight any misunderstandings or areas they have not grasped. They are most interested in analysing issues with persons of their age and who have the same concerns. The research of Blumenfeld et al. (1996) reported that this peer learning is an “educational innovation” (p. 37) and teachers have a wide selection of methods because there are many ways in which “small groups can be organized” (p. 37). However, group work can be unsuccessful because students don’t become automatically responsible when working with others. Also, “when practiced in an uninformed manner, it can exacerbate status differences and create dysfunctional interactions” (p. 37). Here, the teacher’s role is very important; research (O’Donnell & O’Kelly, 1994) has proved that “effective teachers adapt their instruction to changing situations in the classroom” (p. 321). They need to include new methods like “peer learning and cooperative learning techniques as part of their repertoire of strategies” (p. 321) in order to make group work successful. Students also need to be active and part of the teaching/learning process. The research of Biggs and Tang (2011) proved that, with their teaching methods, teachers prepare their students to be “active citizens” (p. 7) in a changing world and must “support their personal development” (p. 7).

The action learning notion, first introduced by RegRevans in the late 1940s, represents a key stone of the teaching/learning process. In 1998, Johnson defined the action learning set as a “learning laboratory” (p. 298). He also wrote that “people are most motivated to
learn when tackling an issue close to their hearts” (p. 296). A solution is reached when one understands his situation better, by “exploration through reflection” (p. 298), by “reflecting on experience” (p. 298), and by observing. Moreover, this collaboration between the students was the core of a new experience for them, especially on the personal level. As reported by Johnson (1998), students “gained awareness of self and others” (p. 299), learned a “more disciplined way of working” (p. 299) and how to “formulate more informed actions” (p. 299). They are now “more inclined to listening and communicating” (p. 299).

2.2.1.1 Working in groups successfully

As stated by Moon (2009), there are many other principles that must be applied for “academic assertiveness” (p. 4), like engaging “critical thinking” not critics, a “willingness to listen” (p. 9), to disagree or to change one’s mind if we are wrong or if we believe that one can change. However, group work is not always the “best issue for a better learning” (Blumenfeld et al., 1996, p. 37). Some people may rely on the rest of the group and not contribute while others might dominate. Furthermore, according to an article from the Institute for the Advancement of University Learning in the University of Oxford, students who adopt deep approaches to learning tend to have higher quality learning outcomes.

2.2.1.2 Key aspects for interesting lectures

In 2009, Dickens and Arlett argued that lectures have traditionally involved the “one-way transmission” (p. 230) of course content often in large groups; students can become passive or fail to engage with the subject. However, lecture to large groups is still efficient to “deliver large volumes of core knowledge” (p. 266) and there are some keys for a successful lecture or for what “make it ‘unmissable’” (Revell & Wainwright, 2009, p. 209). First, a good organization of the teaching and learning experience, reflected on outcomes-based planning is necessary. Students expect to have a clear structure of the course which enables them to interact and which facilitates their studies. Moreover, it encourages them to have “deeper approaches to learning” (Revell & Wainwright, 2009, p. 215). Second, the teacher’s charisma and enthusiasm can be very catching and students will engage actively in the learning process. Virtual learning environments for our digital-native students will certainly attract them and grab their attention too.

Moreover, according to Fry and Ketteridge (2009), “enhancing personal practice by establishing credentials” (p. 469), by reflection or reflective practice and writing, and by “observation of teaching” (p. 472) with the intention of providing positive feedback will lead to teaching excellence. Our universities are now aware of our changing world. They are supporting the professional development of staff engaged in teaching and learning through workshops, credentials from accredited organisms and institutions.
Last but not least, some practical issues also help the learning process like regular breaks for discussion and questions, group activities and presentation works, and encouraging effective feedback. Teachers need to stick to giving effective feedback to students; it is like a commitment between the teacher and his students. For our students, we give them our feedbacks for the assessments they do; it is rather a “guidance system” (Burke & Pieterick, 2010, p. 4) for understanding their mistakes which are “a necessary part of the learning journey” (Burke & Pieterick, 2010, p. 97), correcting them, and achieving therefore better results in future assessments.

2.2.1.3 Practice of inclusive teaching

By definition, inclusive teaching means recognising, accommodating and meeting the learning needs of all your students. Inclusive teaching values all students and embrace the ones with special needs. It promotes equality of opportunities for everyone to be able to learn in HE institutions. However, barriers exist; according to the research of Adams and Holland (2006), barriers may be “structural, organisational, behavioural, and attitudinal” (p. 12). There is a big step to do in order to change or ‘sweeten’ people’s points of view and attitudes, we certainly can provide teaching to impaired students without affecting academic integrity. However, some issues that make inclusiveness of impaired students do exist and can’t be changed that easily. For example, any social event programmed for the night won’t be accessed by sight-impaired students. As for deaf students registered in engineering, following the pace of the class is not evident. Lots of information is given and time doesn’t allow continuous interruptions. Also, access to fieldwork may be impossible in some cases and one needs to “understand fully the boundaries and nature of its impairment” (Farrar, 2006, p. 183).

3. Designing and evaluating for Learning and Teaching

3.1 The theory and ideology of design

Good design in HE is that which promotes a deeper and more effective learning experience. It must accommodate the complexity of both HE purpose and the complexity of individual learners. For Biggs (1999), the key issue in designing learning experiences is to ensure “constructive alignment”, that is, “identifying clear learning outcomes”, “designing appropriate assessment tasks”, and “designing appropriate learning opportunities for the students”. The design must also meet personal requirements (teacher’s philosophy, experience, research, interest...), departmental and institutional requirements (syllabi, the university learning and teaching philosophy), and external requirements (market needs). In application to Confucius famous quote: “I hear and I forget. I see and I remember. I do and I understand”, active learning engage students in
the learning process. It requires from students meaningful learning activities and a deep thinking about what they are doing. This is why designing and evaluating for learning and teaching is quite an important task. It encourages a deep approach to learning based on a well-structured and integrated knowledge base. It also involves interaction with others like peers or the tutor himself. An intrinsic motivation exists that pushes the student to get an ownership of his learning. This active process teaches the students to learn the skills of inquiry.

3.2 Aims and Learning Outcomes:
Learning Outcomes (LO) will be written clearly in a language that is comprehensible to students at that level in HE (Moon, 2002.) and by the need to “align learning outcomes with assessment and assessment criteria” (Gibbs and Simpson, 2004). Nevertheless, the lecturer’s role is to ensure that the “LOs do not stifle creativity and become too prescriptive” (Ecclestone, 1999). Flexibility is essential for encouraging discussion and creating a flourishing environment for students. In Race’s Ripple Model, some interesting factors are underpinning successful learning like “learning by doing, learning from feedback, wanting to learn, needing to learn, and making sense” (Race, 2010). Moreover, appropriate learning opportunities are designed for the students “to get them to successfully undertake the assessment tasks” (Biggs, 1999) and peer teaching through group works is of real benefit to an effective and deep learning experience.

3.3 Evaluation techniques
Evaluation plays an important role in shaping professional practice and many evaluation techniques have been implemented; each one being specific to a certain purpose as identified by Chelimsky (1997):

1. Evaluation for accountability
2. Evaluation for development
3. Evaluation for knowledge.

Moreover, in HE, evaluation methods offer the chance to feedback, “allowing teachers to refine their practice” (Huxham et al., 2008, p. 675). These methods may range from institutional evaluation, through programme or module evaluation down to an individual session. However, “difficulties in assessing teaching have led to the undervaluing of teaching skills” (Attwood, 2009). This is why some academics do not seek to improve their teaching since their developments are not recognised. We will be appraising two techniques despite the fact that auto review and self-reflection are also adopted and have a potential role in shaping professional practice.

3.3.1 End of module questionnaire
An online questionnaire is implemented and is filled in by each student at the end of each module. To ensure that all the students will respond to this questionnaire, it has been established that no one can see his final grades unless he has filled the form. The questionnaire contains many parts and each part consists of many questions. It allows students to indicate their level of agreement or disagreement to a topic concerning the whole module, the method of teaching, the assessment exercises and individual tutors. McCullogh and Radson (2011) wrote that despite their importance, student evaluations of teaching analysis and interpretation data are not given the correct care and concern, making discriminations between professors. Consequently, there is a need to implement a method which does not appear to misrepresent a teacher’s performance and is not sensitive to outliers. In their research, Kember et al. (2002) found no evidence that the use of questionnaires made any contribution to improving the overall quality of teaching. This may be true since some students answer randomly the questions, without any effort of positive reflection, but only to be able to see their final grades. This may cause random results. Moreover, no space is allocated for students’ personal comments which can be their chance to express their opinion. This possible space can also help students envisage themselves as “stakeholders” in their learning (Macdonald, 2006). Furthermore, there might be a correlation between student evaluations of teaching and expected grades as written in the research of Boysen (2008, p.218). A survey done by Tabachnick et al. (1991) showed that some teachers admitted to give easy tests to ensure popularity with students (p. 510). This is how students reward professors with high evaluations in exchange for high grades. It is worth noting here some pertinent reflection that one can ask himself: “Are students qualified to rate their instructors and the instruction?” (McCullough and Radson, 2011, p. 201). This is why, student end of module questionnaire is not used alone but along with a peer review of teaching.

3.3.2 Peer review of teaching

Another common method of evaluating faculty includes the peer teaching review experience. A checklist is used by the peer while evaluating a faculty member’s teaching. This method is a little delicate since not every teacher accepts this idea of peer review positively, despite the fact that it has been very clearly stated that the purpose of this evaluation method is for teaching development not judgment as stated in Macdonald and Kell (2006, p. 404). There are certainly many reasons for this opposition to peer review. It may simply be the “reluctance to be involved or engage with the process” (Lomas and Nicholls, 2005, p.139). Also, the reasons to this lack of involvement and engagement are that peer review of teaching can be seen as challenging academic freedom and concerns about the objectivity of those who review...On the other hand, for a successful peer review process, the faculty must implement a clear and objective procedure in order to avoid any misunderstandings. In their research, Macdonald and Kell (2006, p.405-406) explicated the steps to follow in order to ensure a most effective peer review experience:
1. Advance meeting: the reviewer discusses the context and purpose of the peer review and the reviewee establishes the ground rules for the process.
2. Discuss the focus of the peer review.
3. Collect the evidence: the reviewer may search to what is recognized as good practice in the field.
4. The reflective dialogue: at the end of the meeting, both parties will benefit from exchanging “gains” as identifying areas for development and enabling the production of an action plan.
5. Implications for your practice – the key step.

But above all, it is crucial to perceive peer review as a development process with no judgmental elements for a positive and mutual reflection on our teaching experience. Moreover, an “advantage of peer observation is the peer’s own development fostered through the ideas obtained from watching a colleague” (Fernandez & Yu, 2007, p. 156). It is also essential to understand how this peer review will help shape the teaching practice for a life learning experience. For example, a proper training for the observers and a certain number of visits per semester, not only one observation, are required (Arreola, 2003). This is however time and potential consuming.

4. Conclusion

Teaching has always been a vocation; nowadays, new methods and new approaches are established in order to improve the way information is transmitted from the teacher to the student. Teachers must show a broad, critical view of knowledge and learning, they have to be conscious of their role in the larger world we want to build and adopt a global perspective by “enhancing their understanding of the many forces that shape the existence”. The Development Education Association provided what “developing a global perspective” means, like for example, “developing skills, attitudes and values to enable people work together towards a more just and sustainable world where power and resources are more equitably shared ...”. Teaching appears to be an attitude that is always positive, that tries to improve and not criticize, and that aims to empower individuals and gives equal opportunities to all. Moreover, it goes together with sustainable development which “meets the needs of the present without compromising the ability of future generations to meet their own needs” (Retrieved from http://www.sustainable-environment.orh.uk/Action/Brundtland_Report.php).
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TRANSFORMATIVE LEARNING IN AN ENGINEERING PROGRAM

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ABSTRACT

Transformative learning Theory is a concept that was proposed by Jack Mezirow in the mid 1970’s. This concept developed into an educational theory over the years and posits that people have certain perspectives of things which may change when a person encounters a situation that does not fit that perspective. Engineering education has the reputation of housing less chance for transformation. Theoretically, using Blooms taxonomy, it can be shown that in a typical Mechanical Engineering program, transformative learning increases year-by-year. A student survey of a three-year engineering study system indicates that the change in transformative learning from one year to the next is almost the same. Thus, it may be concluded that while TL occurs in engineering education, further study is required to fully understand current and future mechanisms.

Keywords: Transformative Education, Transformational Learning, Transformation engineering, Mechanical engineering.
1. Introduction

The attention given to the study of the quality of university education has been increasing in the last 10 years or so. Accreditation has become a main goal of many university programs as they review what they had previously been doing in a more-or-less random manner. Accreditation in a university program normally involves the programs having to address a set of criteria handed down by the accrediting without the need to analyze the actual mechanics of learning. While this is certainly sufficient for outcome fulfilment purposes, those interested in the actual learning process would need more.

Transformative learning theory (TLT) provides a framework that allows us to understand a different type of learning, one that is effective and more enduring. The basic premise in TLT is that when someone encounters an incident, called ‘disorienting dilemma’ [1], that leads this person to examine his/her previous knowledge, assumptions and beliefs on the topic. This reflective examination causes some change in the person’s knowledge base and his/her beliefs and affects that person’s behaviour. Hence, the person is transformed during this process that entails self examination as well as an examination of his/her basic assumptions and beliefs.

In this paper transformative learning in engineering education is considered – a field that appears, as evidenced by the lack of many articles on this, not to have been the subject of much research. This work will address this gap to discover the peculiarities of transformational learning (TL) in engineering education. Transformative learning is thought to be more durable and leads to more self confidence and higher competence [2].

In general, education at universities starts with the very basic concepts given in introductory courses that impart essential knowledge to students. These basics allow students to grasp, internalize and analyze the richer concepts or ideas that they encounter later on. A course in a discipline can be placed on a continuum from introductory to advanced [3] and courses can be compared and analyzed using Bloom’s taxonomy.

According to Bloom and associates [4] higher level cognitive skills are built on top of lower level ones. Anderson and Krathwohl [5] reviewed the model proposed by Bloom and made small changes and used new words for describing the levels. According to Anderson and Krathwohl [5], knowledge progresses from factual – knowing basic facts and ideas, to procedural – knowing how to do something. This corresponds to the following levels of cognition: remembering, understanding, applying, analyzing, evaluating, and last, creating [5].

Universities in general sequence courses in accordance with Bloom’s taxonomy, universities present the basic and more superficial information first. Vermunt [6] did studies that revealed that exams used in the first years of higher education do not reflect any expectation of critical or
analytical processing by students. As students advance in their studies, instructors start introducing more complex concepts until the student learns to use analytical and critical skills.

In engineering education there has been increased interest in creating environments for more transformative learning. Chen [7] described how transformative learning may be activated through specific measures within a given engineering course by creating opportunities for team work, peer-assisted learning as well as rapid feedback. However, before we can venture into changing the nature of engineering learning, we need to understand existing engineering education first. Accordingly, the research questions that this paper attempts to answer are the following:

RQ1: Is there TL in engineering education?
RQ2: Does TL increase with the level of engineering education?

The following section will introduce Transformative Learning Theory, which is a theory that describes how education may transform individuals and their thinking styles, thus modifying their mental models of the realities of the world. The paper then presents an analysis of transformative learning in engineering education taking a curriculum in mechanical engineering as a case study. The paper ends by presenting the results of a quantitative survey and commenting on them.

2. TRANSFORMATIVE LEARNING THEORY

Mezirow first introduced transformative learning theory over thirty years ago [8]. The idea that people undergo perspective transformation went through several changes before it developed into the theory of transformative learning that is currently between our hands. This section summarizes the main concepts of the theory and the changes it underwent, including the critique that it was subjected to.

2.1 The Theory

Transformative learning occurs through ten phases. It starts when an individual encounters a disorienting dilemma that contradicts that person’s knowledge or beliefs and leads that person to self-examination. During self examination the person notices some incontinences or unfruitful characteristics. This leads to a critical assessment of the person’s assumptions allowing the person to explore new ways of acting. After that the person starts building confidence in doing something new and plans a new course of action. This leads that person to seek to acquire more knowledge on how to execute this new course of action. Then the person starts trying these new behaviours, and if successful, the person integrates these into his or her life [1, 2].
Learning, according to Mezirow, is trying to make sense of the meaning of an experience and creating out of that a guide to action [9]. Transformative learning, on the other hand, is about re-examining an experience and attempting to understand it with a new set of expectations, thus providing a new meaning to that experience [9, 10]. Then the person has to start using this new learning or new perspective gained in his or her life [11]. A person build a “frame of reference” that allows him or her to understand the experiences that that person went through. Frames of reference shape and mold expectations, perceptions, cognition, and even feelings [10].

Several researchers [e.g. 12, 13, 14] criticized Mezirow’s early work for its lack of the effect of context on the learning experience. According to those researchers the earlier theory lacked the effects of social, emotional and affective contexts, which are important for learning [14]. Taylor also suggested that a disorienting dilemma may be the result of a cumulative process rather than a sudden incident. In his later works, Mezirow acknowledged the effect of context and culture on the learning process [2].

### 2.2 Reflection and Transformative Learning

Reflection is important for learning. When people reflect on the way they see things, their frames of reference, then they have the opportunity to adjust those frames [2]. People may need to ask others for their input and advice regarding their own point of view. Feinstein [15] commented that without reflection learning may not be transformative. Reflection guides people to evaluate their beliefs, values, and assumptions and challenge personal and professional opinions [16], which may lead to the creation of new frames of reference (or meaning perspectives) [10, 17]. “Becoming critically reflective of one’s own assumptions is the key to transforming one’s taken-for-granted frame of reference,” [10].

A person makes sense of the world through the values, beliefs, and assumptions (Orlikowski and Gash, 1994; Merriam, 2004). The frames of reference of a person are the result of cultural effects and the influences of primary caregivers [10]. However, “Frames are constraining when they reinforce unreflective reliance on established assumptions and knowledge, distort information to make it fit existing cognitive structures, and inhibit creative problem solving,” [18]. Thus, without reflection knowledge may be distorted when it does not fit existing frames. Through reflection and transformative learning knowledge is not distorted, but the frame of reference may be modified and adapted (Merriam, 2004). Those new frames of reference are “more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action” [2].

Reflecting is not a superficial activity. It involves wondering about facts or assumptions, probing the condition, analyzing the situation, synthesizing the findings, and connecting or relating to the conclusion [19]. Hedberg identified three types of reflective learning:
1) **Subject reflective learning:** it relates to a deeper understanding of the ideas that the person faced during the experience and is reflection upon the topic itself.

2) **Personal reflective learning:** it relates to the self-understanding and self-awareness of the person doing the reflection.

3) **Critical reflective learning:** it relates to questioning the society’s assumptions, beliefs, and commonly accepted wisdom.

Mezirow [9] had three types of reflections as well:

1) **Content reflection:** it relates to reflection on the experience itself.

2) **Process reflection:** it relates to reflection on the process and way of handling the experience.

3) **Premise reflection:** it relates to reflection on the assumptions, beliefs, and values of society concerning the experience.

The main difference between the two taxonomies is that according to Mezirow [9] premise reflection is the only type of reflection that can lead to transformative learning. While Hedberg (2008) hinted that only personal reflective learning may lead to transformative learning.

### 3. TLT IN ENGINEERING EDUCATION

The nature of the specific academic discipline influences the kind of strategies that students use to learn [6, 20]. Engineering study domains, involve large amounts of remembering of basic and applied sciences in the early year(s). This very low taxonomic level of intellectual behavior, leads to very few occasions for TL to occur in the sophomore year. It is only in the junior or even senior year that there are vehicles for transformative learning. To try to dissect this situation a specific engineering program at RHU is studied – the bachelor of mechanical engineering program.

#### 3.1 Mechanical Engineering Program

BS Engineering programs at RHU include 114 credits hours beyond the freshman year which involves 30 credits – thus adding to a total of 144 credits. This compares with similar programs in the US for example. The 30 credits are spread amongst Math, Physics, English, Humanities and electives courses. The mechanical engineering program course listing is shown in Appendix 1. The so-called bloom levels are assigned by starting at the lowest Bloom level (remembering) and assigning it a value of “1”. The highest level (creating) is assigned a value of “6”. For each course, the anticipated learning levels are listed as well as the highest learning level.

A premise is set that assumes that the chance of encountering transformative learning is greater the higher the Bloom level of learning. This permits the introduction of a “probability of TL” to
be defined as: “the ratio of the highest Bloom level to the maximum Bloom level (6) – modified by multiplying by the ratio of the number of contact credits hours per week divided by 3 (since 3 is the standard for a didactic course), this can be quantified as:

\[ P = \frac{n_{\text{highest}}}{6} \times \frac{n_{cr}}{3} \]  

[1]

Where \( n_{\text{highest}} \) is the highest Bloom level for the course, \( n_{cr} \) is the assigned weekly credit hours, and \( P \) is the probability of encountering transformative learning within a course.

