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ABSTRACT
Although certain basics of engineering will not change in the future, the explosion of knowledge, the global economy, and the way engineers learn, work and innovate will reflect an ongoing evolution, and we must prepare well for this wave of change. Future civil engineers will need to master many newer fields, such as sustainability, computer applications, advanced materials, nanotechnology, and the like. The need to Raise the Bar for future entry into engineering practice at the professional level has been articulated by the National Academy of Engineering (NAE), the National Society of Professional Engineers (NSPE), the National Council of Examiners for Engineering & Surveying (NCEES), and the American Society of Civil Engineers (ASCE). The Raise the Bar initiative promotes raising the basic educational requirements for licensure of future professional engineers beyond a bachelor’s degree and to intensify the pre-licensure experience to meet their responsibilities to protect public health, safety and welfare. This keynote summarizes the guidelines and objectives of this strategic initiative and its implications to engineering students and faculty in the U.S. as well as signatory and potential signatory countries of the Washington Accord.
Developing Engineering Skills: An ongoing Debate

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Abstract: The past few years have witnessed a steady stream of reports either from Government Departments or industry calling into question the skills that graduates have upon leaving university and entering the world of work. The Engineering Education community can appear to be on the defensive when attempting to respond to these questions. The reality is that many stakeholders are involved in the development of engineering graduates and understanding what each stakeholder can contribute and then identifying effective ways of bringing these contributions to bear is very important. This presentation discusses the recently launched European Society for Engineering Education (SEFI) position paper on 'developing engineering skills' and the plan for developing a more detailed approach to this important topic. The paper argues that engineers are transforming the world and that in order to do that, the various stakeholders must work together to ensure their student experience develops both technical and reflective thinking skills, among others.

Keywords: Engineering Skills, Engineering Education, Technical Skills, Reflective Thinking, Transferrable skills
THE STANDING OF PROFESSIONAL ENGINEERS AND THE PROCESSES ON WHICH IT IS FOUNDED

Dr Peter Greenwood
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Abstract

This paper is strongly linked to WCEE 2015’s theme of sustainability. The paper discusses the processes and infrastructure and the main stakeholders in the on-going need to produce quality professional engineers. Trading service across and within national boundaries involves the engineering sector and the standing of its engineers. Trade is also affected by the availability and location of certified professional engineers — loosely referred to as the Mobility of professional engineers. The World Federation of Engineering Organizations (WFEO) plays a number of important roles. The main international accreditation and certification agreements and organisations, which I will refer to as “iaca”, are mostly well established and others are increasing their participation. More countries want to improve the certification of their engineers and to acquire the capacity including appropriate processes, administrative staff and physical resources within which to operate. “iaca” have shifted their focus from certifying individual engineers and quality control of the processes, towards cooperating with their peers and providing assistance to countries that aspire to national or international recognition. A comprehensive model is used to illustrate what is needed and who needs to be involved. The related activities of international engineering organisations are described and WFEO’s involvement is explained. The emerging partnership between WFEO and the International Engineering Alliance (IEA) is offered as an example of the need for close cooperation in giving help and informing governments and interested international organisations. The need to raise awareness is shown to be very important and some of the wider issues are raised.

1. Conclusions

a. The number of countries wanting international recognition for their engineers is growing, but many lack appropriate infrastructure and processes.

b. WFEO and “iaca” are refocusing on facilitating countries to acquire appropriate capacity.

c. ““iaca”” are also cooperating to bring their requirements closer together and more interchangeable.

d. Donor agencies and non-engineering beneficiaries can see benefits and are very interested in participating and funding.
e. Awareness of these matters needs raising urgently by more meaningful communications, which should be helped in part by the model used in the paper to illustrate the big picture.

f. Much more progress is needed to encourage self-help, inform governments and lift our gaze to the future. Changes in the need for engineers and in the work they will do are inevitable and have to be identified and accommodated.

g. Accreditation and certification involves standards and quality control. Countries aspiring to have their engineers educated and certified to an internationally recognised standard must have or establish the necessary capacity including:
   i. Attributes of an engineering graduate and education facilities to provide graduates with them.
   ii. Competencies of a practicing professional engineer and the arrangements to provide applicants with appropriate training and experiential learning for certification.
   iii. A national accreditation system to achieve consistent outcomes among graduates from different universities.
   iv. A national registration board to certify professional engineers for professional practice.
   v. A mechanism to obtain peer review against other national systems.