Equation 1 is applied, course-by-course, to the Mechanical engineering curriculum at RHU, with the course chronology as listed in the catalogue (save for the shifting of the Introduction to Engineering course to the beginning of the listing). What emerges is a figure that plots the probability of theoretically encountering TL throughout the progress of the mechanical engineering program. Of course, the chronology is not precise at a given date since the listings may be altered within a given semester – nevertheless overall some order may be observed. It is noted that for the program being analyzed the total number of courses are 39 – hence the ordinate. This “Blooms course program Spectrum” or simply “Blooms spectrum” as it has been dubbed, provides a vehicle to assess the intellectual quality of a given college program.

![Figure 1: Blooms spectrum for a Mechanical engineering program](image)

### 3.2 Transformation in a mechanical engineering program

The Blooms spectrum for the mechanical engineering program at RHU clearly exhibits a rise in the probability of encountering Transformative learning. In fact, the average probability of encountering transformative learning for year 1 (sophomore) is 0.38, while for the junior year it
becomes 0.48, and for the senior year it increases to 0.76. The last figure is still high at 0.73 if the COOP internship is excluded. Most likely, as courses become more specialized, students tend to question theory.

In year 1, students are normally struggling with so-called “gateway courses” – foundational courses which future courses build on. If students do not do well in these, it is likely they will not succeed in future courses. Incorporating transformative learning into this level may be a way to improve the opportunities of success. For the program being analyzed, the TL probability may be improved by incorporating means or events that allow students to “question” concepts rather than simply memorize. Chen [7], in his experimental gateway project course, found that there could be enhancement of results if transformative measures are worked into the course. Rapid feedback, conceptual learning and peer-assisted learning are identified as components that lead to TL.

A definite encountering of TL takes place in the COOP internship as expected when students become exposed to real life practical applications in engineering. In fact, it is seen that the probability in the graph goes above one, which is artificial but is a result of the fact that in the program studied COOP is assigned 4 credits while the base is 3 credits. This COOP experience is handled very seriously at the university in a variety of ways which will not be discussed here.

3.3 Questionnaire on TL in engineering education

The survey instrument used to measure transformational learning is a standard instrument used by researchers for measuring the amount of reflective thinking [21, 22] with four more questions added. The new questions ask whether there has been any change in thinking or behaviour of the student due to the studies undertaken. The addition of these questions was necessary to understand whether transformation actually took place due to learning.

4. RESULTS OF QUESTIONNAIRE

The results of the survey include values for change, critical reflection, reflection, understating, and habitual action for the three levels of education: sophomore, junior, and senior. The total number of usable completed surveys acquired is 80: 16 sophomore, 28 junior, and 36 senior. These results answer the first research question regarding the existence of transformational learning in engineering education. According to these results it is possible to say that transformational learning does exist in engineering education as evidenced by the occurrence of critical reflection and change in thinking and behaviour of students. The means of the survey samples for every concept variable and for separate years are shown in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Change</th>
<th>Critical Reflection</th>
<th>Reflection</th>
<th>Understanding</th>
<th>Habitual Action</th>
</tr>
</thead>
<tbody>
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<td>Sophomore</td>
<td>2.09</td>
<td>2.36</td>
<td>1.85</td>
<td>1.61</td>
<td>2.63</td>
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</table>
From this table one can see that the means of the values are very close. However, further analysis is required to see whether these differences are significant or not.

The first idea was to use tests of means to compare sophomore survey results with junior and senior survey results. Since the number of observations is less than desired, yet not very low, there did not seem to be a consensus on whether to use parametric or non-parametric tests of means.

Using SPSS to execute Kolmogorov-Smirnov test of normality the outcome showed that most samples are normally distributed except the following: the Understanding sample for senior students, and the Habitual Action sample for junior and sophomore students. Based on these results we could use parametric tests of means to compare all samples except the ones with non-normal distribution.

The un-paired t-test for comparing sample means together with Leven’s test of equality of variance showed that the means are not significantly different between sophomore and junior students for any pair of means, and not significantly different between sophomore and senior students for any pair of means.

Yet, some researchers might not be comfortable with the use of parametric tests for what might be considered small samples, so we used the Mann-Whitney U non-parametric test of the samples and it showed no significant differences between any pair of means of the three years.

After first looking at the data our expectation was that sophomore students may be different from junior and senior level students in transformational learning variable. That is why we choose mean tests for comparison of two samples. Yet, to complete the analysis we used ANOVA to test all three groups (sophomore, junior, and senior) at the same time. The ANOVA results were very similar to the results provided by the parametric and non-parametric tests of means. There is no significant difference between any pair of samples from the survey.

At first glance the results may seem disappointing. They show that there is no difference in transformational learning concepts between the three levels: sophomore, junior, and senior. However, looking closely at the survey questions and referring to the figures that map the mechanical engineering program to transformational learning outcomes and Bloom’s taxonomy, one might understand the results in new light. The survey questions ask for transformational learning that occurred within the last year. The survey results might be showing that the amount

<table>
<thead>
<tr>
<th></th>
<th>1.91</th>
<th>2.09</th>
<th>1.80</th>
<th>1.60</th>
<th>2.42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junior</td>
<td>1.90</td>
<td>2.18</td>
<td>1.70</td>
<td>1.70</td>
<td>2.60</td>
</tr>
</tbody>
</table>

Key: 1 = definitely occurred, 5 = definitely did not occur

*Table 1: Means of variables per year*
of increase in transformational learning is not significantly different from one year to the next, as students could be building upon previous knowledge. This means that $\mu_1$ is similar to $\mu_2$ is similar to $\mu_3$ as explained in Figure 2 below. However, the amount of transformational learning in year two (junior) is larger than that in year 1 (sophomore), and that of year 3 (senior) is larger than that of year 2 (junior).

![Figure 2: possible explanation of results](image)

5. LIMITATIONS OF THE STUDY

One of the limitations of this paper is the relatively small amount of data used for testing. However, the data acquired is more than 15% of the population, which means that it is good enough for reference regarding this population. Another limitation is restraining the collection of data to only one institution. Since this is an initial study, it was pragmatically useful to limit data collection to one institution. More institutions will be surveyed in future research.

6. CONCLUSIONS AND DISCUSSION

This work has addressed two research questions regarding the existence and level of transformational learning in engineering education. TL occurs when a person encounters a situation that challenges his or her beliefs and leads this person to reflect on his or her thoughts and behaviour and ultimately leads to changes in this person’s thoughts and behaviour.

This work showed that TL exists in engineering education. All levels of engineering education showed that students undergo transformations and learn new concepts and new ways of thinking and behaving. However, this work was not able to show conclusively that TL increases as one advances in engineering education at least as far as the curriculum studied is concerned.
Acknowledgements

The authors wish to thank Miss Yasmine Al-Yamani for her patient effort in data collection and sorting. Thanks also go to Dr. Jad Kozaily and to Dr. Dina Serhal for their help in motivating and urging their students to participate in the questionnaire.

References


## Appendix 1: Mechanical Engineering course listing at RHU with Blooms Taxonomic level

<table>
<thead>
<tr>
<th>No.</th>
<th>Term</th>
<th>Course No.</th>
<th>Description</th>
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<th>Available Bloom Levels</th>
<th>Maximum Bloom Level</th>
<th>Comments</th>
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<td>1,2</td>
<td>2</td>
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<td>3</td>
<td></td>
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<td></td>
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<td>English</td>
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<td>2</td>
<td></td>
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<td></td>
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<td>1</td>
<td>May be improved</td>
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Total credits 114

Bloom levels:
1. Remembering
2. Understanding
3. Applying
4. Analyzing
5. Evaluating
6. Creating
THE EFFECT OF GLOBALIZATION ON EDUCATION IN VIRTUAL UNIVERSITY

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Abstract

Internationalization in higher education is an inevitable result of the globalized and knowledge-based economy of the 21st century. Other trends affecting the universities, including diversification, expansion, privatization, and so on, also have implications for the international role of academic institutions. The intersection of the logic of globalization and other pressures facing universities make a reconsideration of international programs and strategies necessary. Exchanges, university linkages, patterns of mobility, and international and regional arrangements among universities are all changing. Much has been said about the impact of globalization on higher education. Some have argued that globalization, the Internet, and the scientific community will level the playing field in the new age of knowledge interdependence.

Keyword: globalization, virtual university.

1. Introduction:

Higher education the world over has now become part of the globalization process and can no longer be strictly viewed from a national context. The realities of globalization and its attendant impacts on the sector is an urgent priority for higher education [1].

In the 19th century, for example, American students flocked to Germany, which pioneered the modern research university, combining teaching and research under one roof. Soon, Americans were copying the model, founding institutions such as the Johns Hopkins University and the University of Chicago. Before long, they had perfected it, building universities that achieved worldwide renown after World War II. Today, in a 180-degree turnaround, Germany is
looking to the competitive ethos of American universities for inspiration as it seeks to revive its floundering higher-education system[2].

But if humility is in order when forecasting the exact form that university globalization will take in the years ahead, it seems safe to say that the trend is here to stay. The sheer degree of global activity in higher education is extraordinary. Some three million students worldwide now study outside their home countries 57% increase in just the past decade. Branch campuses have seen similarly rapid growth, with more than 160 around the world. Almost everywhere, governments eager to reap the economic benefits of an educated citizenry are trying to boost overall enrollment (China's has quintupled in a decade) and achieve "world class" status for at least some of their universities. Global college rankings, and global for-profit universities, are booming [1].

To what extent will each of these trends continue? Student mobility, for one, seems likely to surge: By one estimate, the number of globally mobile students will nearly triple, to eight million, by 2030.as shown in fig.1.

At the same time, the overall direction of mobility could change significantly. India and China are likely to continue to be the world's leading single-nation exporters of students, but China has already started taking in more foreign students overall mostly from other Asian countries than it sends overseas. Indeed, with the emergence of Europe's Bologna Accord, which standardizes degree requirements across the European Union, together with similar efforts in Asia, Don Olcott Jr., head of the Observatory on Borderless Higher Education, suggests that a new "regional globalism" may emerge, in which students study abroad within their regions [2].

On the branch-campus front, it would be a mistake to read too much into setbacks like Michigan State University's recent decision to close most of its Dubai programs. Even as some branch campuses fail, many new ones open. That is in keeping with the entrepreneurial nature of such efforts, which vary significantly and face very different financial expectations and regulatory constraints.

An even more significant movement to watch, however, will be the efforts under way in so many countries including China, Singapore, and Saudi Arabia to create top-tier research
universities. These efforts are certain to continue, but it remains to be seen which will deliver results, either academically or economically [2].

As values of competition and meritocracy spread in universities worldwide, global college rankings will surely remain popular. With improvements, particularly in measuring the quality of teaching and learning, they can serve as useful guideposts. But it is worth bearing in mind that, for some students, a flourishing for-profit sector with appropriate oversight, to be sure may be an effective route to advancement, with no need to pass through the doors of a top-ranked university. That's one reason that continued fast growth among global for-profits seems probable.

One final lesson for educational prognosticators, particularly in the United States: The "us versus them" prism through which American universities and policy makers sometimes view stepped-up global competition is becoming less and less relevant. Cross-border research collaborations have more than doubled in 20 years and will surely grow. Partnerships between leading Western universities and rapidly improving institutions in Asia, Europe, and beyond are expanding quickly. Universities may take on entirely new forms.

In this evolving world, academic improvement in one country need not mean that others should fear falling behind. More than ever, the key to innovation and economic growth will lie in the freest possible movement of people and ideas on campus, and beyond.

When the world's financial, information networks and production systems globalized, greater globalization of learning and science became inevitable. It seems reasonable to me that "regional globalization" is likely to be with us for a while as ... how far do most parents really want to send their child away from home? While greater globalization seems inevitable, at the same time it is amazing now that it is here. The universities and nation may begin to more actively consider the role of global student recruitment in balance of payments, and in balance of prestige. As knowledge and education becomes more spread out around the world, there is likely to be a relative leveling of the power among nations. The stats in the article do not appear to address international online education, which may be making the globalization greater [1].

2. Construction strategy paper of virtual university:

This strategy paper is a result Develop Strategies Addressing the Implications of Globalization. The main objective of this project was to enable to improve education in universities for them to be well equipped to tap global knowledge resources and apply their knowledge to support local and regional development. As an outcome of this project, each participating institution was to develop a strategy for responding to internationalization [2].

3. Relation to virtual University Strategic Plan:

It is important that this strategic plan falls within the context virtual University’s Strategic Plan. Current Strategic Plan covers a ten year period from 2015 -2025. The plan takes into account the experiences of the university over the last 25 years and the current national and global challenges that have implications on the realization of the mission and vision of the university.
The plan articulates the vision, mission, core values and objectives of the university and also provides the strategies to be implemented in order to give the virtual University a considerably enhanced service delivery in the next ten years. The plan has been developed within the framework of emerging educational issues brought about by national demands, new management ethos and globalization.

During the plan period, the university will focus its attention on the improvement of teaching and learning through intensified use of ICTs, and adopting curricula which are responsive to current global needs. The university intends also to improve its research capacity and develop more linkages with local and international institutions with a view to producing high-level manpower for sustainable development of society. In the plan, the university also intends to transform the overall quality of governance through devolution of responsibilities and functions to operational units to achieve best corporate management practices[3].

The plan has taken into consideration the relevant global, national and international policy frameworks and is in line with previous plans of some of universities, the Millennium Development Goals, the National Poverty Eradication Plan, and the Vision 2030 among other policy frameworks.

While the university has enjoy phenomenal growth over the past years, it has also faced considerable challenges related to governance, increasing student numbers, inadequate funding, low infrastructural capacity, human resources among others. There have also been challenges posed by globalization and the growing international dimension of a number of university activities and processes.

4. **Institutional Profile, Context and Capacities:**

This section provides basic and general background information on virtual University (VU) and the context within which the university operates. It mainly presents the history, organization, management, academic programmers, infrastructure, financing and institutional profile of the university.

The Objectives suppose of VU can be summarized as;

1- To pursue excellence in teaching, research and outreach.

2- To produce well informed practical and self-reliant graduates capable of contributing to development in a variety of contexts.

3- To offer expertise in areas of national development.

4- To promote Science and Technology for national development

5- To participate fully in the promotion of culture and develop individuals who are responsive to the needs and well being of others.

6- To offer a range of opportunities for training through continuing education.

7- To secure and manage resources to achieve the above goals efficiently.
8- To be an innovative, competitive and world class entrepreneurial University.
9- To offer expertise in national and international development in a globalized world.

5. Mission and Vision:

To preserve, create and disseminate knowledge and conserve and develop scientific, technological and cultural heritage through quality and relevant teaching and research; to create a conducive working and learning environment; and work with government and private sector for betterment of society.

The Core Values of proposed virtual University are;

1- Promotion and defense of intellectual and academic freedom, scholarship and relentless search for the truth.
2- Fostering team work, innovation, networking, tolerance and a culture of peace.
3- Embracing excellence, transparency and accountability
4- Practicing professionalism, meritocracy, equality, integrity and social justice
5- Maintaining self-respect, discipline, responsibility, institutional loyalty, national patriotism and international competitiveness
6- Continual improvement of services in order to remain competitive and relevant [4].

6. Management and organization Structure:

This is the framework within which the strategy, objectives, planning and monitoring of quality and standards of all activities in the university take place. It is specifically concerned with organs, post holders and procedures that form the framework. The university operates as a State Corporation under the Ministry of Higher Education. The governance structure is composed of various bodies such as the Chancellor, the Council, the University Management Board, the Senate, School/Campuses Academic Boards and the Departments.

The new Strategic Plan envisages further amendments to the Act to introduce new governance structures. Currently, the organs of the university comprise:

The Chancellor, honorary academic head of the university, conferring degrees and awards of certificates of the university at graduation ceremonies.

Council, as the overall administrative governing organ of the university Senate, the supreme organ that is in charge of the academic functions of the university and that makes recommendations to council on administrative matters.

University Management Board which is responsible for the day to day running of the university and is made up of the Vice Chancellor, the two Deputy Vice Chancellors, the Chief
Academic Office, the Chief Administrative Officer, the Finance Officer and the Principals of the respective campuses.

School academic boards which consider the academic functions of the respective schools and are in charge of the day today running of the schools.

The Strategic Plan also proposes further reorganization of the management structure of the university during the plan period [5].

7. Financing:

The financing of the university budget mainly comes from the exchequer and complimented by income from other sources such as privately sponsored students programmers, rent, interest, research grants, partnerships and other fundraising activities. Government funding has stabilized at 85% of the overall recurrent budget and mainly goes to meet the costs of staff salaries. For effective and timely administration, the university has decentralized most financial services to the respective schools so as to enhance efficiency and unclog the central administration.

Funding remains one of the major challenges facing the university. Reduced government funding has led to overstretched of university facilities and resources leading to the need by the university to continually re-double its fundraising and income generation efforts. According to the Strategic Plan, the University will diversify its revenue base by engaging in income-generating activities through optimal utilization of existing physical and human resources.

8. Academic programs:

VU runs a range of programs at degree (BA equivalent), post-graduate (MA equivalent) and PhD equivalent levels. These are offered within the fourteen schools i.e. School of Agriculture and Biotechnology, School of Business and Economics, School of Education, School of Engineering, School of Human Resource Development, School of Medicine and School of Science.

The duration of undergraduate programs varies from 4 to 6 years depending on the school. MPhil and DPhil programs take a minimum of two and three years respectively. A number of programs use the Problem-Based Learning (PBL) approach where students are subjected to real life situations in their areas of study. Other innovative approaches include the Legal Aid Clinics in the School of Law, interdisciplinary BA programs, and industrial attachment for students in Engineering and Science programs. These innovative teaching and learning approaches are offered in an effort to produce practically oriented graduates.
9. Strategic positioning choices

This section elaborates on the strategic choices related to globalization

(i) Enhancing education with ICT by integrating ICT in curriculum, delivery of programs and course management. Promote ICT research and innovation.

(ii) Develop an institutional ICT strategy including a financing model and capacity development.

(iii) Building core institutional capacity including utilization of the capacity building initiatives being developed within Africa.

(iv) Policy reforms, leadership commitment and supportive regulatory frameworks.

(v) Develop new funding streams to supplement government funding.

(vi) Develop and implement a quality assurance system and a quality culture.

(vii) Enhance meaningful collaborations and partnerships.

(viii) Join consortiums and relevant partnerships.

10. Capacity, Resources and Financial Requirements for Implementation of Strategic Choices

This section addresses the resources and capacities required to implement the strategic choices.

10.1 Human Resources.

10.2 Financial Resources:

The University’s financial resources have to a large extent been dependent on the government, which has stabilized at 85% of the total required budget. The balance is funded by students’ tuition and other income generating activities. In developing and implementing this plan, the following assumptions have been made in the financial projections; Government funding is expected to stabilize at the current levels.

The government will continue to fund university staff salary wage bill the student’s population is expected to increase leading to increase in student related incomes.

Further investments in the PSSP program will increase revenue. The proposed increase in physical facilities will enhance asset turnover. The Income Generating Projects and RIVATEX will thrive as a commercial wing of the University. Cost reduction measures will compensate increased operations that will in the long run reduce overheads. Partnerships and fundraising will be institutionalized[1].
11. **Information Technology and Globalization:**

The information age carries the potential of introducing significantly change in higher education; although it is unlikely that the basic functions of traditional academic institutions will be transformed. The elements of the revolution in information technology (IT) with the power to transform higher education include the communication, storage, and retrieval of knowledge. Libraries, once the repositories of books and journals, are now equally involved in providing access to databases, websites, and a range of IT-based products (Hawkins and Battin, 1998). Scholars are increasingly dependent on the Internet both to undertake research and analysis and to disseminate their own work. Academic institutions are beginning to use IT to deliver degree programs and other curricula to students outside the campus. Distance education is rapidly growing both within countries and internationally. IT is beginning to shape teaching and learning and is affecting the management of academic institutions.

IT and globalization go hand in hand. Indeed, the Internet serves as the primary vehicle for the globalization of knowledge and communications. As with the other aspects of globalization, significant inequalities exist. Inevitably, the information and knowledge base available through the Internet reflects the realities of the knowledge system worldwide. The databases and retrieval mechanisms probably make it easier to access well-archived and electronically sophisticated scientific systems of the advanced industrialized countries than the less networked academic communities of the developing countries.

The Internet simplifies the obtaining of information for scholars and scientists at universities and other institutions that lack good libraries. This change has had a democratizing effect on scientific communication and access to information. At the same time, however, many people in developing countries have only limited access to the Internet. Africa, for example, has only recently achieved full connectivity to the Internet.