2. Introduction — Accreditation and Certification of professional engineers internationally

When countries trade goods and services and their companies operate across national boundaries problems can arise in the recipient country and between provider and client. In the engineering sector problems can involve engineering education and the certification of engineers. Engineering companies and their employees, as well as individual engineers, can be affected. International accreditation and certification organisations are well aware of the problems and IEA members have adapted their processes to accommodate the effect on engineering practice.

The number of engineers is rarely in balance, which is ever changing and different around the world. The ability of engineers can be seriously affected in such circumstances.

Learned societies and other agencies can facilitate engineering practice through mutual recognition agreements, which are helped by a country’s membership of one of the international accreditation or certification organizations.

This paper describes what a country needs when it:

1. Is not able to accredit its engineering courses or certify its engineers or
2. Wants to establish a national system to ensure consistency or
3. Wishes to raise its national system to an international level, perhaps with a view to membership of international agreements.
3. WFEO’s key roles

Two of WFEO’s key roles, in this context, are firstly to help its members to improve the quality of their engineering graduates and professional engineers. And secondly, ensure that WFEO represents its members and the profession globally to international agencies. Most of these agencies are not engineering related. But they are all strongly interested in having high-quality professional engineers, available in countries that they work with.

General comments about WFEO and Mobility

WFEO has 10 Standing Technical Committees (STCs) and its WFEO-UN Relations Committee (WURC). One STC works on engineering education, another on capacity building and a third on anti-corruption and ethics. The WFEO UN Relations Committee (WURC) plays a key role liaising with the United Nations and its agencies. With all our committees’ work we avoid replicating the work of our national members.

We have come to the view that the mobility of professional engineers throughout their careers involves most aspects of engineering education. This view is influenced by the needs of our national members and the international agencies we work with on behalf of the engineering profession. We complement the engineering education work of our national members, particularly their accreditation and certification activities.

WFEO has had a policy on Mobility of Engineering Professionals for many years. Part of this policy is that WFEO will publicize the work of all the organizations involved through its website and other opportunities. Several papers have been issued, which are all on the WFEO website in the Education Committee section.

Accreditation and certification of professional engineers

WFEO has very important work to do on this topic. Our members in some regions urgently want to improve the quality and recognition of their engineers. Even our members with established accreditation and recognition processes see an important need for compatibility across regions, which will serve in place of a world approach for the short to medium term.

The same urgency, reasoning and needs apply to the development banks, regional development agencies and government agencies like the World Trade Organization. The availability and ability of engineers affects agency success rates.

My paper at WCEE 2013 was a scorecard based on Fig 1., which describes an engineer’s career with the typical first two stages consisting of engineering education and formation (meaning training and experience) needed for certification or registration (which I will use in the paper). After the formation an engineer is said to be capable of independent ethical professional practice. The remaining stages are about gaining more experience, perhaps becoming a technical expert or an engineering manager. Finally the engineer moves into retirement and often continues some work or a contribution to the profession through a learned society.

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Dr Peter Greenwood
In broad terms I reported progress across the diagram — the whole-of-career journey, based on life-long-learning over the three colored zones — in terms of what we were doing “Now” and what we needed to do “Next” (into the future). In 2013, I believed that internationally and in many countries Stages 1 and 2 were at a sustainable level and working reasonably well — the “Now”. Much more work was needed on the other four stages for which I made a number of comments and suggestions — the “Next”.

Recent developments

In the last two years, many things have happened in various parts of the world, and many of them involve the quality, development and number of available engineers around the world. I have based my paper for WCEE 2015 on some of those changes involving WFEO. A good example is WFEO’s cooperation with the International Engineering Alliance (IEA). For the moment we have shifted our main focus away from individual engineers, more to the capacity (or infrastructure) building that is vital to the accreditation and certification stages in an engineer’s career. I will show you what capacity institutions and their processes need and how they fit into the overall picture. This will result in a need for physical and related resources including funding.

The three major future actions evident in 2015 are:

1. Within the engineering sector — universities, learned societies and engineering industry — there is a big internal communication problem about the nature of engineering work and the meaning and extent of regulation of professional engineers. Personal pride and aspirations must be included. Without meaningful communications at best progress will be suboptimal and at worst we will fail.

2. We need to re-engineer 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. Estimating the number of engineers needed is difficult but some indication is essential. We’ll be lucky if the answers are right but at least they would give some conception of what might emerge.

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3. When we have informed ourselves and reached some sort of consensus, we can make a start on informing governments and the general public. It sometimes seems that trust between governments and engineers has been lost. The public can’t believe or understand what governments or engineers say, so they demand detailed explanations they can’t understand, which is another communication dilemma.

The profession has to identify the key players with whom it needs to cooperate.

**Understanding the accreditation and certification “Big Picture”**

The starting point for my discussion is a general model to help our understanding.

The model represented in Figure 2 explains the overall picture of actions and agencies that work towards the licensing and certification of professional engineers. It shows the organizations involved both nationally and internationally.

It is said that only about 20% of engineering work requires licensing. Some countries reserve the title Engineer to certified professional engineers. I will use “registration” and licensing to mean engineers in the 20% and “certification” for engineers in the 80%. The latter may have a number of personal or other reasons for becoming certified.

The model shows the intricacies and importance of its components for aspirants to institutional membership of the one of the international accreditation and registration/certification agencies. It should also be of use to the many people who want to understand the basis of the validity of their standing as professional engineers or aspirants. Engineers and non-engineers, who have heard of the accreditation accords and related certification organizations, may also want to understand what they are and what they do. And finally the model shows in general terms, the infrastructure capacity needed from providers.

The NOW section on the left-hand side of the vertical line shows all the stages in the development of competent professionals engineer, the blue shapes, up to the time when they are accepted as ready for independent practice. The red, yellow and orange shapes show the national and international agencies involved. The agencies ensure that the education, training and experience gained meet the standard required for national or international practice. Generally such models are working satisfactorily in whole or in part and they continue to improve. Some consolidation is needed in the NOW section to increase participation. Participants will need appropriate responses to adapt to changing circumstances.

The FUTURE section, to the right-hand side of the vertical line, shows the areas of the model where further work is needed to increase the availability of facilities and lift the standard of the later periods of an engineer’s career.

The complete model, in Figure 3, shows we need much more work in the FUTURE section l. The complete diagram describes a country licensing professional engineers with all its agencies in place in partnership with the international accreditation and certification agencies (“iaca”). This outcome is also the aim of WFEO and the reason why it is cooperating with engineering sector and the “iaca”.

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Figure 2. The making of an internationally recognized professional engineer — present picture.

Figure 3. Complete picture — consolidation and the future
Non-engineering agencies

We must keep in mind the international significance and importance of the recognition and quality of professional engineers with respect to migration and work mobility between countries. Apart from the impact on the countries involved and the engineering sector in general, the recognition and quality of professional engineers is of considerable importance to international humanitarian, development, funding and trade organizations. WFEO has a major role to play with the non-engineering sectors, representing the profession and engineering learned societies to these sectors’ international agencies.

The International Federation of Consulting Engineers (FIDIC) is WFEO’s counterpart, representing companies providing engineering consultancy and other services in these sectors. It is an example of the business and company side of the engineering sector, which is very important to the work of the international agencies listed above.

WFEO plays a second role with some non-engineering sectors, offering a technical contribution of skills and information from its technical committees and networks — notably WURC and the Standing Committee on Engineering and the Environment (CEE) as well the other STCs mentioned earlier. A third role is to use its website and networks to publicise the work of “iaca”.