The Internet and the databases on it are dominated by the major universities in the North. The Internet functions largely in English, and much of the material carried on it is in English. These realities also affect access and usage of information.

Multinational knowledge corporations have become key players, the owners of many of the databases, journals, and other sources of information. Academic institutions and countries unable to pay for access to these information sources find it difficult to participate fully in the networks. Tightening copyright and other ownership restrictions through international treaties and regulations will further consolidate ownership and limit access.

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Distance education comprises another element of higher education profoundly affected by IT. Distance education is not; however, a new phenomenon the University of South Africa, for example, has been offering academic degrees through correspondence for many decades. The
Open University in the United Kingdom has effectively used a combination of distance methods to deliver its highly regarded programs. IT has greatly expanded the reach and methodological sophistication of distance education, in the process contributing to the growth of distance education institutions. Of the 10 largest distance education institutions in the world, 7 are located in developing countries, and all use IT for at least part of their programs. Universities and other providers in the industrialized nations are beginning to employ IT to offer academic programs worldwide, a significant portion of which are aimed at developing countries. Entire degree programs in fields such as business administration can be found on the Internet, and most providers see the international market as critical for the success of their programs.

As with the other aspects of globalization discussed in this analysis, the leading providers of IT consist of multinational corporations, academic institutions, and other organizations in the industrialized nations. The Internet today combines public service-mail and the range of websites to which access is free with a commercial enterprise. Many databases, electronic journals, e-books, and related knowledge products are owned by profit-making companies who market them, often at prices that preclude access by those in developing countries [1].

12. Recommendations:

The university should strategize and invest in E-learning (the use of digital technologies and media in order to deliver, support and enhance teaching and learning, assessment and evaluation) which should include possibility to:

a) Integrate E-learning in classroom teaching

b) Replace face-to-face teaching

c) Increase outreach through distance learning to students who are not in a position to attend face-to-face education.

d) Offer new courses focused on lifelong learning (professionals who want to advance/change their career).

e) Increase access and reduce costs through substituting scientific journals and books.

f) Engage in joint action to acquire affordable internet connectivity for tertiary education through collaboration with peer institutions in the country and region at large:

  g) Initiating or joining a NREN (National Education and Research Network) such as TERNET.

  h) Joining the Unbent Net Alliance initiative.

  i) Joining and maintaining the Bandwidth Consortium (BWC) In order to reduce operational costs, the university should find ways to:

     a) Engage in international partnerships whereby students could benefit from internet based courses provided by the partners through distance education.
b) Embark on a two pronged strategy of expanding post-graduate programs and faculty research as a major avenue to enhancing the region’s intelligentsia and knowledge creation capability (focus on a limited number of well-funded post graduate programs with regional rather than national focus).

The University will also lobby with the Government to take a more proactive role in attracting and tapping the intellectual Diaspora in the knowledge domain as well as those in business and financial investment, by promulgating appropriate and conducive policies and actions. Such policies and guidelines to be developed include those to tap the intellectual Diaspora which may consist of [6]:

1-Academic exchange programs
2-Sabbatical visits
3-Sponsorship of selected departments
4-Mentoring students
5-Establishing endowment and academic chair
6-Shared published resources such as highly sought journal and books to home

13. Conclusion:

Globalization in higher education and science is inevitable. Historically, academe has always been international in scope, and it has always been characterized by inequalities. Modern technology, the Internet, the increasing ease of communication, and the flow of students and highly educated personnel across borders enhances globalization. No academic system can exist by itself in the world of the 21st century.

The challenge is to recognize the complexities and nuances of the modern context and then seek to create a global academic environment that recognizes the need to ensure that academic relationships are as equal as possible. Recognizing inequality is the first step. The second is to create a world that ameliorates these inequalities. These tasks, in the context of marketization and the pressures of mass higher education, are not easy ones. Yet, it is important to ensure that globalization does not turn into the neocolonialism of the 21st century.
References

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[3] University of California Office of the President from the Selected Works of Richard Atkinson

May 2001 The Globalization of the University.


Research by Undergraduate Engineering Students

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Abstract

In addition to being the vehicle of advancements of sciences and developments of technologies, research is known as the venue of faculty members to get promoted and consequently maintain their academic positions, in addition to being also the butter and bread of graduate students. But, what about research at the undergraduate (UG) level? Is it possible in Lebanon at the Lebanese universities? What are the conditions required to have a successful research environment at the UG level? This paper presents successful cases of research by UG engineering students at the United Arab Emirates (UAE) University. Problems preventing research at the UG level in the Lebanese universities, in particular at the Lebanese International University (LIU) will be investigated.

Finally, thoughts and suggestions will be shared and discussed.

Keywords – Research, Undergraduate Students, Engineering, Universities

1. Introduction

Engineering research experience builds teamwork skills transferable to many real world problems. It is one of the natural human pursuit of progress and service, the catalyst for innovation, and it has been, and will forever remain a formidable adventure for researchers [1].
Working with UG students provides the opportunity to work with highly motivated, skilled, and in many cases also highly appreciative students. According to Baumgrate [2], it is particularly useful to bring students to conferences in order to boost their motivation for studies and research.

For students, the attendance at a technical conference is truly exciting considering the large community of faculty and student attendees who work on similar or related research subjects.

Such activities represent an excellent opportunity to get new research ideas and expert feedback on the topics of interest. The regional activity meetings provide a useful forum because they are informal, inexpensive, and allow students to present their projects. International conferences, on the other hand, allow student attendees to establish new research collaborations with other world researchers, and will also widen the students’ perspective of research achievements in their areas of interest. In all cases, whether it is regional or international conferences, these UG student activities require proper budgeting from the faculty member’s research grants (internal or externally funded research work), from the university’s research or student budget. This means that involving UG students in research requires a constant financial support. This draws the line between research oriented universities (i.e. UAE) where UG research receives adequate and constant support from the university and local industry, and teaching oriented universities (i.e. LIU) where research support funds for students are almost inexistent if not available at all!

2. Research versus Teaching Oriented Universities

The pressure on institutions to do research is a worldwide phenomenon, and for the majority of institutions, academicians are brought up to think and do research. Research is fundamental to economic growth, and part of a general innovation agenda set by a given academic institution.

The reward system (promotion and tenure) makes faculty members think that research is more valuable than teaching, and the main focus in promotion process remains on research activities.

Taking into account this fact, the rule for any faculty member becomes “Publish or Perish”, and as a result, teaching quality may be at stake. In general, it is possible for a good researcher to get away with being a lousy teacher at any university, but it is unlikely for good teachers to slip under the radar if they are not active in research. The emphasis on research is by large money driven, that is why universities focus mainly on securing substantial grants and scholarships by building a strong research profile that attracts major donors.

Research at academic institutions draws its importance from being a key performance indicator of the institutional growth in any strategic plan. Usually
universities start as pure teaching institutions (i.e. polytechnics), the move from being a polytechnic to becoming a comprehensive research university requires the establishment of a large number of graduate programs along with the needed funding for capital facilities and equipment and for research faculty and staff. A comprehensive university should demonstrate significant research activity, and offer a wide range of undergraduate and graduate programs including professional degrees. On the other hand, teaching universities or colleges are mainly for undergraduate education with relatively few graduate programs and small graduate student body. This is exactly the case of UAEU that jumped from a pure teaching institution to a research oriented one in less than 10 years. UAEU has built its name pursuing an aggressive research agenda by building a strong and healthy research environment. UAEU demonstrated significant research activity, and offered a wide range of undergraduate and graduate programs including professional degrees. On the other hand, LIU mainly has focused on undergraduate education and on being a purely teaching institution, where the majority of faculty members are most of the time busy with teaching-related activities.

A distinguished example of research oriented institutions, MIT has built its name pursuing an aggressive research agenda by attracting the top students and building a competitive research environment. It went even further in establishing technology innovation (commercialization) centers to transform promising research ideas into innovative products and cutting-edge spinout companies [3].

On campuses where structured research programs do not exist, or where large proportions of students do not participate in such programs, i.e. like the Lebanese International University (LIU) faculty must themselves offer research training to students if they want students to gain hands-on research experience. When involved in research, UG students will work on small project ideas that, most probably, faculty members with heavy teaching load and research would not have the time to tackle. Such student research activity is self-satisfying, educational and beneficial for students’ formation as future engineers.

Many universities still put major emphasis on teaching. The majority of faculty members in such institutions focus on teaching and the welfare of UG students. Teaching-oriented institutions provide training to assist faculty members in developing their teaching methods, skills, curriculum, assessment strategies, and strengthening the connection between teaching and research. New professors are required to attend at least three mandatory teaching methodology courses during their first year at such universities. The faculty Teaching Chair program is another initiative of teaching oriented universities, where a particular department chooses one professor to act as teaching chair. Teaching Chair position holders are responsible for addressing faculty-specific teaching or learning concerns and suggesting proper solutions. For example, a typical challenging problem is the management of the large sections of first-year engineering courses. Such classes can hold up to 300 students as compared to the university’s average class ratio of 30 students.

A fruitful interaction between students and faculty members has been shown to increase retention and graduation rates. Students benefit from the wisdom, knowledge, and experience of a mentor. On the other hand, faculty members benefit from the questions students ask, the discoveries they make and the energy they bring to the project they are involved in [4].
The orientation and mentorship of UG students in research consumes a significant part of faculty time. Unfortunately, the promotion process does not value such efforts as part of the research activities. It is thus important to devise a mechanism in the promotion rules to recognize such valuable contributions which reflect positively on the student research and critical thinking abilities.

3. Research by Undergraduate Students at UAEU

Founded in 1976 by HH Sheikh Zayed Bin Sultan Al Nahyan, the UAEU is the UAE's first national university with 13,075 students enrolled in 2012/13. As a research-intensive university of international standing, UAEU has established research centers of strategic importance to the UAE and the region which are advancing knowledge in critical areas ranging from water resources, petroleum resources, solar and other forms of renewable energy, to medical advancement as well significant social and economic activities. UAEU is currently ranked as the number one research university in the Gulf Cooperation Council (GCC), number two in the Arab World, and ranked # 370 in the 2012/13 Quacquarelli Symonds (QS) World University Rankings [5].

The UAEU provides UG students with opportunities to conduct research under the supervision of their professors. This UG research requires proper facilities and infrastructure at UAEU and became an important part of the University’s strategic plan.

In research-oriented universities like UAEU, faculty members are required to allocate 40 percent of their time to research, 40 percent to teaching and 20 percent to the university and community service. These ratios are not enforced, and may vary depending on the faculty member’s involvement in each category. While universities, in general, are in the business of teaching, they have increasingly become more and more research oriented. This is exactly the case of UAE University which kept improving its research ranking during the last decade to become # 370 on QS World University Rankings® 2012/2013. The difficulty for professors at UAEU is the management of research expectations while still paying adequate attention to teaching mandate.

For the administration and students, however, the worry is always: will teaching suffer with the faculty member’s focus being increasingly biased towards research?

A typical faculty member in the Electrical Engineering Department at UAEU, like the co-author of this paper, spends a weekly average of 20 hours on research, 20 hours on teaching, and five hours on administrative duties. As employees, faculty members at UAEU aspire for better living standards. On the other hand, many have a personal desire to publish and seek sizable research grants with or without engaging UG students.

The mean classroom size at UAE University is in the range 20-30 students. The low student-to faculty ratio promotes good interaction between faculty and students. This intimate educational environment increases the willingness of faculty members to involve
UG students in their research projects. A highly achieving and well motivated student can be of significant help to faculty on research [6]. Faculty can also become more selective as the number of highly achieving students increases.

Table I shows some statistics regarding the involvement of UG students in research at UAEU’s College of Engineering during the academic year (2012/13):

<table>
<thead>
<tr>
<th>Department</th>
<th># Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architectural Engineering</td>
<td>2</td>
</tr>
<tr>
<td>Chemical &amp; Petroleum Engineering</td>
<td>0</td>
</tr>
<tr>
<td>Civil &amp; Environmental Engineering</td>
<td>12</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>7</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>

Working on a research project with a faculty member at UAEU, whether within or outside of a formal research program, not only provides the hands-on training but also allows students to establish closer ties with the faculty member. Meaningful student interaction with faculty members can increase the student’s chances of pursuing a graduate degree in the chosen field [7].

At UAEU, many students who were involved in research at the UG level decided to continue their graduate studies, and many are eagerly pursuing their PhD degrees. The following are two testimonies from two PhD students at UAE University who were involved in research at the UG level:
"Working as a research assistant was an incredibly rewarding experience for me. I have gained academic skills as well as lifelong skills which are not easily learned in the classroom. In addition, I have learned how the research is conducted; starting from the proposal write-up and submission, to securing funding, and carrying out the research that culminates with reports and publication of results and outcomes in scientific journals and conferences. I strongly encourage undergraduate students to engage in research. It is a worthwhile experience, regardless of whether you choose to attend graduate school or not because it provides you with the opportunity to think, organize information, solve problems, and demonstrate your commitment, with the reliability and capacity for research."

Maitha Al Shamisi

"Getting involved in many research activities during my undergraduate program was indeed very rewarding. Research has not only exposed me to groundbreaking concepts or cutting edge technologies, but it also made me appreciate the knowledge gained from classrooms, which definitely improved me as a student. I had the privilege to work with distinguished faculty members and graduate students to tackle challenging research problems. Besides, I had the chance to participate in numerous scientific conferences, symposia, and workshops. Currently, I am a PhD student and will always look back at my undergraduate research experience as an incredible turning point in my life."

Mohammed Abdi Jama

4. Research by Undergraduate Students at LIU

Founded in 2001 by H.E. Mr. Abdul Rahim Mourad; the LIU is the largest private university in Lebanon and the second after the national Lebanese university with around 14,000 students enrolled in 2012/13. At the engineering school of LIU, where a well defined and structured research program does not exist, and where the majority of students do not participate in faculty research activities, faculty members need to offer research training to students if they want them to have hands-on research experience.

In general, faculty members at LIU face numerous barriers to involve UG students in their research projects. These barriers include a heavy workload, a reward structure that does not provide incentives for mentoring students, very limited funding, and the potentially daunting amount of time required to mentor and train UG researchers. Even with the difficulty to devote time for research, faculty members at LIU should write research proposals and publish as it is the most rewarded activity when promotion and renewal decisions are made [8]. However, without the incentives to create research opportunities, few faculty members at LIU decided to involve UG students in research projects solely as a result of a good will to do research, keep in touch with the research world, and secure their positions as faculty members. In other words, only those faculty members who feel strongly about mentoring or who
understand the mutual benefits of collaborating with students will offer research opportunities to UGs. Extraordinarily at the

Computer & Communication Engineering department, we have witnessed this year (2013) a jump in the number of UG students who showed active participation in research and publication with faculty members.

Table II shows some statistics regarding the involvement of UG students in research at the LIU’s

School of Engineering during the academic year (2012/13):

Table II- Student research involvement at LIU’s School of Engineering

<table>
<thead>
<tr>
<th>Department</th>
<th># Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical &amp; Electronics Engineering</td>
<td>1</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>5</td>
</tr>
<tr>
<td>Biomedical Engineering</td>
<td>0*</td>
</tr>
<tr>
<td>Computer &amp; Communication Engineering</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
</tr>
</tbody>
</table>

* This may not be accurate due to the difficulty of getting the information

5. Reasons for Involving Undergraduate Students in Research

The research experience builds teamwork skills and is transferable to many real world problems.

Research promotes innovation in teaching and learning. It challenges the intellectual curiosity, and instills creativity and critical thinking in UG students’ minds. It also allows students to apply the knowledge acquired in the classroom to solve challenging real-world problems, and as a result leads to better appreciation of the discipline. A lot of learning occurs when UG students do research – learning that does not happen during traditional coursework. Classroom knowledge is reinforced and more completely assimilated when students are given the opportunity to apply that knowledge.

The brain-storming activities accompanying challenging research problems tends to boost students’ confidence and especially at the project completion stage when they feel the extent of accomplishment. Furthermore, the research publications with their faculty mentors tends to enrich their technical profile and improve their chances for acceptance in graduate school.

Research invariably leads to a better understanding of and a deeper appreciation for the discipline under investigation. Students' career goals are usually clarified after they participate in research. How would you know you will enjoy being an engineer, for example, without getting a chance to do some of the thinking, researching and writing what an engineer does? [4]
Research is also a significant confidence booster. The more students are mentally stretched (wrestling with surprising results or unanswered questions or pertinent to the previous studies), the greater their sense of accomplishment upon completion of the project. This is especially true when a caring faculty member guides and encourages students.

Establishing a fruitful interaction with a faculty mentor is another big advantage of UG participation in research. It has been shown to increase retention and graduation rates. Students benefit from the wisdom, knowledge, and experience of a mentor. On the other hand, faculty members benefit from the questions students ask, the discoveries they make and the energy they bring to the project.

Scholarly activity helps make the student’s profile more attractive to graduate schools and prospective employers. It also allows faculty mentors to write more detailed letters of recommendation. UG research promotes more meaningful learning experiences for students while helping them to carry out their research programs [4].

6. Including Credited Research Courses in the Engineering Curriculum

UG engineering programs focus on educating students to be properly equipped for successful careers in today’s global economy. An engineering program curriculum usually includes intensive classroom, laboratory, and hands-on learning. The work should be challenging and the curriculum preferably customizable. The first-year introductory engineering courses allow students to become familiar with the different engineering majors offered before making a specialization decision. Technical skills and methods are the foundation for all engineers.

However, technical expertise cannot be a stand-alone skill. Innovative thinking, leadership skills, global awareness, and interdisciplinary collaboration are key components of the UG experience.

A successful engineering curriculum encourages students to confront problems of a professional scope by working, in teams, to recreate a true work environment. Courses should be project based, and students should be able to learn and practice their trade under the supervision of well experienced faculty members. Including UG credited research courses in the curriculum improves the learning process and establishes the road towards graduate studies [9].

The Accreditation Board for Engineering and Technology (ABET) requires engineering programs to provide students with a variety of skills in order to prepare them for engineering practice and successful careers. The UG electrical and communication engineering programs at UAE University have been accredited by ABET since 1998 (“substantial equivalency on 1998, 2004 and Accredited on 2010). The programs are designed to satisfy the ABET criteria for accreditation. In addition to the intensive classroom and hands-on lab learning, students are encouraged to acquire other long-life learning skills
that include innovative thinking, leadership skills, global awareness, and teamwork skills. These can be gained through the one-semester industrial experience working for partner industries and government authorities. In addition, the two-semester capstone design experience (Graduation Project I and II) allows students to work in teams on real-world design problems. Selected motivated students participate under the supervision of faculty members in local, regional, and international scientific competitions sponsored by local student chapters, such as IEEE or ASME, AICHE, ASCE, etc. Few others with sights toward graduate school approach faculty members to work on their research projects.

It is, therefore, of utmost importance to include an additional research–based course in the UG curriculum that addresses research methodologies and allows students to have a closer look at real-world engineering and science applications. The Electrical Engineering Department at UAE University is very active in organizing, on an annual basis, the Electrical Engineering Student Activities Day, the Engineering Students Renewable Energy Competition (ESREC), and on a biannual basis the International Conference on Renewable Energy: Generation and Applications (ICREGA). These locally organized events in addition to participation in national competitions and exhibitions such as the IEEE Student Day, International Defense Exhibition and Conference (IDEX), Water, Energy Technology and Environment Exhibition (WETEX), aim at exposing students to the latest technology applications and stimulating the interaction with other university students and researchers.

Therefore, the involvement of UG students in research greatly enhances their analytical, critical thinking and long life learning abilities, and prepares them better for future careers.

7. Thoughts and Recommendations:

Creating institutional incentives for faculty members to work with UGs on research will not only reward those faculty members, who already encourage students to work with them, but will motivate others to engage students in research. The dependence of any program on few volunteering motivated and load burdened faculty members to provide research opportunities for UGs, or to advance scientific talent for the nation, is not a sustainable way on the long run. The development and sustainability of UG research programs by any institution requires the support of all faculties. For this to happen, institutions need to provide appropriate support and rewards to the teachers, researchers, and mentors who are largely responsible for educating, expanding, and diversifying the scientific workforce [7].

8. Conclusions

This paper presents a comparison between the teaching experience and research in view of the worldwide tendency to establish more research and commercialization-oriented schools at the expense of quality education. It addresses the added value of
undergraduate students’ involvement in research on their learning skills and thinking abilities.