The main international engineering learned societies

Regions of the world, loosely based on continents, already have representative engineering organizations. The Pan American Union of Engineering Organisations (UPADI), the European Federation of national Engineering Associations (FEANI), the Federation of African Engineering Organizations (FAEO), the Federation of Arab Engineers (FAE) and the Federation of Engineering Institutions in Asia and the Pacific (FEIAP) are the main ones. They are already important members of WFEO, mainly because of their learned society function. They also have a second function playing a part in certifying professional engineers. Some are also involved with their members’ accreditation of engineering education courses. There are other, usually smaller, international learned society groups, which may have the second function at a formative stage or at a local level.

WFEO relates to the learned society roles and the accreditation and certification roles of its members differently. WFEO does not get involved directly in standards setting.

International Engineering Alliance (IEA) members are independent of government (with the exception of the APEC example described below) relying on member funds. IEA members accredit engineering education programs and certify professional engineers in their countries, as well as maintaining consistency across IEA’s membership by periodic peer assessment. IEA is the only global agency with membership open to countries in all geographic regions.

The IEA comprises two agreements for professional engineers, the International Professional Engineer Agreement (IPEA) and the APEC Engineer Agreement (APECEA). APEC is the Asia-Pacific Economic Cooperation forum for governments in the region. The engineering certification organisations of the APEC economies form the APEC Agreement, the members of which are linked to their governments but not generally funded by them. The APECEA professional engineer standard is equivalent to the IPEA standard.
The APEC Engineer Agreement is working with APEC to re-establish its links to the APEC secretariat. Keen interest in the APEC Engineering standard has re-emerged in APEC because of the growth in free trade agreements linked to APEC and the economies wanting to join a trade agreement.

IEA’s work is on standards and consistency of processes that use the standards. WFEO has been cooperating closely with IEA for some years, as it adopted a more outward-looking approach. We expect to have a formal agreement by the end of 2015.

The European Network for Accreditation of Engineering Education (ENAAE) grew out of the Bologna Declaration and the Bologna Process. It is the European equivalent of the IEA’s Washington Accord. ENAAE and FEANI represent the European region, which comprises 47 members of the European Higher Education Area (EHEA) including 27 European Union (EU) member countries.

ENAAE and FEANI have equal standing with their IEA counterparts — the Washington Accord, the International Professional Engineer Agreement and the APEC Engineer Agreement. All are working towards harmonizing their respective requirements for professional engineers, to avoid confusion and improve interchangeability.

Cooperation between the regional and global organizations is very much helped by many common memberships of countries across all these organizations.

The IEA and ENAAE could join WFEO in an associate role, which would be acceptable to WFEO as long as the relationship did not endanger the independence and integrity of their standards and processes.

FEIAP has produced an Engineering Education Guideline, originally written to help a small number of its members to achieve the Washington Accord level. The Guideline is based on the Engineers Australia Accreditation System. UNESCO’s Jakarta Office has endorsed the Guidelines and called for its widespread acceptance. This development needs some clarification to avoid confusion between programs accredited under the guideline and those accredited under the Washington Accord.

UNESCO has provided some funding to assess the standard of some FEIAP countries aspiring to improve the quality of their engineers and educational institutions. This will be an opportunity to assess the use of the Guideline.

UPADI has begun an initiative on accreditation and has sought the involvement of WFEO’s Committee on Education in Engineering.

**Capacity or Infrastructure Building: WFEO, WFEO’s STCs and international agencies**

One aspect of our agreement with IEA is about national accreditation and recognition processes that require support and funding from government or other agencies to provide and administer. The processes might be called “soft” capacity or infrastructure, which is an integral part of the physical infrastructure of universities, training facilities, learned societies and regulatory offices.

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Government assistance is also needed for the physical infrastructure. Aid agencies and development banks are very interested in funding this sort of national and regional capacity. WFEO’s Committee on Capacity Building (CCB) is well established to contribute with its Capacity Building Guidelines and its network of interested participants. Contributions are also coming from CEIE on the education and university aspects through its networks and conferences. The Committee on Anti-Corruption (CA-C) contributes through its model code of ethics and extensive training programs from its partner, the Global Infrastructure Anti-Corruption Centre (GIACC) based in England. WURC is also in a unique position to present information on this work to UN committees and to a wider international audience.