References

Abstract

In this study, the assessment frequency of engineering knowledge disseminated in Lebanese engineering colleges is investigated. Four categories of knowledge signals are identified: the targeted and acquired knowledge signals are modeled as continuous signals, while the delivered and assessed knowledge signals are identified as the sampled (discrete) versions of the previously mentioned signals, respectively. Based on these models, the concepts of learning and assessment and the relationship between them are described. Subsequently, Signals theory, namely Nyquist-Shannon’s sampling theorem, is used to show that if the reconstruction of the acquired knowledge signal is only based on the main assessment activities (i.e. the commonly administered exams known as midterms and final) it will be corrupted by aliasing errors. Towards that end, a short survey was conducted for the main purpose of estimating the average frequency of the supplementary assessment activities (quizzes, homework, projects, etc.) commonly administered in engineering colleges, in comparison with the average frequency of the knowledge signal. It was found that even when the main assessment activities were added to a weighted average of the supplementary assessment activities, the Nyquist-Shannon sampling theorem would still not be satisfied! In addition, the survey suggested that the management of these supplementary assessment activities in Lebanon needs major improvement. Consequently, a number of suggestions were proposed including the establishment of Centers for Learning Effectiveness (CLE).

Keywords: assessment, learning, targeted knowledge signal, delivered knowledge signal, acquired knowledge signal, assessed knowledge signal, assessment frequency, signal reconstruction, Nyquist-Shannon’s sampling theorem, aliasing error, main assessment activity, supplementary assessment activity, center for learning effectiveness.
1. Introduction

Improving classroom learning effectiveness, particularly in the engineering domain, has been the subject of numerous studies and various proposals. One of the popular approaches suggested to improve learning effectiveness is Active Learning, in which the educator is encouraged to complement his/her lecture with questions and short quizzes designed to solicit feedback from students and promote class interaction [1, 2, 3].

In a previous study, a variant of the Active Learning approach, dubbed Paced Active Learning (PAL) was suggested, particularly in engineering education [4,5]. In that approach, it was proposed to administer short quizzes on a regular basis, in an effort to improve the 3-exam-per-semester assessment model, widely adopted in institutions that follow the American system of education. It is to be noted that the rationale for PAL was mainly empirical. It was merely inspired by the perceived need to increase the frequency of assessment and learning in engineering education.

In the present study, a more formal approach is used to question the effectiveness, if not the validity, of the 3-exam-per-semester model – designated in this study as the main assessment activities – in engineering education, if this model is the only source of assessment data. Even if the main assessment activities are supported by an inadequate set of supplementary assessment activities (quizzes, homework, projects, etc.), it is shown that assessment problems still exist. First, several categories of the engineering knowledge signal are identified. In particular, the delivered knowledge signal is identified as a sampled (discrete) version of the – analog or continuous - targeted knowledge signal, and the assessed knowledge signal is identified as a sampled (discrete) version of the acquired knowledge signal. Through the above definitions, the concepts of learning and assessment are briefly examined, and the relationship between these two concepts is particularly addressed. More importantly, Nyquist-Shannon’s sampling theorem is then used to identify a condition under which the sampled (delivered and assessed) knowledge signals approximate the continuous (targeted and acquired) knowledge signals respectively, without aliasing (or reconstruction) errors. In fact, the sampling frequency of the delivered knowledge signal needs to be at least twice as large as the highest frequency of the targeted knowledge signal. Similarly, the sampling frequency of the assessed knowledge signal needs to be at least twice as large as the highest frequency of the acquired knowledge signal.

In order to estimate average (typical) sampling frequencies of delivery and assessment of engineering knowledge signals in Lebanon, and compare them with the average (typical) frequency of the targeted and acquired knowledge signals, a short engineering education assessment survey was conducted among engineering educators in four leading local universities. Data provided by the survey suggested that while the sampling frequency of the delivered knowledge signal does satisfy Nyquist-Shannon’s sampling theorem, the average sampling frequency of the assessed knowledge signal falls short of satisfying this theorem, even if a weighted average of the supplementary assessment activities are added to the main assessment activities to form the assessed knowledge signal. More importantly, it was shown that the supplementary assessment activities are administered in Lebanon in quite an unregulated fashion, which may affect their validity. Subsequently, ways to manage effectively the supplementary assessment activities are discussed, particularly in view of the specific economic and cultural constraints commonly prevalent in Lebanon.
In the following section, a brief theoretical background on signals and Nyquist-Shannon’s sampling theorem is presented. In the third section, the four categories of the engineering knowledge signal are defined. In the fourth section, current trends in the delivery and assessment of the engineering knowledge signal on the Lebanese scene are identified, using an engineering education assessment survey. In the fifth section, the data provided by the survey is used for the verification of Nyquist-Shannon’s sampling theorem, particularly for the reconstruction of the acquired knowledge signal from the assessed knowledge samples. In the last section, a number of recommendations are provided for the purpose of improving the assessment (and learning) of engineering knowledge in Lebanon.

2. Brief Background on Signals Theory – Nyquist-Shannon’s Sampling Theorem

A signal is a measurable variable (voltage, current, force, speed, mass, etc.) that may be varying in time. It is said to be “continuous” if it is defined for all instants of time; however, if it is defined for only specific, equally spaced instants of time, it is said to be “discrete”.

A special class of discrete signals is the class of “sampled signals” which are obtained by sampling (i.e. taking samples of) a continuous signal at equal intervals of time, $Ts$. The time interval $Ts$ is called the sampling period and its inverse, $N_0$, is the sampling frequency (See Figure 1 - A Continuous Signal, $f(t)$, and its sampled version.)
Based on the findings of Jean Baptiste Joseph Fourier (1768-1830), any signal, whether continuous or discrete can be approximated by sinusoidal signals, and the data (frequencies, and corresponding amplitudes and phases) necessary to approximate the signal by sinusoidal signals is called the “frequency spectrum” of the signal. This frequency spectrum is typically represented by two graphs: the graph of necessary amplitudes/magnitudes and the graph of necessary phases in terms of frequency.
Based on the so-called Fourier transform, Harry Nyquist (1889 – 1976), and later Claude Elwood Shannon (1916 – 2001) showed that the frequency spectrum of a discrete signal, $f_s(t)$, obtained by (ideally) sampling a continuous signal, $f(t)$, is composed of scaled replicas of the frequency spectrum of $f(t)$, periodically repeated every sampling frequency. Consequently, they showed that in order to be able to properly reconstruct the frequency spectrum of $f(t)$ from the frequency spectrum of $f_s(t)$, the sampling frequency needs to be at least twice as large as the largest frequency existing in the frequency spectrum of $f(t)$ [6,7]. In other words, the sampled signal has to have at least two samples in the smallest period of the original signal, $f(t)$. Otherwise, a certain type of error occurs in the reconstruction process called aliasing errors.

3. The Knowledge Signal – Types and Categories

Figure 1 - A Continuous Signal, $f(t)$, and its sampled version, $f_s(t) = f(t)|_{t=nT_s}$.

Figure 2 - Targeted versus Delivered Knowledge Signal during a 15-week Learning Period.
Noting that knowledge is generally a measurable variable, it is possible to model it as a signal. A knowledge signal could indicate the level of complexity, depth, breadth, etc. Furthermore, given the limited scope and finite duration of delivered and acquired knowledge in contemporary engineering colleges, it is possible to identify several categories and types of the engineering knowledge signal.

3.1. Targeted versus Delivered Knowledge Signal

In modern engineering colleges following the American system of education, engineering knowledge is typically delivered in the form of individual courses, each offered in a near-cyclic fashion, where each cycle is largely focused on a textbook chapter. In addition, the duration required to complete a course is commonly known to be a semester, a trimester, or a quarter. In this context, it is normally desired to disseminate a knowledge profile that is higher at the end of each chapter than at its start. Nevertheless, it is common that this targeted knowledge signal goes through peaks, bottoms, and flat periods, along the way. Given these observations, and based on purely empirical data, it is possible to build a preliminary model for the targeted knowledge signal, considered in a 15-week-semester-based engineering college as in Figure 2.

On the other hand, the delivery of the engineering knowledge signal is typically provided only 2 or 3 times a week, each time for a duration not exceeding an hour and a half. That is the reason why the delivered knowledge signal is considered to be a discrete signal. It is worth mentioning that the delivered knowledge signal is usually expected to approximate the targeted knowledge signal.

3.2. Acquired versus Assessed Knowledge Signal
In a similar fashion, we can model the acquired knowledge by a continuous signal that follows the path of the knowledge acquired by the student, when exposed to the delivered knowledge signal. Finally, the assessed knowledge is modeled by a signal that represents the knowledge demonstrated by the student during formal assessments. In an assessment model based only on two exams and a final, the assessed knowledge signal during a complete semester is typically a 3-sample discrete signal as depicted in Figure 3.

Here again, it is worth mentioning that the assessed knowledge signal is normally expected to approximate the acquired knowledge signal.

In this context, learning may be defined in terms of the proximity between the acquired and the targeted knowledge signals; however, assessment is defined in terms of
the accuracy (reduced errors) of approximation (reconstruction) of the acquired knowledge signal from the assessed knowledge signal.

In this context, we could state that satisfactory assessment can be seen as a necessary condition for satisfactory learning; however, it is not a sufficient condition, since the reconstruction of the acquired knowledge signal could be satisfactory, while the gap between the acquired and the targeted knowledge signals could still remain high! Along the same lines, since a higher assessment frequency can lead to a better assessment process (by Nyquist-Shannon’s sampling theorem), and because more assessments mean more learning lessons, which may mean better learning, we usually associate the two processes, learning and assessment, with each other’s!

4. Engineering Education in Lebanon – Current Trends

In an attempt to explore the main features of the engineering knowledge signal in Lebanon, particularly the assessed learning signal, a short engineering education assessment survey was conducted in May and June 2013. One of the main objectives of the survey was to validate, confirm, or adjust the preliminary knowledge signal model described in Section 3. Other objectives included the investigation of the types of assessment activities and the modes of assessment commonly adopted in Lebanese engineering colleges.

The survey was distributed to 233 engineering educators affiliated with the engineering faculties of four leading universities in Lebanon: The American University of Beirut (AUB), The University of Balamand, The Lebanese American University (LAU), and Notre Dame University – Louaize (NDU). The proportions of recipients and respondents are shown in Figure 4.
The survey included ten questions on issues ranging from the number of supplementary assessment activities (exams, quizzes, homework assignments, and projects) given to students per semester to the perceived level of plagiarism in students’ work, passing by the number and qualifications of Teaching Assistants and the estimated

![Percentage Survey Recipients & Respondents](image)

**Figure 4 – Engineering Education Assessment Survey - Recipients and Respondents.**

<table>
<thead>
<tr>
<th>Numbers</th>
<th>None</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>&gt; 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework Assignments</td>
<td>20.4%</td>
<td>0%</td>
<td>10.2%</td>
<td>10.2%</td>
<td>6.1%</td>
<td>14.3%</td>
<td>6.1%</td>
<td>12.2%</td>
<td>2.0%</td>
<td>18.4%</td>
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<tr>
<td>Quizzes</td>
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<td>0%</td>
<td>14.3%</td>
<td>24.5%</td>
<td>10.2%</td>
<td>10.2%</td>
<td>4.1%</td>
<td>2.0%</td>
<td>4.1%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Projects</td>
<td>20.4%</td>
<td>61.2%</td>
<td>12.2%</td>
<td>6.1%</td>
<td></td>
<td></td>
<td></td>
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</table>

**Table 1 - Percentage of Respondents Offering Particular Supplementary Assessment Activities.**
The received responses showed that 79.6% of respondents give three main assessment activities (i.e. exams or midterms and finals) per semester as opposed to 12.2% giving two exams and 4.1% giving only one exam per semester. On the other hand, the respondents showed a wide variation margin in the number of supplementary assessment activities. 28.6% of respondents reported that they give no quizzes at all, while 24.5% of them stated that they give three quizzes per semester. Similarly, 20.4% of respondents stated that they give no homework at all, while 18.4% reported that they give more than nine homework assignments per semester. A similar percentage of instructors (20.4%) also reported that they offer no projects, while a remarkable large proportion (61.2%) indicated that they give one project per semester (See Table 1).

<table>
<thead>
<tr>
<th>Assessment Mode</th>
<th>Full</th>
<th>Partial</th>
<th>TA</th>
<th>Inspection</th>
<th>Other</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework Assignments</td>
<td>24.5%</td>
<td>4.1%</td>
<td>18.4%</td>
<td>34.7%</td>
<td>18.4%</td>
<td></td>
</tr>
<tr>
<td>Quizzes</td>
<td>61.2%</td>
<td>4.1%</td>
<td>4.1%</td>
<td>8.2%</td>
<td>2.0%</td>
<td>20.4%</td>
</tr>
<tr>
<td>Projects</td>
<td>65.3%</td>
<td>8.2%</td>
<td>4.1%</td>
<td>0.0%</td>
<td>2.0%</td>
<td>20.4%</td>
</tr>
</tbody>
</table>

Table 2 - Percentage of Respondents Using Various Modes of Assessment.
Concerning the assessment modes, an interesting pair of figures is the **61.2% and 65.3% of instructors** who reported that they **fully grade their quizzes and projects**, respectively, compared with **24.5% for the homework assignments**. Also, another noticeable figure is the **34.7% of respondents** who stated that they **simply inspect the homework assignments**, instead of grading it (See Table 2).

In order to get an idea of the equivalent number of combined supplementary assessment activities (quizzes, homework assignments, projects), it was possible to compute a **weighted average of the combined supplementary activities** for each mode of assessment (fully or partially graded, TA assisted, or inspected). This was done by first calculating the average number of each assessment activity separately, for each assessment mode and then combining these averages after multiplying each one by a selected weighting coefficient (for the quiz, 1 for the homework and 3 for the project). The result of this operation is shown in Figure 5). It is readily seen that the weighted average of fully-graded or TA-assisted combined supplementary assessment activities adds up to **6.02 equivalent assessment activities per instructor per semester**.

![Weighted Average of Fully-graded or TA-assisted Combined Supplementary Assessment Activities by Assessment Modes](image)

Figure 5 - Weighted Average of Combined Supplementary Assessment Activities.

Also, in order to get a more accurate idea of the average frequency of the knowledge signal, survey recipients were asked to estimate the average number of lecture-hours it takes to finish one typical chapter in their corresponding discipline. As a result, the total **estimated average number of lecture-hours per cycle of the knowledge signal** turned out to be **5.7 lecture-hours**.

Additional significant figures revealed in this survey include a **maximum percentage of respondents of only 18.4% who use a Teaching Assistant** for supplementary assessment purposes (See Table 2), 67% of them being graduates and
33% undergraduates. It was also noted that **65.3% of respondents** believe that plagiarism is either quite common or highly widespread among engineering students in Lebanon.

### 5. Interpretations and Recommendations

First, as an immediate result of the survey, the estimated average period of the cyclic knowledge signal turned out to be the time necessary to deliver 5.7 lecture-hours. This is equivalent to about two weeks in a typical American style engineering college. Interestingly, this value matches the value of the period of the knowledge signal empirically defined in Section 3!

The most important implication of the value of this period, however, is determined based on Nyquist-Shannon’s sampling theorem. At least two samples of the assessed knowledge signal should be contained in this two-week period. This means one assessment activity is to be performed every week of the semester, or a 15-week semester should include at least 15 samples (assessments), in order to avoid aliasing errors.

Accordingly, the (discrete) delivered knowledge signal (See Figure 2) may be sufficient to reconstruct the targeted knowledge signal, because it typically includes four or six samples (lectures) per period (3 lecture-hours per week). On the other hand, it is clear that the assessed knowledge signal, based on the three-exam-per-semester model (Figure 3) is not adequate for the reconstruction of the acquired knowledge signal, since it has only 1 sample (assessment activity) per 2.5 periods.

It is worth mentioning here that the one-learning-activity-per-week figure was suggested in an earlier publication [4], but then, the figure was purely based on empirical data, as opposed to theoretical analysis and derivation conducted in the present study.

Even if we add the 6.02 weighted average of combined supplementary assessment activities to the three main assessment activities (exams or midterms) of the assessed knowledge signal, we would still remain below the minimum number of assessment activities required to reconstruct the acquired knowledge signal with an acceptable level of accuracy.

Another important observation based on the data provided by the survey is that each respondent seems to have adopted his or her own system of supplementary assessment. Some instructors, for example, opted for no homework assignments at all, while some others gave more than nine assignments per semester; some instructors chose to inspect the quizzes only, while some others preferred to fully and personally grade them. This widely varying approach and lack of regulation with respect to the supplementary assessment activities appear to be harmful for the overall assessment (and
learning) effectiveness, since these activities should be considered as an important integral part of the assessment process.

It is to be noted that, not only the number of the presently adopted supplementary assessment activities is of concern in the sampling (assessment) process, but the characteristics and criteria for each sample is also important. In fact, the individual quiz may be too short to be considered a valid assessment activity; on the other hand, a project may be considered quite demanding. The required criteria for a supplementary assessment activity to qualify as a sample is very important, but it is not considered to be within the scope of this study. Nevertheless, this issue prompted the assignment of different weights for different assessment activities.

In general, we may note that two main limitations affect the quantitative and qualitative assessment deficiencies mentioned above. On one hand, economic constraints may limit the academic institutions’ ability to reduce the load of instructors so they can properly manage the supplementary assessment activities; on the other hand, cultural problems such as corruption and plagiarism in particular significantly affect the validity of assessments.

Consequently, a number of suggestions are proposed:

5.1. In the Short Term:

5.1.1. Establishment of Centers for Learning Effectiveness (CLE)

Based on the engineering education assessment survey, 59.2% of respondents reported that they do not use the services of any Teaching Assistant. This may be due to the weak presence, if any, of graduate programs in Lebanese engineering colleges. In fact, out of the four surveyed universities, only two have graduate engineering programs. In order to compensate for the lack or absence of Teaching Assistants in undergraduate engineering colleges, it is recommended to establish (self-funded) Centers for Learning Effectiveness (CLE), at the department level. The main tasks of these centers would be to manage the supplementary assessment activities properly and systematically. Interestingly, one way to fund these centers is through the undergraduate scholarships distributed to distinguished students. In return for their scholarships, high achievers would be asked to give some of their time to their department CLE, for the purpose of preparing and grading supplementary assessment activities, reporting on the corresponding levels of achievement, conducting appropriate tutorials in their chosen fields of expertise, helping fellow students during specific office hours, and liaising with the corresponding course instructors. As part of their duties, these Undergraduate Teaching Assistants (UTA) could be trained to identify various types of plagiarism, using various tools such as turnitin [8], and appropriately penalize the corresponding offenders, thus helping to reduce the damaging effect of this problem in the long run.
5.1.2. Reduction in Teaching Load

At the same time, it is recommended to reduce the teaching loads of engineering instructors, which will enable them to properly oversee the management of assessment activities, and act as liaison between the UTA and the administration for better reporting, accountability, and scrutiny. In addition, instructors may use the spare time for other duties more in line with their qualifications such as research! Although this second recommended action may impose more financial constraints on the engineering college, in the short term, there is no doubt that it will lead to significant benefits in the long term, due to improved assessment and learning effectiveness, an enriched learning environment, and a broader scholarly horizon.

5.2 In the Long Term:

5.2.1. Graduate Programs:

In the long term, we are expected to work towards establishing graduate programs, which could assume at least part of the roles of CLEs. Nevertheless, given the Lebanese demographic and cultural circumstances, graduate programs are not expected to reach a stage where they can satisfy the full needs of undergraduate assessment activities. That is the reason why the CLEs (if they get the chance to see the light) will be expected to continue to play a major role, even after the establishment of graduate programs in Lebanese engineering colleges.

6. Conclusion

In this study, the issue of engineering education assessment was addressed. Four variants of the engineering knowledge signal were identified, and an engineering education assessment survey was conducted. Based on Nyquist-Shannon’s sampling theorem, it was then shown that aliasing errors would occur if the acquired knowledge signal is to be reconstructed from the assessed knowledge signal, even if common supplementary assessment activities are added to the typical main assessment activities. The characteristics of these assessment activities were also found to be questionable. Consequently, a number of recommendations were suggested, mainly the establishment of Centers for Learning Effectiveness (CLE) for the systematic management of supplementary assessment activities, and the active counter-corruption engagement. In addition, it was suggested to reduce the load of engineering instructors, which will enable them to perform in line with their qualifications and better serve their respective institutions and the community at large.
References


Building Information Modeling in civil and construction engineering curricula

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Abstract

Building information modeling (BIM) brings many benefits to the Architecture, Engineering, Construction and Operations (AECO) industry when compared to the traditional design and construction approaches. To properly prepare students, many schools are introducing BIM in their curricula as a response to the current and future needs of the AEC industry. The aim of this research was to evaluate the current implementation of BIM and to identify trends in the teaching of BIM in civil and construction engineering academic programs. A survey that investigated the implementation of BIM into existing civil and construction engineering curricula was sent to civil and construction engineering academic programs in the U.S. The survey results indicated that over 40% of the responding civil and construction engineering academic programs in the U.S. The survey results indicated that over 40% of the responding civil and construction engineering academic programs either had an interest in or had already implemented BIM into their curriculum. The majority of these academic programs expected students to have at least a basic knowledge of BIM upon graduation, perceived BIM as important to industry, and planned to fully integrate BIM into their curriculum.