Our common ground with IEA

In exchanges over recent years, IEA and WFEO have developed similar interests with the same obligations to their members and prospective members. We exchanged letters of understanding, then a memorandum of understanding last year. In building a partnership we are helped by close cooperation between senior office bearers from both our organizations. From these discussions, the synergies of need, experience and the ability to tap resources made a formal agreement very much appropriate. Each of us has established a team to work on the form of an agreement, with the document to be signed by the end of the year.

An IEA member has been working closely with us, attending our last Executive Council meeting and the meetings to progress a major project, the Africa Catalyst Project. IEA Council immediate-past chair has also been an active long-standing facilitator of these moves towards an agreement. As well, last year he joined WFEO’s team doing an annual assessment of the STCs to gain an understanding of their work.

The Africa project is a good example of the work we will do under the agreement. Good accreditation and recognition arrangements can’t be achieved without institutional capacity, which in turn requires plans, the involvement of political agencies and a major development agency. This is happening with the Africa Catalyst Project through the FAEO and appropriate agencies. WFEO has played its part but the key point is that African engineers themselves are driving the project. WFEO also has a team helping, which has obtained strong encouragement from a British government-funding agency.

In 2013 WFEO’s President signed the Abuja Declaration setting out details of cooperation on mobility in the Sub-Saharan region.

WFEO and IEA independently have also identified Southern South America, the Middle East and others as regions with similar needs but different circumstances. In the last mentioned, the Federation of Arab Engineers has taken some initiatives, using some internationally recognized processes. Interest is growing in South America in Brazil and Peru. The latter has become a provisional member of the Washington Accord.

Awareness

Although many countries are aware of the main international accreditation and recognition systems, they are not clear about the extent of their jurisdictions or how many countries are involved in each system. My advice is that the IEA is the biggest in terms of recognition, membership and global jurisdictional coverage, although membership seems to be growing in most “iaca”.

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In engineering practice a providing country or company has to be aware of the requirements for international professional engineers or those of the receiving country — if there are any. The receiver country needs to be aware and understand the certification of engineers working in its jurisdiction. Although some of these matters are known and dealt with there are many countries where they are not, because of lack of knowledge, processes and the capacity itself.

Another global aspect, the current shortage of engineers in many developed and less-developed countries, is very important. Some other developed countries, in the EU for example, have a surplus of engineers although they would not like to lose them permanently. Loss of any professional from any country, is reflected in a lost investment in human capital. An engineer who returns to his country after gaining training or experience brings back that investment with interest. In the case of developing countries the needs and shortages, and the impact of migration, are much greater, affecting their economic and technical development.

Although we can’t solve the political matters, we can work to improve the quality and recognition of professional engineers. The WFEO/IEA Agreement and our close cooperation with all international accreditation and certification agencies will, I am sure, have a very significant impact.

END
Summary

Higher education has to develop in order to meet the challenges of the Globalisation and the inclusive growth sought in many countries. Developing Engineering education is in the frontline in responding to these challenges. Engineering education as an applied and down to earth science should contribute to the development of communities and is the basic component for progress and technological development.

One of the main challenges to be faced by the Engineering education in this century is to develop an integrated educational system that offers engineers a comparative and competitive advantage in a globalized and privatized market.

There have been many big changes on the patterns of thinking and learning in the philosophy of education at the level of creativity, learning theory, curriculum and technology education control. Engineering education has, before any other discipline, to follow these changes and adapt to its requirements in terms of concept and tools.

On the other hand, we see that the rapid growth of technology has helped in the dissemination of knowledge, and made information and data at hand, and that had a significant impact on the engineering profession during this century.

In addition, the increased mobility in the workplace is generating pressure to expand competencies beyond countries. Hence, internationalisation and international competencies have to be taken into consideration in any design or conception of new curricula or programmes.

In Lebanon, the numbers of institutions that offer engineering programmes have increased from 7 before the year 1995 to 17 currently. The number of students in various engineering disciplines in the year 2014 is approximately 25000 students.

Different systems are applied in Engineering studies in Lebanon: 5-year study (LU, AUB, BAU, …), 3-year Bachelor + 2-year Master (UOB, RHU, …) and a special system applied at CNAM-Liban.