Keywords: BIM, Construction Engineering, Civil Engineering, Implementation, Curriculum

1. Introduction

Building Information Modeling (BIM) is the process of generating and managing information about a building during its entire lifecycle. BIM is a collaborative tool which when used in virtual design and construction allows us to explore and evaluate different design alternatives and to rehearse and evaluate different construction alternatives to achieve optimal value before construction starts. Once construction is completed the modeled information can be transferred
to computerized facility management software systems to effectively manage facilities. This life cycle approach to the adoption of BIM maximizes its value to the Architectural, Engineering, Construction and Operation (AECO) industry. Over the last few years, this trend has been gaining enormous momentum in different countries. In the U.S., the General Services Administration [1] has had since 2008 a policy in place requiring all building designs to be in BIM format.

Currently, BIM is the modeling approach of choice in many leading design and construction companies. To properly equip students with the BIM skills demanded by the AECO industry, many schools are introducing BIM in their curricula and hiring new faculty with expertise in BIM.

The extent of BIM implementation in architecture and construction curricula at universities in the U.S. has not yet been fully determined. Information about the current state of BIM education would be helpful to both the industry and to academia. Therefore, the aim of this study was to evaluate the current implementation of BIM into curricula and to identify trends in the teaching of BIM in civil and construction engineering academic programs.

2. **Background**

Colleges and universities in the U.S. recognized the need for CAD and began implementing CAD courses into their engineering curricula in the 1980s. Although CAD has been one of the primary design tools, BIM is becoming more utilized due increased awareness of its collaborative and visualization capabilities. Colleges and universities are restructuring curricula to reflect this change from CAD to BIM. Students do not need to know CAD to learn BIM; once they learn BIM, they easily extract 2D drawings out of their models. With the increased utilization of BIM in the AEC industry, its incorporation into civil and construction engineering programs has been vital for the advancement and preparation of students. Engineering students are expected to interpret and understand 3D project designs. In addition, construction engineers are expected to perform quantity take-offs, cost estimating, and scheduling tasks. One of the largest challenges faculty face in teaching BIM is promoting its integration of different areas within the curriculum.

3. **Methodology**

A survey was developed to investigate the implementation of BIM into existing architecture and construction curricula. The survey was made accessible to invited respondents from via the online survey tool Zoomerang™. The survey collected the following information from the respondents:

1) Demographics (number of students, background and position of faculty teaching BIM).
2) Current BIM implementation (number and level of classes implementing BIM, BIM software taught, scheduling and estimating software taught).
3) Type of BIM implementation (3D, 4D, 5D, 6D, etc.).
4) Academic philosophy of BIM implementation (plan to implement, introduce/become familiar, fully integrate, etc.).
5) Students’ expected level of BIM knowledge upon graduation.
6) Perception of importance of BIM to industry.
7) Complete responses were received from 31 civil and construction engineering programs surveyed.

4. Results

4.1 Demographics

As shown in Figure 1, a majority (60%) of the respondents had between 101 and 300 students. The results also indicated that 42% (13) of the respondents had implemented BIM in the curriculum with 23% (7) offering at least one dedicated course in BIM. The responses from the rest of the respondents indicated that some academic programs are waiting for student interest, others lack faculty expertise and yet others have not yet determined the need to implement BIM in their curriculum.

Some of the responses as far as the philosophy behind implementing BIM in their academic programs were:

- BIM is a useful skill for design/build applications and for students entering the consulting world.
- Try to integrate the introduction of BIM with decision science and mathematical modeling, use cases to organize related functionalities of software tools
- Using BIM as a teaching tool. Teaching BIM is not about teaching BIM, it's about doing a better job of teaching building design, sciences, construction, and engineering.
- Discipline specific - move towards discipline collaboration
- That Civil Engineering students need to know more about it, since it is the change in the industry. And also, from a research stand point of view, the department is looking into becoming a leader in BIM related research.
- One professor, Mitchell, believes it is important and has introduced it into his courses as projects within the overall framework of the course.
- While we don't have a formal philosphy, I would state that it is a tool, like many of our other engineering technology tools.
- To provide a basic understanding of what BIM is and what it is used to accomplish.
The respondents were asked about the position and background of the faculty teaching BIM. As shown in Figure 2, the 42% (13) of the respondents indicated that they had implemented BIM in the curriculum by using a faculty from a variety of different employment status to deliver the BIM course content. Note that respondents were asked to select “all that apply” when answering this question.

The respondents were subsequently asked about the number of classes implementing BIM in their curriculum. As shown in Figure 3, a majority (9) of the 13 respondents indicated that they had implemented BIM in 1-2 classes.

![Bar chart showing student enrollment in responding Civil Engineering programs.](image)

Figure 1. Student enrollment in responding Civil Engineering programs.
Figure 2. Employment status of faculty teaching BIM.

Figure 3. Number of classes implementing BIM.
Regarding the academic level of the class in which BIM was implemented in the curriculum, the majority of the 13 respondents had implemented BIM at the Senior class level (see Figure 4). BIM was implemented at the graduate level by 6 of the 13 respondents. Note that respondents were asked to select “all that apply” when answering this question.

![Figure 4. Level of classes in which BIM was implemented.](image)

**4.2 BIM software used**

Autodesk Revit was the BIM software used by the majority (12) of the 13 academic programs that implemented BIM. Bentley was used in four of the 13 academic programs that implemented BIM. Note that respondents were asked to select “all that apply” when answering this question.
4.3 BIM knowledge expected at graduation

Eight of the 13 civil and construction engineering programs that had implemented BIM indicated that they expected their undergraduate students to have at least basic knowledge of BIM upon graduation (see Figure 7). Of the remainder (5) of the 13 civil and construction engineering programs, four indicated that they expected their undergraduate students to graduate with intermediate knowledge of BIM and one expected their undergraduate students to graduate with advanced knowledge of BIM.

Figure 6. BIM software taught.
4.4 Type of BIM implementation

Respondents were asked to describe the type of BIM implementation in their programs. The respondents were able to select one or more of the following BIM implementation categories: create models for 3D coordination (3D), implement scheduling into models (4D), implement cost into models (5D), implement other information into models such as “operations and maintenance” (6D), “none”, or “other”. Regarding the undergraduate curriculum, more than half (62%) of the respondents stated that in their schools BIM was used for 3D coordination (Figure 9). Fifteen percent of the respondents (2) indicated that in their schools BIM was used for 4D, and 5D modeling. Responses for “other” types of BIM implementation included validation of laser scans and energy and environmental analysis.
4.5 BIM research

Most of the programs that had implemented BIM in the curriculum also had active research programs in BIM, which included research in the following BIM topic areas:

- Integrating BIM with laser scanning data for error/change analysis
- Using BIM based design analysis for achieving net zero energy
- BIM in Facilities Management
- BIM implementation in the Mechanical Industry
- Incorporation of safety and risk data into BIM
- Pedagogical approaches in utilizing BIM as a teaching tool
- BIM in Sustainability
- Using BIM model for supporting spatial analysis of buildings for Facility Maintenance

5. Conclusions

The response rates to the survey were encouraging; the survey yielded a xx% response rate. As interest in the implementation of BIM into educational curriculum grows, schools in the U.S. are restructuring curriculum and hiring faculty with expertise in BIM to better prepare students for
the growing demand for BIM knowledge by the industry. There was a wide range in the size of
the schools that responded indicating an interest in BIM which is not limited to large schools.

Forty two percent (13) of the civil and construction engineering academic programs have
implemented BIM as a response to the industry’s demands and a majority of programs that had
implemented BIM expected their students to have at least a basic or intermediate level of BIM
knowledge upon graduation. These forty-two percent of the respondents felt that BIM was
important to the AEC industry and that students graduating with knowledge of BIM were very
important in satisfying industry demand.

References

Modeling, Series 04 - 4D Phasing, 3D-4D Building Information Modeling.
ENGINEERING STUDENTS’ ATTITUDES TOWARDS LEARNING TECHNICAL ENGLISH: THE CASE OF TECHNICAL WRITING ENGINEERING STUDENTS

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Abstract

This study investigates the attitude of the engineering students towards learning technical English. The paper analyzed the students’ motivation for learning technical English and explored if gender and academic level affect their motivation for learning. The study particularly analyzed the source of their motivation: did the students put effort to learn technical English to maintain a high GPA or are they powered by their personal motivation? The study sample consisted of the technical writing engineering students in Summer I 2013. A questionnaire to test their attitudes and motivation was developed, and used after piloting, as the instrument for data collection. A focused group interview to triangulate the findings was also conducted. The data was analyzed, computed and tabulated using SPSS. Findings revealed that the participants have positive attitude towards technical English and believe it will further their status and employment chances. Although there was no difference in attitude or motivation between the genders, there was a difference of attitude with respect to academic level.

Keywords: engineering students, technical English, attitude, motivation, second language acquisition
1. Introduction

Language is the most important feature of humanity and human existence. With language, people can send their messages to others (Tavil, 2009). Learning many languages allows people to expand their knowledge and thus affects their personalities and attitudes. When learning a foreign language, many factors that influence the process surface. Factors such as motivation, intelligence, age, attitudes and gender have been investigated (Gardner, 1985; Shams, 2008) where the learners’ attitude towards the language was found to be one of the vital factors influencing the language acquisition (Fakeye, 2010; Kara, 2009).

Attitude is a psychological paradigm which is revealed when one evaluates a certain entity in terms of favoring or disfavoring it (Eagly&Chaiken, 1998). To explain consistent patterns of behavior, psychologists resort to attitudes (Baker, 1992), because attitudes are people’s feelings regarding their language and other languages (Crystal, 1997).

Evaluating a language depends on the variation of attitudes towards this language (Kara, 2009). Researchers argue that students’ attitudes affect their ability of learning the language. For example, students having positive attitudes towards English tend to learn better and easier than those with negative attitudes. Those with negative attitudes experience anxiety and low cognitive performance (Victori& Lockhart, 1995).

Research since the 1990s in the field of engineering revealed that English is very important in the academic and professional domain of the engineering students (Basturkman, 1998; Pendergrass et al., 2001; Pritchard & Nasr, 2004; Joseba, 2005; Sidek et al., 2006; Hui, 2007). Moreover, research also revealed that English is regarded as a good language to acquire because it provides more job opportunities and economic advantage (Hohenthal, 2003) as well as social status (Hogan-Burn &Romoniene, 2005).

This research is significant, although it can’t be generalized (because of the limited sample) since to the researcher’s knowledge, no study investigating the influence of demographic factors (such as gender, level of university, GPA) on the students’ attitude
and motivation towards learning technical English writing has been done in Lebanon. What drives the engineering students to learn technical English? Do they study the language because of its instrumental value or to feel they fit in the prestigious community of engineers? Baker (1992) concludes that individuals could be motivated by both trends. This study investigates the reasons why some engineering students are motivated to learn and have healthier attitudes towards technical English while others do not.

2. Research Objectives

The study’s objectives are to investigate the attitude of the engineering students towards learning technical English. The study’s investigation focused on gender differences, university level and GPA. To investigate this matter, the following questions were addressed:

1. What attitudes do engineering students have towards technical English:
   - Positive: beneficial?
   - Negative: useless?

2. What motivated students to learn technical English:
   - Self-professional development?
   - Maintaining high GPA?
   - Major requirement?

3. Does gender affect motivation and attitude?

4. Does academic level affect motivation and attitude?

3. Literature Review

Motivation and attitude are two of the most predominant factors for successfully learning a second language. The literature reveals the existence of numerous studies investigating the influence of these factors on language learning over the past forty years (Gardner, 1983, 1985 & 2006; Wilkins, 1972; Brown, 2000; Alhmali, 2007; Ghazali et al, 2009; Saidat, 2010). Gardner (1985) regards attitudes and motivation as two sides
of the same coin while learning a language, for motivation is the effort one puts to learn a certain language when one has ‘favorable attitude’ towards the target language.

In this section, an overview of the literature regarding motivation and attitude in the field of second language acquisition is presented.

3.1. Motivation

To Gardner (1985), learners’ attitude towards the second language plays a crucial role in motivating the learners to acquire the second language. He believed motivation to be complex phenomena that has many facades; thus it becomes difficult to define (2006). This difficulty has yielded several definitions, depending on the school of thought. To the behaviorists, motivation is the “anticipation of reward” (Brown, 2000, p 160); to the cognitivists, motivation has to do with the learners’ decisions and choices they make in regard to the experiences or goals they want to reach or avoid (Brown, 2000, p 160); to the constructivists, motivation is influenced by the social context (Brown, 2000). Although the definitions are presented by three different schools of thought, they all stressed on the ‘needs’ of the individual, where these needs are fulfilled and individuals feel rewarded after consciously making choices to improve to be appreciated by society.

Literature indicates that motivation plays a crucial role in enhancing second language acquisition (Lifrieri, 2005; Brown, 2000; Gardner, 2006). Students with high motivational levels do better than those with low or no motivational levels. Studies on second language acquisition also reveals that students’ have different types of motivation: instrumental and integrative (Gardner, 1983) and developmental (Cooper & Fishman, 1977). Instrumental motivation is when one learns a language because s/he sees it as a utility, as a means to their end (Gardner, 1983; Wilkins, 1972); whereas integrative motivation is when one learns a language to belong to a society or group (Gardner, 1983) and become integrated in the culture (Wilkins, 1972). The third type, developmental, is personal motivation which relates to the individual’s personal satisfaction or development (Cooper & Fishman, 1977). Students might be motivated to learn second language for any one or collection of these motivations (Spolsky, 1989; Crookes & Schmidt, 1991). For example, in 1993 Sarjit (as cited by Al-Tamimi & Shuib, 2009) concluded in her study that her participants were mainly motivated to learn the second language because of its
instrumental use which supported their personal need to improve in their domain. In the Arab context, Qashoa in 2006 (as cited by Al-Tamimi&Shuib, 2009) concluded that students were only motivated to learn the language because of its instrumental use-to pass the exams.

### 3.2. Attitude

When defining attitudes, researchers have agreed on common features of attitude; they believed that attitude is a set of complex beliefs which evaluates an object based on the individual’s beliefs or opinions that are predisposed to react in favor or not to the object (Gardner, 1985; Baker, 1992; Ajzan, 1988). Taking the definition a step further, Wenden (1991) defines three types of attitudes: cognitive: the beliefs the individual holds about the object; affective: the feelings the individual holds about the object, whether s/he likes or dislikes it; and behavioral: the consistency by which the individual is performing the action to acquire the desired learning behavior. When learners have positive attitudes towards the language, they tend to show positive behavior towards the course, thus learn faster (Kara, 2009). Attitudes help the students express their feelings toward the target language (Choy & Troudi, 2006), thus making it an emotional process (Feng & Chen, 2009). These inner feelings and emotions of foreign language students affect how they see the language and also affect their attitudes towards the foreign language.

Attitudes are important factors in language acquisition and performance (Reid, 2003; Visser, 2008; Gardner, 1985). When learning a language, one should approach the process not as merely an intellectual process, but as a social and psychological phenomena, which in itself relies on the students’ motivation and attitude towards the language (Padwick, 2010). How the students regard and perceive the language affects their mastering of the language (Gardner & Lambert, 1972). De Bot et al. (2005) asserted that all those involved in language education and learning must recognize the importance of students’ possession high motivation and attitude in learning the language.

Learning a language is affected by the attitudes the learners have towards the language (Shams, 2008; Momani, 2009; Al-Tamimi&Shuib, 2009). When students exhibit positive attitudes towards the language, the learning process becomes easier. Moreover, studies revealed that attitude affect achievement (Fakeye, 2010). Thus, the
literature reveals that attitudes and motivation play a vital role in the acquisition of second language and language in general. They appear to determine the students’ success or failure in acquiring the language. However, can we assume the same case is applicable in the Lebanese context? The next part of the study explains how the research was conducted and attempts to address the matter.

4. Methodology

The study was carried out to analyze the engineering students’ attitudes and motivational orientations in learning technical English.

4.1. Design

The study follows the non-experimental approach that is a mixture of quantitative and qualitative method. It followed the descriptive method of data analysis. Two research tools were used to gather the data: a questionnaire and one focused group interview. The two tools aim at establishing a kind of triangulation (Creswell, 2002). To ensure ethical procedures, triangulation is needed to guarantee a broader understanding of the phenomena (Silverman, 2000). This is needed in this study since it was conducted on a small sample during one semester.

4.2. Population and Sample

The participants were the class of ENGL 212-Technical Writing of Summer I 2012-2013, who consisted of 24 engineering students: 12 males 50% and 12 females 50%. The sample was conveniently chosen for they are the researchers’ students. 5% of them were sophomores, 14% junior and 38% senior. Finally, 19% were on the honors list (average between 80-84), 10 % distinction (85-90) and 7% high distinction (above 90).

Table 1: Descriptive Statistics of Students' Demographic Information

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>University Level</th>
<th># English Courses</th>
<th>GPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Mean</td>
<td>1.5000</td>
<td>3.5833</td>
<td>2.4167</td>
<td>2.8333</td>
</tr>
</tbody>
</table>
Table 1: Descriptive Statistics of Students’ Demographic Information

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<th># English Courses</th>
<th>GPA</th>
</tr>
</thead>
<tbody>
<tr>
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<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Mean</td>
<td>1.5000</td>
<td>3.5833</td>
<td>2.4167</td>
<td>2.8333</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>.51075</td>
<td>.65386</td>
<td>.65386</td>
<td>1.30773</td>
</tr>
</tbody>
</table>

4.3. Measurement

A questionnaire was developed and piloted before administering. The questionnaire was used because data collected can easily be quantifiable and allows participants time to respond freely while remaining anonymous. The items in the questionnaire were 42 and adapted from Boonrangsri et al. (2004) and Attitude and Motivation Test Battery (AMTB) designed by Gardner (1985). The questions were to be answered in a 5-point likert scale of 1=Strongly Disagree to 5=Strongly Agree.

A pilot survey was performed on a small sample to check the feasibility of the questionnaire. From the outcome of this pilot study, the questionnaire was amended and finalized.

Focused group interview was also carried out to supplement the questionnaire. Students were asked about the reasons why they study technical English and if they consider taking some more courses.

4.4. Data Collection and Analysis

The questionnaire was distributed to the participants in class and the directions were explained for them. The researcher left the class for 15 minutes to allow the participants to fill out the questionnaire. During the rest of the session, the focused group interview was conducted and notes were taken while the interview was recorded and later transcribed.

The data collection was analyzed using SPSS. Descriptive statistics were used to determine the frequencies, the means and standard deviation of the data. Moreover, a T-test was administered to answer the research question 1, and the One-way ANOVA to answer research question 2.
5. Results and Discussion

24 questionnaires were distributed and all filled out. The response rate was 100% and the population was equally divided between males and females. The majority of the respondents were honor to high distinction students. As figure 1 show, more than 60% of the participants had GPA above 80%. The majority were also senior students-around 38%.

![GPA distribution](image)

Figure 1: Students’ Results of GPA %

5.1. Attitude

To investigate the students’ attitudes towards technical English, the participants responded to 29 questions that reveal their opinion. The first eight statements reveal the students’ perceptions and impressions regarding technical English and whether they like or dislike English. This feeling can be seen in how the respondents feel proud when communicating well in English. As Table 1 reveals, 26% strongly agree that technical English is important, 26% agree it is the case. Hence, 23 respondents believe that technical English is important to effectively communicate with others. Again, the majority of the class agreed that technical English will assist them in successfully completing their senior project. (19% Agree & 31% Strongly Agree). 23.8% (SA) & 16% (A) are very proud when speaking English and 28.6 agree that it improves their image.23.8% agree that technical English provides them with more knowledge and
understanding while 14.3% strongly agree with this opinion. However, the majority of the class would rather not speak out in class for 31% were neutral and 26.2% were not enthusiastic about taking another technical English course in the future.

Table 1. Students’ Attitudes towards Technical English

<table>
<thead>
<tr>
<th>students' attitude</th>
<th>strongly disagree %</th>
<th>disagree %</th>
<th>neutral %</th>
<th>agree %</th>
<th>strongly agree %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study TE important for communication</td>
<td>2.4</td>
<td>-</td>
<td>-</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Helps senior project</td>
<td>-</td>
<td>2.4</td>
<td>4.8</td>
<td>19</td>
<td>31</td>
</tr>
<tr>
<td>Proud to communicate in English</td>
<td>-</td>
<td>2.4</td>
<td>14.3</td>
<td>16.7</td>
<td>23.8</td>
</tr>
<tr>
<td>Speaking English in different situation worries me</td>
<td>7.1</td>
<td>14.3</td>
<td>19</td>
<td>16.7</td>
<td>-</td>
</tr>
<tr>
<td>TE improves my image</td>
<td>2.4</td>
<td>-</td>
<td>2.4</td>
<td>28.6</td>
<td>4.8</td>
</tr>
<tr>
<td>I like to give opinion during TE class</td>
<td>-</td>
<td>2.4</td>
<td>31</td>
<td>21.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Have more knowledge and understanding because of TE</td>
<td>2.4</td>
<td>9.5</td>
<td>26.2</td>
<td>11.9</td>
<td>7.1</td>
</tr>
</tbody>
</table>

As Table 2 shows, the result of the descriptive analysis that answers the first research question shows that the overall mean is 3.693. This result shows that the participants have a positive attitude towards learning technical English although most of them worry about speaking English in different situation (16.7% agree while 19% are neutral). This means that, although students believe technical English is important, they don’t have the courage to verbally communicate in English for they worry they will not be fluent and might make mistakes. This concurs with Shams (2008) and ZainolAbidin et al. (2012) whose studies reveal that most of their participants felt nervous when having to speak English in public.

Table 2. Descriptive Statistics of Students’ Attitudes towards Technical English

<table>
<thead>
<tr>
<th>students' attitude</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studying TE Important Communication</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>4.2917</td>
<td>.90790</td>
</tr>
<tr>
<td>English Helps Senior Project</td>
<td>24</td>
<td>2.00</td>
<td>5.00</td>
<td>4.3750</td>
<td>.82423</td>
</tr>
<tr>
<td>Proud Communicating English</td>
<td>24</td>
<td>2.00</td>
<td>5.00</td>
<td>4.0833</td>
<td>.92861</td>
</tr>
<tr>
<td>Speaking Eng. Different Situations Worries Me</td>
<td>24</td>
<td>1.00</td>
<td>4.00</td>
<td>2.7917</td>
<td>1.02062</td>
</tr>
<tr>
<td>TC Improves My Image</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>3.5833</td>
<td>.82970</td>
</tr>
<tr>
<td>I Like Give Opinions During TE</td>
<td>24</td>
<td>2.00</td>
<td>5.00</td>
<td>3.4167</td>
<td>.65386</td>
</tr>
<tr>
<td>Have More Knowledge &amp; Understanding Because TE</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>3.8333</td>
<td>.96309</td>
</tr>
</tbody>
</table>
Questions 9 to 29 also reveal that the majority of the class regards technical English in a positive manner. They prefer studying in English and not their native language as Table 3 indicates, which contradicts with previous research (Al-Nofaie, 2010; ZainolAbidin, 2012) and that technical English makes them more confident.

<table>
<thead>
<tr>
<th>Valid</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>11</td>
<td>26.2%</td>
<td>45.8%</td>
<td>45.8%</td>
</tr>
<tr>
<td>Disagree</td>
<td>7</td>
<td>16.7%</td>
<td>29.2%</td>
<td>75.0%</td>
</tr>
<tr>
<td>Neutral</td>
<td>5</td>
<td>11.9%</td>
<td>20.8%</td>
<td>95.8%</td>
</tr>
<tr>
<td>Agree</td>
<td>1</td>
<td>2.4%</td>
<td>4.2%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>57.1%</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>

The overall mean is 2.77, somewhat low for such positive attitude. But as Table 4 in appendix A reveals, students’ means were high where the students expressed their belief that technical English improves their personality, makes them more confident and would like to have more English speaking friends so that they can communicate in English with them. Moreover, unlike ZainolAbidin (2012) conclusion, the results disclosed that most students pay attention in class and would probably ask what was given in class during their absence.

The focused group interview revealed that the students’ attitude towards English is also positive. They acknowledged the importance of the skills gained from the course, such as writing professional letters, emails and formal reports, admitting that ability of these skills of improving their chances of getting high paid jobs- particularly in the Gulf countries. The group agreed that knowing English in general and technical English in particular, would open closed doors for them in the engineering field.

5.2. Motivation

As table 5 reveals, students are motivated to learn technical English for instrumental reasons: either to maintain high GPA or to pass exams since it is a university
requirement. The finding concurs with previous results (Al-Tamimi & Shuib, 2009; Joseba, 2005; Sarjit, 1993; Qashoa, 2006). The second source of students’ motivation is the personal aspect with almost half of the class agreeing that technical English improves their professional development and helps further their education. The least is integrative motivation where only 25% found technical English important.

Table 5. Descriptive Statistics of Students’ Motivation towards Technical English

<table>
<thead>
<tr>
<th>Motivational Aspect</th>
<th>Very important %</th>
<th>Important %</th>
<th>Of some importance %</th>
<th>Of little importance %</th>
<th>Not important %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allows me carry tasks better</td>
<td>23.8</td>
<td>23.8</td>
<td>7.1</td>
<td>2.4</td>
<td>-</td>
</tr>
<tr>
<td>Enables me get a job</td>
<td>16.7</td>
<td>26.2</td>
<td>11.9</td>
<td>2.4</td>
<td>-</td>
</tr>
<tr>
<td>Enables me to further my education</td>
<td>16.7</td>
<td>26.2</td>
<td>9.5</td>
<td>4.8</td>
<td>-</td>
</tr>
<tr>
<td>Is a university requirement</td>
<td>19</td>
<td>26.2</td>
<td>9.5</td>
<td>2.4</td>
<td>-</td>
</tr>
<tr>
<td>For personal and professional development</td>
<td>23.8</td>
<td>21.4</td>
<td>9.5</td>
<td>-</td>
<td>2.4</td>
</tr>
<tr>
<td>Improves status among friends</td>
<td>4.8</td>
<td>19</td>
<td>21.4</td>
<td>2.4</td>
<td>-</td>
</tr>
<tr>
<td>Enhances performance in the engineering department</td>
<td>7.1</td>
<td>21.4</td>
<td>16.7</td>
<td>2.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Need to maintain high GPA</td>
<td>7.1</td>
<td>19</td>
<td>23.8</td>
<td>4.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Facilitate my senior study</td>
<td>19</td>
<td>31</td>
<td>4.8</td>
<td>-</td>
<td>2.4</td>
</tr>
</tbody>
</table>

The overall mean is 2.21 as reflected in table 6 in the appendix; quite low for a motivated class. The results could be attributed to the fact that sophomore and regular students (GPA ≤ 79) in the class do not believe that the course could improve their performance in their senior project.

The interview results confirmed the questionnaire findings. The respondents stated that they study technical English because they need to maintain good grades since most of them are on scholarship.

5.3. Gender and Technical English

To answer research question 3, a One Sample T-Test was carried out (Table 7. Appendix). The T-Test revealed that the P-value was 0.0. Since the P-value is less than 0.05, there was no equal variance of attitude by gender. Having P-value 0.00 indicates that there is no difference in attitude between genders; this contradicts with some earlier research (Shoaib & Dornyei, 2005; ZainolAbidin, 2012). The results could be due to
students’ GPA: most male students in the class were on the honor or distinction list and regarded technical English as an instrument for maintaining their status.

Moreover, Chi-Square Test further affirmed the results where Chi-Square calculated <Chi-Square tabulated=11.0705, implying that there is no significant relationship.

<table>
<thead>
<tr>
<th>Table 8. Chi-Square Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Pearson Chi-Square</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
</tr>
<tr>
<td>N of Valid Cases</td>
</tr>
</tbody>
</table>

a. 10 cells (83.3%) have expected count less than 5. The minimum expected count is .08.

The interview confirmed the findings. Most participants agreed that technical English is good for their résumé and professional development. There was no major difference between the genders. The minor difference was the group of participants who were female graphic design students that did not put as much importance on the course as the rest of the group.

**5.4. University Level and Technical English**

To investigate the last research question, One-way ANOVA test was conducted. Table 9 reveals that the P-value is 0.730 which is less than Alpha level 0.05. The table reveals that there is a difference in the students’ attitudes towards technical English among the groups with P-value 0.730. Based on ANOVA results, the study concluded that there is a difference among the students attitudes towards technical English based on university level, particularly between seniors and sophomore for seniors regarded the technical English course as a facilitator for senior project. This finding is supported by the interview where one senior student stated that the course helped improve their research skills and the rest of the senior students agreed.

<p>| Table 9. ANOVA University Level |</p>
<table>
<thead>
<tr>
<th></th>
<th>Sum of square</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>.603</td>
<td>3</td>
<td>.201</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within groups</td>
<td>9.231</td>
<td>20</td>
<td>.462</td>
<td>.435</td>
<td>.730</td>
</tr>
<tr>
<td>Total</td>
<td>9.833</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Limitations

Two major limitations are present in the study so as not to overgeneralize the findings or misinterpret the data. To begin with, the sample cannot be considered a representative one for it was a convenient sample since the participants were the researcher’s students. Due to time constraints, the study was conducted on only 24 students who happened to be taking ENGL 212 during Summer I of 2012-2013. The second limitation is the number of participants. Researchers recommend a minimum of 30 participants (Cohen et al., 2006) for a study so as the results can be generalized; however, this is not the case here. Therefore, the finding can’t be generalized, not even among the participants’ university students. One might also question the outcomes because the majority of the class students were high achievers, thus sought high performance which in turn could be the cause of the results.

7. Recommendations and Conclusion

The study revealed that the engineering students regard technical English positively. Their motivation was primarily instrumental and second came personal motivation. The engineers had no problem in studying all their subject matter in English and regarded the technical English course as an asset that will improve their chances for a good paying job. The students’ desire to learn technical English is for its utilitarian reason. They see in the course’s skills of work-related communication as a ‘ticket’ for them into a prestigious firm as one senior student commented. The study, however, also revealed that the students do not feel comfortable communication in English. For this, instructors in the university are recommended to teach the English language from the perspective of
communication. Students need English as lingua franca, a language of communication, whether written or oral. More emphasis should, therefore, be put on oral communication.

In conclusion, the study revealed that the engineering students participating in the study exhibited positive attitude towards English in general and technical English in particular. Because of this positive attitude and motivation to learn, learning the skills of technical writing became easier. This explains why the final grades of the participants were good leading to the highest class average (-B) the researcher has had in years. The learners can achieve cognitive performance when they possess positive attitudes towards the language they are learning and enjoy acquiring that new language. This study supports this conclusion. Hence, attitude and motivation should be an integral part of any language research.
References


<table>
<thead>
<tr>
<th>Perceived Aspect</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answering Ques. in TE Not Make Me Anxious</td>
<td>24</td>
<td>2.00</td>
<td>5.00</td>
<td>3.2917</td>
<td>.90790</td>
</tr>
<tr>
<td>Can Easily Pay Attention in TE Class</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>3.8750</td>
<td>1.07592</td>
</tr>
<tr>
<td>Hearing Classmates Speaking English Well...</td>
<td>24</td>
<td>2.00</td>
<td>5.00</td>
<td>3.6250</td>
<td>.87539</td>
</tr>
<tr>
<td>Prefer Studying In My Native Language Not Eng.</td>
<td>24</td>
<td>1.00</td>
<td>4.00</td>
<td>1.8333</td>
<td>.91683</td>
</tr>
<tr>
<td>Studying TE Makes Me More Confident</td>
<td>24</td>
<td>2.00</td>
<td>5.00</td>
<td>3.8750</td>
<td>.79741</td>
</tr>
<tr>
<td>Studying TE Improves My Personality</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>3.5000</td>
<td>.97802</td>
</tr>
<tr>
<td>Put Off TE HW as Much as Possible</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.7500</td>
<td>.98907</td>
</tr>
<tr>
<td>I Study TE Just to pass Course</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.5417</td>
<td>.97709</td>
</tr>
<tr>
<td>I Don't Enjoy Studying TE</td>
<td>24</td>
<td>1.00</td>
<td>4.00</td>
<td>2.6250</td>
<td>.92372</td>
</tr>
<tr>
<td>I Feel Anxious When Speaking in TE</td>
<td>24</td>
<td>1.00</td>
<td>4.00</td>
<td>2.6250</td>
<td>.92372</td>
</tr>
<tr>
<td>I wish I can Communicate in English Fluently</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>3.7083</td>
<td>.95458</td>
</tr>
<tr>
<td>Studying TE Helps Me Communicate in Eng. Effect.</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>3.9167</td>
<td>.82970</td>
</tr>
<tr>
<td>Can't Apply Learned Skills from TE in Real Life</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.1667</td>
<td>1.12932</td>
</tr>
<tr>
<td>I Have Little Interest in TE Course</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.5000</td>
<td>1.14208</td>
</tr>
<tr>
<td>Wish I Have Many English Speaking Friends</td>
<td>24</td>
<td>2.00</td>
<td>5.00</td>
<td>3.4583</td>
<td>.88363</td>
</tr>
<tr>
<td>When Missing Class, Rarely Ask About Material</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.6250</td>
<td>1.27901</td>
</tr>
<tr>
<td>Am Not Satisfied with my Performance in TE</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.6667</td>
<td>1.00722</td>
</tr>
<tr>
<td>I Believe TE is Difficult to Learn</td>
<td>24</td>
<td>1.00</td>
<td>4.00</td>
<td>2.3750</td>
<td>.92372</td>
</tr>
<tr>
<td>Don't Look Forward To Going To TE</td>
<td>24</td>
<td>1.00</td>
<td>4.00</td>
<td>2.5000</td>
<td>.93250</td>
</tr>
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</table>
Table 6. Descriptive Statistics of Students’ Motivation towards Technical English

<table>
<thead>
<tr>
<th>Item</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitates my Senior Project</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>1.8750</td>
<td>.89988</td>
</tr>
<tr>
<td>Have To Learn For High GPA</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.5833</td>
<td>.97431</td>
</tr>
<tr>
<td>Enhances My Performance Engineering Depart.</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.7500</td>
<td>1.25974</td>
</tr>
<tr>
<td>Improves My Status Among My Friends</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.8750</td>
<td>1.19100</td>
</tr>
<tr>
<td>For Personal &amp; Professional Development</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>1.8750</td>
<td>.99181</td>
</tr>
<tr>
<td>Is a University Requirement</td>
<td>24</td>
<td>1.00</td>
<td>4.00</td>
<td>1.9167</td>
<td>.82970</td>
</tr>
</tbody>
</table>

Table 7. One Sample T-Test

<table>
<thead>
<tr>
<th>Item</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Gender</td>
<td>14.387</td>
<td>23</td>
<td>.000</td>
<td>1.50000</td>
<td>1.2843</td>
</tr>
<tr>
<td>Enables me To Further my Education</td>
<td>24</td>
<td>1.00</td>
<td>4.00</td>
<td>2.0417</td>
<td>.90790</td>
</tr>
<tr>
<td>Enables me To Get Good Job</td>
<td>24</td>
<td>1.00</td>
<td>5.00</td>
<td>2.0417</td>
<td>.95458</td>
</tr>
<tr>
<td>Allows Me To Carry Out Tasks Better</td>
<td>24</td>
<td>1.00</td>
<td>4.00</td>
<td>1.7917</td>
<td>.83297</td>
</tr>
<tr>
<td>Overall mean</td>
<td></td>
<td></td>
<td></td>
<td>2.21</td>
<td></td>
</tr>
</tbody>
</table>
INTEGRATION OF MOBILE APPLICATION DEVELOPMENT IN COMPUTER ENGINEERING CURRICULA

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ABSTRACT

With the tremendously increasing use of mobile application in the world, the introduction of mobile app development in Computer Engineering’ courses became a necessity. In this paper, we present the learning materials used at the Lebanese International University to build up the required skills of the students in this domain. First, some facts and numbers about the smartphone and mobile app global markets are exhibited for Lebanon and worldwide. Then, the course based on Android platform for application development is shown with the various learning outcomes and assessment methods. Finally, we introduce the promising outcomes of these teaching strategies in a form of “Student Achievement”, by illustrating some mobile applications developed by the students at the Lebanese International University.

Keywords: Educational tools, assessment methods, technology education, mobile application development, Android.
1. Introduction

Recently, the International Telecommunication Union (ITU) estimated that there were 6.8 billion mobile subscriptions worldwide at the end of 2012[1]. That is a huge increase from 6.0 billion mobile subscribers in 2011 and 5.4 billion in 2010. People around the world are now using their mobile devices to do much more than making phone calls. Cell phones have become a portal for an ever-growing list of activities: accessing the internet, capturing photos, checking emails or bank accounts, etc... In a recent survey in USA, it was revealed that 56% of American adults own a smartphone (mobile phone with more features and functionalities) [2]. In Lebanon, more than 1 million cellular users have an Internet subscription with their mobile lines [3].

Nowadays, it is very familiar for smartphone users to download and use mobile applications (Apps). Portio Research estimates that 1.2 billion people worldwide were using mobile apps at the end of 2012 [4]. ABI Research predicts that 56 billion smartphone apps will be downloaded in 2013, which constitutes revenues of approximately 20-25 billion USD in 2013 [4].

As it can be clearly seen, science and technology are playing an important role in our modern society that is continuously evolving [5]. In 2007, the Organization for Economic Co-operation and Development (OECD) claims that a country’s performance in the educational field and especially in science and technology is directly related to the economic development of the country [6]. In this perspective, several initiatives have been developed in Engineering Education to promote students’ scientific and technological literacy, in order to prepare them to meet the needs, challenges and expectations of society. Therefore, we have decided to integrate a mobile application development course at the School of Engineering in the Lebanese International University (LIU). Actually, LIU is the largest private university in Lebanon with more than 20,000 students [7]. The School of Engineering at LIU has approximately 3,000 fulltime students from which 800 students approximately are enrolled in the Computer and Communication program.

In this paper, the choice of Android platform for development of mobile apps in the integrated course is justified in section 2. Section 3 summarizes the literature review while in section 4, a list of educational tools and materials used in the course will be explained in details. Section 5 summarizes the main outcomes and results achieved by our students during and after the course.

2. Technologies and Tools

Android is a mobile operating system (OS) that is widely used worldwide because it was adopted by several mobile manufacturers as their primary OS for their smartphones (see...
Google had purchased Android and took developmental work on it for more efficient application generations. Google set Android language into public making it an open source code, in which everyone could develop using android just by downloading the full source code. As a result, Android allowed vendors all over the world to benefit from its features and develop their own applications differentiating their products from other vendors’ products by adding their propriety extensions at their applications. The main advantage of adopting Android is that it offers a unified approach to application development. In other words, the developers need not to worry about on which device the code will be running, as long as it’s Android powered [8].

![Figure 1. Market share of different Operating Systems worldwide. [Source: Nielsen, July 2012.]](image)

### 2.1 Android Features

Android Architecture is made up of four layers which are: Application layer, Application framework layer, Libraries layer and Linux Kernel layer. It supports a variety of features used by mobile hardware and applications such as: storage, connectivity (3G, LTE), messaging, web browser, media support, hardware support (sensors, camera), multitouch and tethering.

### 2.2 Android development resources

Installing and using Android is a straightforward task that is compatible with almost all operating systems such as Windows, Mac and Linux. All the programming tasks are done inside the Eclipse IDE Java software [9]. Users have to download the Android SDK tools along with the Android ADT (Android Development Tools) which are both offered for free on Google’s developer website [10]. The ADT comprises an emulator that lets the developer tests the developed apps without the need to purchase an Android-powered smartphone.

The decision to choose Android development rather than its archenemy, iOS (Apple’s OS), was not only based on the wide range of features offered by Google’s OS, but was also affected by several other factors such as the low learning curve due to its Java root, flexibility of development platform, low to non-existent costs and availability of devices. Android can be developed inside the Eclipse software which runs on Windows, Linux, and Mac, while iOS can be only be programmed using Xcode which only runs on Mac machines. This limitation
has led to choose Android as our labs are all equipped with windows machines. An additional benefit of this choice is that the majority of students (and market share) own a laptop than run windows which allows the students to replicate all programming environments at home, giving the student the opportunity to work on assignments and projects at his/her convenience [11,12].

3. Literature Review

Universities have been advancing their curricula in the same pace as the technology around us is advancing. A number of universities across the world have been integrating mobile computing into their computer science or engineering curricula, dubbed m-learning. The study conducted in [13] shows that universities adopted one of five models: undergraduate course on mobile computing, graduate courses, integrating mobile concepts in existing courses, combining the three aforementioned models or offering mobile computing as an area of research. Stanford University, University of Maryland and Zhejiang University all adopt the first model offering an iPhone or an Android course into their undergraduate curricula. In the University of Guelph, they adopted a different approach [14]. Rather than teaching mobile development, they integrated mobile devices into the curriculum, specifically Blackberry. They also offered an academic that targets the blackberry platform including app and game design [15]. Note however, that in all the previous models, students are only exposed to the programming aspect of the mobile computing. In LIU, we tend to extend this model by adding several modules to the course such as social and business models, layout design and studies as well as keep the core programming module.