We believe that, with this substantial increase in the number of students, one must go on with radical reforms in this area based on self-evaluation and external assessment of engineering programmes. This should also be based on the learning outcomes of these engineering programmes and on their impact on the development of the country.

Many ideas are proposed in that regard: Quality Assurance and accreditation processes, continuous audit process, implementing Colloquium examinations in Engineering and reinforcing the admission criteria to engineering programmes.

All these actions require new legislations that need national dialogue with the Orders of Engineers and with all other stakeholders concerned by the sector.
The evolution of US engineering education in the first two decades of the 21st century

Fadi P. Deek, PhD, Provost and Senior Executive Vice President, New Jersey Institute of Technology

ABSTRACT

During the last quarter of the 19th century, engineering education in the United States, now about 150 years old, was subject to significant changes in direction in every generation. From a hands-on focus using apprenticeship models in the first fifty years, engineering education has undergone a strong shift toward an "engineering science" focus starting in the 1930s. This trend toward stronger theoretical basis research and rooting of engineering education in science has accelerated rapidly after World War II. Later developments, starting in the mid 1960s, expanded engineering education into new disciplines (most notably computing, biomedical engineering and signal processing). In the 1980s and 1990s new requirements were imposed—including the formalization of content in oral and written communications and teamwork culture; inclusion of economic imperatives and ethics in curriculum; and requiring better understanding of the societal impact of engineering work. The "swinging of the pendulum" toward theory was moderated somewhat by new emphasis on hands-on experience and lab work.

The early decades of the 2000s have introduced new challenges. Traditional engineering work has migrated from its old geographical centers to new venues, and from its traditional practitioners (individuals with a baccalaureate degree in engineering) to diverse groups with other educational backgrounds and titles (including computer scientists, information technologists, "hackers," and non-engineer designers). The role of computing in engineering practice has grown significantly, and the intersection between engineering computing and, the life sciences has become one of the most dynamic areas of growth.

In this presentation we will discuss how these changes are affecting the curriculum, practice, and management engineering education in the United States. We shall also consider the likely evolution of engineering education in light of the new trends in engineering disciplines, student demographics, professional mobility, program accreditation, and licensing.
Foreword

ENAEE (European Network for Engineering Accreditation) was founded on 8 February 2006, after the successful conclusion of the EUR-ACE® Project which was supported by the EU Socrates and Tempus Programmes and by 14 European associations concerned with engineering education. It stemmed from ESOEPE, the “European Standing Observatory for the Engineering Profession and Education”, that had been established on 9 September 2000.

ENAEE is rooted in the so-called Bologna process which aims at building a European Higher Education Area (EHEA), by strengthening the competitiveness and attractiveness of European higher education and fostering student mobility and employability.

ENAEE addresses specifically the education of engineers, whose importance is increasing in the global economy. ENAEE aims to enhance and promote the quality of the education of engineering graduates in order to facilitate their professional mobility and to enhance their individual and collective ability to fulfil the needs of economies and of society.

To achieve these goals, ENAEE authorises accreditation and quality assurance agencies to award the EUR-ACE® (EURopean ACcredited Engineer) label to their accredited engineering degree programmes. To be authorised, an agency must satisfy the standards published by ENAEE in the EUR-ACE® Framework Standards (EAFS) document. These standards incorporate the views and perspectives of the main stakeholders (students, higher education institutions, employers, professional organisations and accreditation agencies). The EAFS document is the precursor to this new document, the EUR-ACE® Framework Standards and Guidelines (EAFSG) published here.

Since 2006, the EUR-ACE® label has, to date, been awarded to more than 1800 engineering programmes, delivered in more than 300 universities in 28 countries in Europe and worldwide. The EUR-ACE® system has hence proven its reliability and its adaptability to diverse national contexts.

However, after eight years of implementation, the time has come to revise the EAFS document, not by altering its fundamental standards which remain unchanged, but to take into account the feedback of ENAEE stakeholders, to clarify and simplify the presentation and to produce this new document, the EUR-ACE® Framework Standards and Guidelines (EAFSG).