4. Android Development Course at LIU

Android application development is offered at the Lebanese International University through the Software Engineering and Micro-edition course (CENG647) at the Graduate level. This course offers the opportunity for the student to apply his/her Java programming capabilities learned at the undergraduate level, to mobile application development. Moreover, the course aims at bridging between three different levels, namely, technical, design and business levels.

The student learning process of this course should be three-fold: generating an idea that either serves the society or generates revenues, sketching and designing the layout of the app, and finally the technical programming and testing on the desired Android platform as illustrated in Figure 2.
This course is crafted to fulfill the above learning process through an ABET (Accreditation Board for Engineering and Technology)-compliant syllabus, weekly interactive lecture slides, scientific inquiry and hands-on activities through lab sessions, homework assignments, quizzes and exams, and most certainly a project with oral presentation followed by socio-cognitive debates.

4.1 Syllabus

The 15-week course’s ABET-compliant syllabus is designed to adhere to the course objectives and learning process mentioned above. The course’s syllabus outlines six course Performance Criteria (PC), through which, the student who successfully fulfills the course requirements will have demonstrated the ability to (1) install and use an Android platform, (2) develop simple applications for an Android device, (3) design effective and user-friendly interfaces, (4) link an Android app to a database, (5) utilize device sensors for various purposes, and (6) deploy the app on a real device and publish in the app market. The six PCs map to seven different Course Learning outcomes (CLO), as defined by ABET, such as the ability to apply knowledge of mathematics, science and engineering, the ability to design and conduct experiments, the ability to use techniques and skills of modern engineering tools, to name a few. For the full list of CLOs, see [11].

In addition, the syllabus discusses the topics covered by the course and the timeline, in which, they are laid out through the 15 weeks of the semester.

During the first week, students are introduced to the mobile app world from a developer point-of-view rather than its user counterpart. The installation and configuration of the tools are also taught during the first week. They include, but are not limited to, the Eclipse IDE (Integrated Development Environment) software, in which the Android SDKs (Software Development Kit), ADT plugins (Android Development Tools), and AVDs (Android Virtual Device) are installed.

During the following week, the student is introduced to the concept of activities, intents and fragments that represent the link between Java programming, the Android platform and the way the user interacts with the App.

Two weeks are then dedicated to the user interface design, through student-centered activities and active teaching methods (scientific inquiry, group work, Information and Communication technologies (ICT) aids, audiovisual aids, etc…). The imagination and creativity of the student are triggered to develop the flow of the App and the way users
should interact with it, namely, choosing between clicking, swiping, or tapping to switch back and forth between several views of the same App, or to move from one App to the other.

The core programming is laid out during the next eight or nine weeks. The student is introduced to various topics such as data persistence and database creation, content providers, messaging, maps, networking, services, built-in Apps, and publishing, along with several selected topics and programming challenges that are emerging in the App market. The last week is dedicated to project presentations, demos and debates, brainstorming for new ideas, and Q&A.

4.2 Lecture Slides

Aligned with using Eclipse IDE, PowerPoint interactive lecture slides are used in class. They serve two purposes: outlining the theory and methodology of each of the topics mentioned in the previous section, and serving as a tutorial that can be used to help the student develop and test various codes during lab sessions or at home. The lecture slides are aligned with the flow of the course, ranging from installation and configuration, to layout design, and core programming. Divergent open-ended questions are often asked, to develop students’ higher mental functions (analysis, synthesis and auto-evaluation).

4.3 Lab sessions

This course is taught in a computer lab, where each student has his/her own workstation. Each week, one hour out of the 3-hour course, is dedicated for a lab session. The lab sessions serve to bridge and expand the theory learned in the classroom with hands-on experiments to get the students started with real mobile App development. Small to medium exercises are given in the lecture slides. The student has to write the code(s) in Eclipse, compile and test the App either on an emulator (which is also called AVD) or on a real device (if the student owns an Android phone). The emulator is installed with the Android SDK. It behaves like a virtual machine that “emulates” real phones, enabling the student to choose between different resolutions, options, and phone hardware for testing. A sample emulator is depicted in Figure 3.

The first set of labs is dedicated to the installation and configuration of the software, as well as to developing a basic App such as “Hello World”. The second set of experiments focuses around layout design and its restrictions, portrait and landscape modes, as well as trying out various layout views such as vertical, horizontal, or tabular. Core programming experiments follow. Each of them is a direct application to the topic introduced in the classroom. Some of them require mixing between several topics and experiments to achieve the desired functionality. The lab sessions that were done during the past fall semester range from a tracking application that sends an SMS to a predefined number containing the geolocation of the phone holder, a restaurant application based on the built-in database of the smartphone that allows the user to search the menu of the restaurant and marking his/her favorites, to name a few.
4.4 Assignments, Quizzes, and Exams

In addition to the lab sessions that were performed in class, students were given few homework assignments throughout the semester. Assignments not only enhance the student’s skills, but also encourage him/her to replicate the in-lab software platform at home. Assignments contribute to 5% of the final grade of the course.

Five quizzes, which account for 15% of the course final grade, were given during the semester to monitor the student progress and interest in the course. Quizzes are designed to contain few multiple-choice questions along with short-answer comprehension and/or programming questions.

A midterm and a final were given during this course. Each of them contains five to six exercises in increasing difficulty ranging from easy True/False and multiple-choice questions, to harder comprehension questions and programming exercises. The midterm and final exams account for a total of 70% of the final grade.

The evaluation questions asked in the quizzes and in the exams cover all the performance criteria of the course, explained in the syllabus section above. They also cover all Bloom’s taxonomy (knowledge, comprehension, application, analysis, synthesis, and evaluation [16]).

4.5 Course Project

Projects are considered one of the best constructivist approaches to develop student initiative, autonomy, critical thinking and ability to work on his/her own using class material and outside resources and references such as books, tutorials or online forums.

Each student is required to work on and submit a project (10% share of the final grade) by the end of the semester. Project ideas are not necessarily novel but are required to join several features and topics presented in class during the semester.

One of the Apps that relied on the maps feature was developed. It notifies the user about prayer times and then displays a map with an overlay of all the Mosques in the area around the user, with the nearest route.
In another project, a student built a programmable/graphical calculator that is able to solve differential equations, systems with unknowns, and draw parabolic equations.

5. Android Apps developed by LIU’s students

As an instructor, course assessment can be done through investigating if the course goals and outcomes are met by the end of the semester. This can be tracked through the student progress in class, formative assessment, exam evaluations, and the class project that can be considered as the product of the course. In fact, several formative assessments are used to evaluate the student understanding of the course materials given in class and lab, in order to modify teaching and learning activities to improve student attainment and prepare them for the final exam.

At the CCE department at LIU, however, an additional parameter for course assessment was observed: “Student Achievement” dubbed SA. The ‘SA’ demonstrates how the goals and objectives of the course are met in a clear way, rather than the vague and difficult quantification that is followed by the classical assessment approach. The SA of the mobile app development course at LIU was observed through a master thesis project and various independent projects, developed by our students, and submitted to the National Mobile Programming Contest (NMPC), organized by the University of Balamand in Lebanon [17], and sponsored by the Ministry of Telecommunications [18]. The interest and the efforts exercised by the students beyond the scope and time schedule of the course demonstrate the successful decision of integrating a mobile development course into the computer-engineering curriculum. The following two sections briefly introduce a master thesis project and two independent projects, respectively.

5.1 Master Thesis Project: Android Chatting and Music Application

This application allows Android devices to have a chatting platform and to access a shared server to store music on it. Moreover, users will be able to view shared storage, search for music on the server and play songs online. Figure 4 shows some snapshots of the user interface for the chatting part of the application. The features of the music application are shown in Figure 5.
Figure 4. Snapshots from the chatting application user interface. (a) Login page (b) Contact tab (c) Instant messaging page

Figure 5. Snapshots of user interface for the music application. (a) Main page (b) List of music files (c) Upload page

5.2 NMPC projects

Ten students divided into five groups have submitted projects to the NMPC. Four out of five projects were ranked among the best 16 projects across Lebanon and has received attention and sponsoring by a number of experts and companies, such as Touch [19] and BeryTech [20].
The proposed ideas spanned several fields such as social, sports, customer service and medical applications. In this paper, we present two projects, “FixMyCoverage” and “Needlehelp”, as a case study.

5.2.1 “FixMyCoverage”: An Android Application to Improve the Communication Industry

FixMyCoverage is intended to enhance the network coverage of mobile operators based on users feedback. Despite the recent deployment of 3G in Lebanon, users are still experiencing average to poor quality in many areas in the country.

Using this App, the user can mark the spot using the built-in GPS to save the location, then specify the type(s) of problem(s) (no 3G, no Signal, dropped calls, no 2G, low speed, etc.). Speed tests and signal strength can be also appended to the feedback which can be sent automatically or when Internet connection becomes available. The operator can access a website displaying a map with multiple pushpins marking the different kinds of problems. Options to send feedback to the users are also available. In terms of business models, it was intended to partnership with the mobile operators companies and sell them the service, while keeping the service free of charge for the end-user.

This application enhances the user’s experience and increases his/her satisfaction with the mobile operators due to the ease of interaction between them. The application will also help the companies to solve occurring problems faster and have a precise description and position of the error. This application also can define new criteria for the mobile operators and the ministry of telecommunication in selecting new companies according to their dedicated services. Few snapshots of the application in action are depicted in Figure 6.

(a)  
(b)  
(c)  
(d)  

Figure 6. FixMyCoverage App (a) Main page (b) Location on the map (c) Choosing the problem (d) Submit report
5.2.2 “Needlehelp”: An Android Application for Emergency and Blood donation

Needlehelp is intended for use in emergency situations, mainly critical blood donation, ambulance calling, and fast medical facts. Emergency situations requiring blood donation still suffer from several shortcomings such as, the unavailability of donors at an appropriate speed, the chaotic aspect of the broadcast means (Radio and TV broadcasting) and the delays in service resulting in severe drawbacks attached to the health of the patients.

As a handler for such problems, this application intends to acquire the largest possible number of blood donors in the shortest amount of time with the minimum amount of delay of service. It will also include an emergency service that will contact specific emergency responsible institutions (e.g. Ambulance) The application will: Ask the user to fill up a sign up form based on whether it's a donor or a hospital and give the hospital access to the database of the donors in order to perform quick queries and broadcasts to donors who fit the search criteria and are available in the area. In addition, it will allow the user to call the ambulance in one click after displaying his exact location with street names and numbers, so he/she can give easy directions to the driver. This application provides a sense of steadiness within the medical staff and the patients’ families, looking at the level of discomfort experienced by the suffering patients and their families, along with the confusion of the hospitals in dealing with these problems. Few snapshots of Needlehelp are shown in Figure 7.

(a) (b) (c) (d)

Figure 7. Needlehelp App (a) Main page (b) Donor Search Page (c) Results Page (d) GPS- Ambulance calling Page.
6. Conclusion

Enhancing the computer-engineering curriculum at the Lebanese International University is an on-going process. In this paper, the integration of a mobile application development course into the curriculum through some active teaching methods and student-centered activities is presented. The newly introduced course not only serves as a bridge between programming skills and mobile app development, but also develops students’ scientific, transversal and communication skills, as well as their autonomy in self-learning. It also stimulates the student’s imagination, creativity, design skills, critical thinking and business-oriented thinking, which widen the job market for a fresh graduate. The justification of this integration was two-fold: first, through a student-course traditional assessment, and second, through a novel factor, or Student Achievement (SA), which proves the interest of the students beyond the scopes of the course. A case study is presented, in which, several projects were developed by LIU students and participated in national contests.

Since this course is recently introduced in CCE curricula at LIU (2 years ago), we are looking forward to enhancing the course teaching methods, by adding conceptual change teaching strategies, mainly through the analysis of students’ errors and conceptions and through the use of problem based learning (PBL) activities instead of interactive lectures.

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ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT: CASE OF PALESTINE

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Abstract

This paper aims at focusing on integrating sustainability issues in engineering education for the purpose of improving sustainable development. Palestine is taken as an example to prove the necessity of involving sustainability and resources efficiency in engineering education. Energy efficiency and water consumption are discussed with some statistics. Waste recycling and management can be considered one of the resources that serve in improving Palestinian economy. Increasing awareness of resource efficiency and sustainability in education can be done by integrating new courses in the existing engineering curricula or by establishing new programmed specialized in sustainability like the Master program in Sustainable Engineering that will be established at Birzeit University.

Keywords- sustainable engineering, resource efficiency, engineering curricula.

1. Introduction

Palestine has limited natural resources on one hand and good human resources on the other hand. This combination makes the option of maximizing the utilization of human resources and efficiently utilizing the limited natural resources a wise option for Palestine. Among the nature resources are stone and marble, water, solar energy, biodiversity, and land. Human resources include a young society with highly educated people or highly skilled labor. Palestinian youth between 19-30 years old form 17.7% of the total population [1].

According to the report Sustainable Development under Israeli Occupation 2012 [1], the obstacles that face achieving Sustainable Development are of two types: external obstacles related to the Israeli military occupation and internal ones related to the institutional framework in place. The report states “While the most serious constraints on sustainable development for...
the Palestinian people are a result of the continued Israeli military occupation, the Palestinian National Authority exercises all available options to improve the social, economic and environmental conditions of the Palestinian people.” The report asserts that “In the field of environment we also need to assess our own performance critically and acknowledge that environmental issues have not yet been sufficiently mainstreamed.”

On the environmental aspect it affirms that “The environmental pillar probably remains the weakest pillar of the three due to, both, Israeli occupation and internal challenges. Diminishing access to Palestinian resources and increasing pollution of available resources by Israel are the main sets of obstacles. The most important emerging challenges in the occupied Palestinian territory are desertification and climate change.” [1].

In this paper the role of engineering education in sustainable development is addressed in general and in particular for the case of engineering education for sustainable development in Palestine.

2. Sustainable development in Palestine

Sustainable development is mostly defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [2]. Sustainability involves the integration of: economic, environmental, and social dimensions. Economic dimension establishes the framework for making decisions. While environmental dimension recognize the interdependence within living systems, the goods and services produced by the world's ecosystems, and the impacts of human on the ecosystem. While social dimension refers to interactions between institutions and people, human values, aspirations and well-being, ethical issues, and decision making process.

The three main elements of the sustainability paradigm are usually thought of as equally important, and within which trade-offs are possible. Strong sustainability implies that trade-offs among natural, human, and social aspects are not allowed or are very restricted, while weak sustainability implies that trade-offs are unrestricted or have few limits.

Sustainable development definition is not clear; there is an understanding on some of components that would lead to achieving such development within this concept. This includes renewable energy, integrated resources management, green loans, green buildings, green jobs, solid waste recycling, reuse of treated wastewater, and green agriculture.
2.1 Energy

The main problem of energy in Palestine is energy security. Palestinians have no guaranteed energy supply as they rely on gasoline, diesel, electricity and gas purchases from neighboring countries.

For Palestinian territories electricity grid reaches 99% of population. The total power purchased is around 98%, the bulk is supplied by Israel, and Jordan provides around 6%. In Gaza Strip, Israel supply 50% and Egypt supply 7%. The rest is supposed to be generated by the Gaza 140-MW Power Station. Only 20% of the total energy needed in Palestine is generated from local primary production. The sources of the primary production are as follows: 43% of this energy is solar energy; 51% is wood and charcoal, and 6% is olive cake [3]. Figure 1 shows electricity dependency in the MENA region where Palestine is 100% dependent [4].

The other constrain when it comes to energy is the price and the cost. Electricity prices in Palestine are very high because almost all energy is imported from Israel at a relatively high cost and then taxed by the Palestinian Authority. The average selling price of electricity is 0.115 €/kWh. There are no subsidies; energy therefore takes a large part of the household income of Palestinians. The average annual income per capita in Palestine is 1,030 €; the electricity bill amounts to about 10% of the family income [5].

![Figure 1: Electricity dependency in the MENA region.][4]
2.2 Water

Palestinian water abstractions have declined over the last ten years, as the result of the combined effect of dropping water tables, Israeli restricted drilling, deepening and rehabilitation of wells. Per capita available water for Palestinians in the West Bank is about one quarter of those available to Israelis. The total pump water from over 500 Palestinian wells is 51.4 Mcm/yr, while Israel pumps 53.6 Mcm/yr from their 42 wells [6]. Hence by regional standards, Palestinians have the lowest access to fresh water resources as shown in the table 1 below. [7]

Table 1: Availability of water resources in Jordan basin, m³/capita.year [7].

<table>
<thead>
<tr>
<th>Country</th>
<th>m³ per capita per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Bank</td>
<td>75</td>
</tr>
<tr>
<td>Gaza</td>
<td>125</td>
</tr>
<tr>
<td>Jordan</td>
<td>200</td>
</tr>
<tr>
<td>Israel</td>
<td>240</td>
</tr>
<tr>
<td>Lebanon</td>
<td>1200</td>
</tr>
<tr>
<td>Syria</td>
<td>1500</td>
</tr>
</tbody>
</table>

The Palestinian water use is estimated at 73 Liters per capita per day (L/C/day)[8], far less than the World Health Organization (WHO) minimum recommended standard of 100 L/C/day. While the Israeli daily per capita use is about 300 Liters, which is about four times higher than the Palestinian use [8].

During the past 20 years, the contribution of the agricultural sector to the Gross Domestic Product (GDP) in Palestine has been decreasing from 13% to less than 6%[8]. Irrigated agriculture contributes to about 12% to GDP and employing 117,000 people. The declining availability of agricultural water leads to losses in terms of products output and employment. Irrigated area could be increased if water resources are available, as agriculture can play an important economic and social role in building the Palestinian economy [9]. Water resources management is a key factor for agricultural sustainability. Most of the groundwater in Gaza Strip is saline and not useful for human consumption or agriculture use [1].

Water problem in Palestine will be escalating in the coming years due to the increasing demand and diminishing available water resources as shown in the supply - demand gap estimation in table 2 below.

Table 2 : Water supply and demand in Palestine [7].

<table>
<thead>
<tr>
<th>Year</th>
<th>Supply Mcm/yr</th>
<th>Demand Mcm/yr</th>
<th>Deficit Mcm/yr</th>
</tr>
</thead>
</table>
It is thus necessary to implement water efficiency measures on one hand and to seek additional water resources and introduce non-conventional methods that provide water on the other hand.

### 2.3 Solid waste

The solid waste collection coverage in Occupied Palestinian Territories has been significantly improving since 1994. A reduction of the percentage of the population that is non-serviced was achieved from 36% in 1994 to 8% in 2011 [10, 11]. The main objective in this sector is to improve the service delivery of the collection of waste, increase sanitary disposal of solid waste, improve cost recovery to ensure long term sustainability, and initiate recycling activities [11].

To sustain environment and human life and health, it is necessary to manage the solid waste and avoid its hazards. Waste prevention can be done by designing longer life products, reducing packaging and reusing materials and products. The second process is recycling and composting. This can be done by recollecting used materials and reuse or remanufacture them. Solid waste that cannot be prevented or recycled must be treated by disposal in one of two ways; either land filling or combustion as shown in the block diagram of Figure 2.
There are four major material efficiency strategies; these strategies are [12]:

- Component re-use
- Longer Life, More Intense use, repair and re-sale
- Product upgrades, modularity and remanufacturing
- Options for change that will use less material to provide more services.

3. **Engineering education**

Palestinian Education Sector Strategy 2011-2013 built on the four core pillars: enrolment, quality of education, management, and linkage with the needs of the market and society [14].

Engineering programs and study at the university level is the favorite choice of the society, hence engineering program along with IT attract the best students in Palestine. Very common that student with grades above 90% in high school diploma is enrolled in engineering programs. In 2010/2011 11.2% of the 40000 students accepted in the universities in the bachelor programs are
accepted in engineering disciplines. Among the 103000 university students 18.1% are in engineering bachelor programs [15]. Figure 3 shows existing engineering programs at Palestinian universities.

Engineering programs are 5 year programs that include basic science, basic engineering science, specialized courses, labs and practical training in addition to cape stone or graduation project. Those programs are based on credit hour systems.

However because of difficulties imposed on importing lab equipment by Israeli occupation and adding to this the limited funding available for such equipment, some of labs and practical aspects are not covered properly in classes. Such situation assures the need for a stronger relationship between academic programs and industry in Palestine; this is to give student better opportunities to get hands-on experience in direct contact with the local industry [16].
4. Sustainable Engineering in Engineering Programs

A working definition for sustainable engineering will include the topics of energy, water, natural resources, solid waste, quality, management and relevant issues.

Sustainable engineering program does not exist on the Palestinian universities neither as BS nor MS level. However table 3 presents some of the related programs or those which include some elements of sustainable engineering.

Table 3: Sustainable engineering related programs in Palestinian universities.

<table>
<thead>
<tr>
<th>Program</th>
<th>level</th>
<th>university</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment engineering Technology</td>
<td>B.S</td>
<td>Palestine Polytechnic University</td>
</tr>
<tr>
<td>Environment engineering</td>
<td>B.S.</td>
<td>Islamic University of Gaza</td>
</tr>
<tr>
<td>Energy and Environmental Engineering</td>
<td>B.S.</td>
<td>An –Najah University</td>
</tr>
<tr>
<td>Water and Environmental Sciences</td>
<td>M.S</td>
<td>Al-Azhar University</td>
</tr>
<tr>
<td>Water and Environmental Engineering</td>
<td>M.S.</td>
<td>Birzeit University</td>
</tr>
<tr>
<td>Water and Environmental Sciences</td>
<td>M.S.</td>
<td>Birzeit University</td>
</tr>
<tr>
<td>Water and Environmental Engineering</td>
<td>M.S.</td>
<td>An –Najah University</td>
</tr>
<tr>
<td>Clean Energy and Energy Conservation Engineering</td>
<td>M.S</td>
<td>An-Najah University</td>
</tr>
<tr>
<td>Rural sustainable development</td>
<td>M.S</td>
<td>Al-Quds University</td>
</tr>
</tbody>
</table>

Two Bachelor programs in environment engineering exist in Palestine, one in West Bank and another one in Gaza Strip. One program is recently introduced in An – Najah University. While water related graduate programs exist in 3 universities in West Bank and one in Gaza Strip. Only one graduate program for sustainable development exists at Al-Quds University.

Most B.S engineering programs have courses related to energy, water, solid waste and environment. Table 4 presents an example of such courses in some of Palestinian universities.

Table 4: Sustainable engineering related courses in some B.S. engineering programs.

<table>
<thead>
<tr>
<th>University</th>
<th>Program</th>
<th>Energy</th>
<th>Water</th>
<th>Solid waste</th>
<th>environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birzeit University</td>
<td>Electrical Engineering</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical Engineering</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Civil Engineering</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
5. MS Sustainable Engineering at Birzeit University

The Middle Eastern Partnership in Sustainable Engineering (ME-Eng) TEMPUS project comes to address the sustainability challenges discussed above. The Master program in Sustainable Engineering will be established in the faculty of Engineering at Birzeit University with joint resources from An-Najah National University. [17]

5.1 Market survey

This program will teach graduate courses related directly to the needs of the local industry and sustainable engineering. Market study and survey of industries showed their interest in sustainable engineering courses as given in Figure 4.
5.2 Program Mission and objectives

Sustainable engineering program at Birzeit University aims at meeting the economic development needs in Palestine by raising the national production level and providing environmental needs. This is consistent with the international trends for conserving the natural resources and utilizing the renewable energy resources taking into account water conservation, pollution reduction and implementing Remanufacture, Reuse and Recycle processes. Therefore, the program conforms to the principles of sustainability in manufacturing, production and building processes in all industrial sectors in Palestine and abroad. The program aspires to implement the sustainability principle as a foundation for building and development to maintain human life on this globe without causing harm to future generations.

The main objective of the program is to build Palestinian human resources in sustainable engineering. Graduates of this program will have a comprehensive overview in sustainable production. They can integrate sustainability through efficient utilizing of materials, water and energy while decreasing their influence on environment. They will gain analytical tools for the evaluation and assessment of the effect of sustainability on the product lifecycle.

The program aims to achieve the following specific objectives:
- Qualifying local human resources to manage and operate the local industrial establishments.
• Development of production processes and quality control in national industry.
• Providing engineers with analytical tools in the fields of sustainability and cleaner production.
• Increasing competitive capabilities of the local products.
• Enhancing skills required for the best resource efficiency and utilization of local resources.
• Preserving environment and avoiding pollution of air, water and soil.
• Establishing scientific research in sustainable production and its applications.
• Spreading awareness of quality and sustainability.
• Exploring technical and engineering aspects in sustainable development.

5.3 Courses

Table 5 presents some of the courses to be delivered in this program and their type.

Table 5: Courses in Sustainable Engineering program.

<table>
<thead>
<tr>
<th>Course title</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Sustainable engineering</td>
<td>obligatory</td>
</tr>
<tr>
<td>2 Energy efficiency and renewable energy</td>
<td>obligatory</td>
</tr>
<tr>
<td>3 Life cycle analysis</td>
<td>elective</td>
</tr>
<tr>
<td>4 Clean production</td>
<td>elective</td>
</tr>
<tr>
<td>5 Water Efficiency and Water &amp; wastewater Treatment Technologies in industry</td>
<td>elective</td>
</tr>
<tr>
<td>6 Special topics in sustainable engineering</td>
<td>elective</td>
</tr>
<tr>
<td>7 Thesis/ Seminar</td>
<td>obligatory</td>
</tr>
</tbody>
</table>

6. Conclusions & recommendatations

Sustainable development in Palestine though it is hindered by Israeli occupation it is also affected by internal factors. Education, mainly engineering can contribute greatly toward such development, by providing the technical knowledge and analytical tools, initiating research in the topic, participating in creating awareness and building local capacity for the subject.

The developed MS program in sustainable engineering at Birzeit University lies in the direction of improving the education system to serve sustainable development. Improvement in the BS engineering programs to include sustainability topics will further help building human capacity and providing for experience in the topic. An integrated approach is required to achieve sustainable development that combines the social, economic, and environmental aspects.
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MICRO AND NANO-TECHNOLOGIES: FROM RESEARCH TO EDUCATION

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Abstract

Micro and nano technologies are significant areas of scientific development that affected human life in many aspects from the simple to the more complex. The advent of these technologies has brought with it a large number of novel applications in the fields of healthcare, communication, computation, energy and many others. Taking full advantage of the potential of micro and nano technologies requires the transfer and integration of these technologies into engineering education. This curricula integration equips students with the skills required to tackle the new engineering abilities offered by these technologies. Such integration will make engineering students capable of designing, fabricating, and testing optimal high-tech products.

Keywords- Micro/Nano-scale, Microfabrication, Microsystems, Higher Education

1. Introduction

Micro and nano technologies embark on the miniaturization of processes and devices to carry out tasks impossible to achieve at the macro scale. They comprise the production and application of physical, chemical, and biological systems at scales ranging from individual atoms or molecules to microns dimensions, as well as the integration of the resulting micro and nanostructures into larger systems [1].

The basis of microtechnology is micro-electromechanical systems (MEMS), that are the integration of mechanical elements, sensors, actuators, and electronics on a common substrate through the utilization of microfabrication technology initially developed for integrated circuits. An example of MEMS technology is miniature bioreactors which are designed and
microfabricated to enable cell self-assembly and 3D tissue formation. The bioreactor (fig. 1) recapitulates some of the key features of a capillary bed, allowing in situ optical interrogation of the perfused 3D tissue, and providing a high degree of control over fluid flow conditions [2].

![Figure 1: Microfabricated polycarbonate bioreactor [2].](image)

Another example on the remarkable microtechnology outcomes is DNA chips (fig. 2). They are microfabricated to allow the probing of the DNA of an individual. The DNA of interest is broken up into short fragments, using restrictive enzymes. Each fragment is labeled with a fluorescent molecule and then the DNA is washed over the chip which incorporates thousands of spots on it, each with different DNA sequence. Since the sequence of every spot is known, the pattern of fluorescence on the chip can be analyzed to determine the DNA sequence of the original sample [3].

![Figure 2: Fluorescence- detection microfabricated DNA chip [4].](image)

Nanotechnology is now advancing and reshaping technology through its astonishing products. Carbon nanotubes (fig. 3) show superior performance because of their impressive...
structural, mechanical, and electronic properties such as small size and mass, high strength, high electrical and thermal conductivity. They can be used in energy storage and energy conversion devices, high-strength composites, nanoprobes and sensors, actuators, electronic devices, nanorods, catalysis, and hydrogen storage media [5].

Scanning tunneling microscopy (STM) is a device that integrates scanning capacity into vacuum tunneling capability to enable the imaging of the surfaces of conducting samples and study their local electronic properties down to atomic scales. It does so by moving a nanoscale conducting tip in close proximity to the surface of the material. The tip is moved across the surface and the physical interaction between the probe and sample is used to create a map of the surface. This physical interaction is quantum current tunneling that occurs between conductors when the distance separating them is within one nanometer (as shown in fig.4) [7].

Quantum dots (QDs) refer to a large, varied class of nanostructures made from semiconductor materials, which, at nanoscale, demonstrate unique size-dependent fluorescent emissions [9]. They show quantum size effects, that is, the size of a particle changes its
resonance frequency. They can be utilized in optoelectronics devices, quantum computing, information storage, lasers, molecular imaging, etc.

2. Research in Micro and Nano Technologies

Many of the concepts and methods used in micro and nano technologies are originated from the field of precision engineering. Moreover, the need to go down to the micro level in order to communicate with cells was also a driving factor for miniaturization of technology. An essential requirement for the industry was to operate equipment but with a great reduced power drain and smaller size. As a result, there was a need to have the same tools and instruments that are found on the macroscopic level but as small as possible.

Research trends in micro and nano technologies have evolved in the last decades making possible the development and production of important and novel systems and processes. With respect to microtechnology, microdrilling dates back to the 1950’s in the US. Microdrilling refers to mechanical hole making with a diameter less than 50μm. During the 1960’s, integrated silicon sensor technology was presented. In 1962, Researchers at Honeywell used 650μm silicon wafers. In 1965, Nathanson demonstrated a working device using micromachined silicon-based technologies. He used a resonating cantilever beam as the gate contact for a MOS field effect transistor. During 1970’s, bulk micromachined silicon-based technologies was demonstrated by Peterson. Using wet chemical etching of single crystalline (100) silicon, he fabricated a variety of micromechanical devices for optical modulation applications.

![Figure 5: Global MEMS market throughout 2003 till 2007 [I].](image-url)
During the 1980’s, international interest in microtechnology gained momentum [10]. Silicon became the core of microtechnology. In 1987, micromachined movable parts such as gears and turbines were made on a silicon chip. Since then, development has continued in micromachining processes, material varieties, and micro-actuators [11]. In the 1990’s, microtechnology grew exponentially in the fields of fabrication, electronics, optics, fluidics, information, and biotechnology. The first electrostatic micromotors with diameters of 60-120 pm were developed between 1989 and 1990. It utilizes the electrostatic force which acts between the edges of the rotor and the stator both made with polysilicon [12]. This development in microactuators helped advancing microtechnology by enabling MEMS to perform physical functions. The latter discussed development in microtechnology ushered the emergence of various microfabricated electromechanical devices (MEMS) during the 2000’s. Such devices are the integrated and surface-machined accelerometer that took advantage of electronics integrated circuits. In addition to such devices are the ink-jet printer heads that benefited from micromachined channels and integrated heaters that enable ink-jet heads to eject ink droplets of a few picoliter at around 10 KHz from many nozzles in parallel. Moreover, the digital micromirror device was created by taking advantage of the scaling effect associated with miniaturization and the parallel processing capability [11].

In the present time research in microtechnology tends towards further integrating and creating more advanced and reliable systems. Following the success of past devices more sophisticated devices have been invented to progress different fields of technology. Optical MEMS are being researched and developed including variable optical attenuators and optical switches. In the information technology, sensors are developed including microphones, uncooled infra-red cameras, TV-game controller sensors, robotic sensors, taste sensors, and odor sensors. In the communication field, RF MEMS are being developed that includes RF switches, integrated resonators, variable capacitors and variable inductors with high quality factors. Furthermore, biotechnology is being advanced thanks to microtechnology by the development of micro fluidic systems that includes DNA analysis chips, microreactors, specific medical diagnosis chips, and environmental monitoring chips [11]. Moreover, wireless sensor networks and smart pills are being actively researched and developed [13].

The future of microfabrication and microsystems is promising. Future. A pressing need for compact high-density power sources is rising. Research in MEMS is offering several technologies to provide such power sources such as chemical micro-batteries, micro-super capacitors, and nuclear micro-batteries [14]. Moreover, healthcare is anticipated to advance in the future especially in the domain of digitizing hospitals and improving patient monitoring (e.g. smart homes). On the other hand, the development of micromanufacturing processes that use silicon-based materials are already highly developed. The future of development of micromanufacturing processes lies in the ability to manufacture microproducts from engineering materials such as metals and ceramics. Processes that are being developed to enable such manufacturing include selective laser sintering of metals,
laser micromachining using pulsed femto and attosecond lasers, droplet-based manufacturing, and cold gas dynamic molding and spraying of microparts [15].

Research in nanotechnology started in the early 1970’s where the driving force for further miniaturization technology came from the electronics industry. It aimed to develop tools to create smaller and thus faster and more complex electronic chips. In 1974, the term nanotechnology was first used in a paper ion-sputtering machining. In the 1977, Drexler originated the concepts of molecular nanotechnology at MIT. IBM used electron beam lithography in the 1970’s to create nanostructures and devices as small as 40 to 70 nm. [16]. During the 1980’s, the scanning tunneling microscope was invented by Gerd Binning and Heinrich Rohrer (in 1981) [17]. In 1985, Buckyball carbon nanostructure was discovered [18], and Atomic force microscopy was invented in the next year (1986) [19]. In the 1988 at Stanford University, the first course about nanotechnology was taught.

![Figure 6: Growth of nanotechnology market](Image)

The 1990’s included many milestone discoveries such as carbon nanotubes (1991) [18], the first design of nanorobotic system (1997), and the first nanomechanical device based on the B-Z transition of DNA (1998) [20]. Throughout the 2000’s, nanotechnology gained public attentions through conferences, governmental funding, awards and congresses. Development in nanomaterial research and nanofabrication techniques gave rise to nanoelectromechanical systems. These systems are used for precision measurements, probing the properties of matter at the nanoscopic scale, atto-gram scale mass detection, atto-newton force detection, virus detection, and gaseous chemical detection [1].

Current research in nanotechnology is interested in understanding individual basic phenomena on the nanoscale, synthesize components as building blocks for potential future applications, tools advancement, and improving existing products by using relatively simple
nanoscale. Nanotechnology is providing investigation tools and technology platforms for biomedicine. Advancement have been made in measurements at the molecular and subcellular levels. Chemical composition has been measured within a cell in vivo. Another trend in nanotechnology research is building sensors to detect molecular phenomena. For instance, Fluorescent semiconductor nanoparticles (quantum dots) can be used as markers in medical imaging [21]. Furthermore, nanotechnology is advancing tissue engineering by providing solutions for mimicking the extracellular matrix that is responsible for cell growth.

The future of nanomanufacturing and nanosystems is flourishing and anticipated. The next transition lies in the production of molecule-sized systems governed by quantum mechanics. Research in nanotechnology is the next decade is expected to shift towards direct measurements on three-dimensional domains, science-based design of fundamentally new products based on complex nanosystems, and serving new areas of relevance such as quantum information systems. Moreover, due to energy and environmental crisis research in nanotechnology will focus sustainable resources including water, food, energy, materials and clean environment [22].

Processes such as soft lithography and nano-imprint lithography make the future of nanofabrication encouraging. The deposition of colloids and nano-inks of self-assembled monolayers and the impression of nanostructures on soft materials ensure that industries like the semiconductor industry will be presented with processes that will overcome the problems associated with the diffraction limit in optical lithographic processes. The greatest challenge to nanomanufacturers is the development of manufacturing processes that can be applied to engineering materials such as metal alloys and ceramics. Manufacturing processes for these materials appear to be relatively abundant at the microscale but do not appear to be available at the nanoscale [15].

3. **Micro and Nano Technologies in Engineering Education**

As engineering plays an important role in civilization, engineering education research is increasingly important, especially to promote continued innovation. Moreover, the market that utilizes engineering is in ever development and engineers must be prepared to meet the complex industrial and societal challenges of the 21st Century. Hence, engineering curricula must follow these changes and adopt them. Most importantly, research in engineering is producing advanced and new technologies and discoveries. Such developments should be integrated in engineering education in order to offer engineering students new horizons for their studies and projects.

Miniaturization technology, whether it is micro or nano technology, impacted engineering boundaries and expanded its horizon. Engineers are capable of creating ingenious
and reliable solutions for contemporary problems owing to micro and nanotechnology. Engineers working in those domains need to be equipped with considerable amount of knowledge and skills in micro and nanotechnology. This is accomplished by integrating micro/nanotechnology courses into the education system.

Throughout the world, many educational institutions have adopted miniaturization technology in its curricula. This integration of micro and nanotechnology is being done on graduate, undergraduate, and high school level. Its importance lies in introducing, training, and prepare students to have a grip on micro and nanotechnology. Incorporating micro and nanotechnology into education is due to the fact that they are a growing field that is requiring trained personnel for jobs in business and manufacturing as well as research and development [23].

On the graduate level, many universities around the world have adopted micro and nano technologies in their engineering programs. They either make a whole master program about micro and nanotechnology or they offer courses in different engineering majors. For instance, University of Applied Science of Switzerland offers a Master of Advanced Studies in Nano- and Micro Technology program. This program is an opportunity for students with bachelor degrees in engineering majors, physics, biology, and chemistry to acquire knowledge in micro and nanotechnology. In addition, Louisiana Tech University offers a M.S. in Molecular Sciences and Nanotechnology which enhances interdisciplinary applied research in micromanufacturing and nanotechnology including molecular biology and protein engineering [24].

On the undergraduate level, the University of Cincinnati is an example for such integration. In 2006, it started offering two nanotechnology courses for the undergraduate level. The courses are “Introduction to Nanoscale Science and Technology” and “Experimental Nanoscale Science and Technology”. Their goal was to incorporate nanotechnology education into the curricula of Engineering and Arts and Sciences majors. The courses provided an overview about nanoscale science and engineering, shedding light on their application in nanomaterials, nanophotonics, nanoelectronics, nanomechanics and bionanosystems. The laboratory course included nanofabrication, nanosystems characterization, training on computer-controlled systems used in nanotechnology (atomic force microscopy, laser spectrometer, etc.) [25]. Other universities offer majors or minors in nanotechnology. For example, Clarion University offers a minor in nanotechnology which gives students the knowledge and skills to understand and contribute to the field. The minor consists of three phases. In the first phase the student is taught the physics of nanotechnology. The second phase consists of a full semester at a nanotechnology laboratory. The third and final phase consists of the students implementing his acquired knowledge and skills in their own nanosystems designs. Another example is the University of California (San Diego) which offers a major in Nanoengineering [26]. The students have to choose an engineering focus after sophomore year, and it can be bioengineering, chemical, electrical, mechanical or material sciences.

Nano-education at the high school level is important for the development of any country. It helps in creating an interest in nanotechnology between students. Moreover, it prepares them from an early phase to comprehend and use such technology. Many approaches are made to
develop, integrate, and trial nanotechnology courses into teaching programs. Salt Lake City Community School was a trial for a project funded by Utah State Office of Education. Its purpose is to introduce nano-education to students in a systematic and thoughtful way at each school level [27].

Lebanon is an example of developing countries that are working on integrating micro/nanotechnology into their education systems. The driver of this integration is the migration of Lebanese students to developed countries and getting educated in micro/nanotechnology fields. This encouraged them to develop similar programs in their country. Dr. Mohamad Hajj-Hassan is a holder of PhD degree in in Electrical and Computer Engineering from McGill University in 2010. His Research interests are MEMS/BioMEMS, brain computer interface, and chemical and biochemical sensor microsystems. He is now the main contributor in the creation of a master’s program in Biomedical Engineering at the Lebanese University with the option of Biological Microsystems. The program consists of 60 credits comprising courses, an applied project and a research project. The courses offered are Microfabrication, Microbiosensors, Lab-on-a-Chip, Microsystems, Biological Micro Electro Mechanical Systems (BioMEMS), Micro and Nanostructured Biomaterials, and Cellular and Molecular Imaging. Particularly, students will benefit from access to the microfabrication facilities at the Lebanese University to manufacture, test, and characterize microsystems dedicated for biological applications. The lack of equipment and facilities at the Lebanese University will be compensated by collaborating with the Ecole Polytechnique de Montreal and professors from McGill University and Université du Québec a Montréal (UQAM).

4. Conclusion

The emergence of micro and nano technologies has reshaped the world into a better and more advanced one. Research in these technologies evolved from basic applications to advanced integrated systems with promising remarkable results in the future. This research impacted engineering in all its disciplines. The tools and techniques provided by the research were essential to integrate into engineering education. The aim of this integration is to prepare engineers to use these technologies to develop state of the art products for a wide variety of applications. Such incorporation necessitates the development of courses that cover these technologies in details. These courses can be taught on high school, undergraduate and graduate level taking into consideration the level of education and as a result the way the course are to be taught.
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