March 2015
1. General Introduction

(a) The mission of ENAEE is to serve the public and society through the promotion and advancement of engineering education in Europe and abroad. ENAEE aims at building a pan-European framework for the accreditation of engineering education programmes, in order to enhance the quality of engineering graduates, to facilitate the mobility of professional engineers and to promote quality and innovation in engineering education.

To achieve these goals, ENAEE has established a de-centralized system for the standards of accreditation of engineering education degree programmes, leading to pan-European recognition of national accreditation decisions.

Membership of ENAEE is open to all bodies concerned with educational and professional standards in engineering throughout the European Higher Education Area (EHEA) and beyond. Such bodies may include accreditation and quality assurance agencies, professional organisations, associations of higher education institutions, employers’ associations, and engineering student bodies and their associations.

(b) ENAEE carries out its mission by evaluating quality assurance and accreditation agencies in the EHEA in respect of their standards and procedures when accrediting engineering degree programmes.

Those agencies which satisfy ENAEE in respect of these matters are authorised by ENAEE to award the EUR-ACE® label to the engineering degree programmes which they accredit.

It should be noted that ENAEE does not accredit engineering degree programmes. Using the standards specified in this document (EAFSG), ENAEE evaluates the policies and procedures implemented by accreditation and quality assurance agencies which have applied for authorisation to award the EUR-ACE® label to the engineering degree programmes which these agencies accredit.

(c) The EAFSG described here represent a revision to the original document (known as EAFS) produced in 2006. While the original standards remain unchanged, changes based on feedback and usage have been made. They constitute the basis upon which authorisation to award the EUR-ACE® label is granted to quality assurance and accreditation agencies. They are intended to be widely applicable and inclusive so that they can be applied to all branches of engineering; and to reflect the diversity of engineering degree programmes in the EHEA, which provides the education necessary for graduates to enter the engineering profession and to have their qualifications recognised throughout the area.

(d) The EAFSG are for the use of established agencies which have well developed policies and procedures that are continuously under review. They are also aimed at new agencies which may wish to use the information in the EAFSG to assist them as they develop their
policies and procedures for the accreditation of engineering degree programmes and apply for authorisation to award the EUR-ACE® label.

(e) The general basis to the EAFSG can be found in the following policies:

- The overarching framework of qualifications of the European Higher Education Area (EHEA Framework or OF-EHEA) as adopted by the Ministers of Education of the Bologna Process at their meeting in Bergen in May 2005, including the Dublin Descriptors.
- The European Qualifications Framework for Lifelong Learning (EQF) as developed by the European Commission and signed on 23 April 2008 by the Presidents of the European Parliament and of the Council of the European Union.

(f) The EAFSG have been formulated to be substantially compliant with the relevant sections of the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG) as adopted by the Bologna Process ministerial summit in Bergen (Norway) in 2005 and which were revised in 2015.

(g) Throughout the EAFSG, the term “engineering graduate” is used to describe someone who successfully completes an accredited degree programme in engineering. The term “engineer” has been avoided because of the confusion that could arise from its widely different interpretations throughout Europe and worldwide, including specific regulatory meanings in some countries. It is for the appropriate authority in each country to decide if a qualification is sufficient for engineering registration or qualification in that country, or if further education, training or industrial experience is necessary. The EUR-ACE® label will assist such decisions, and particularly those that involve trans-national recognition.

(h) The standards which ENAEE requires of engineering degree programmes which are accredited by agencies are described here in Section 2, Standards and Guidelines for Accreditation of Engineering Programmes.

(i) The standards which ENAEE requires of agencies are described here in Section 3, Standards and Guidelines for Accreditation Agencies.

(j) The process of authorising an agency to award the EUR-ACE® label is described in EUR-ACE® Label Authorisation Process.

2. Standards and Guidelines for Accreditation of Engineering Programmes

2.1 Introduction

The EUR-ACE® Standards and Guidelines for Accreditation of Engineering Programmes (EAFSG) are described here in terms of Student Workload Requirements (Sect 2.2), Programme Outcomes (Sect. 2.3) and Programme Management (Sect. 2.4).
The Student Workload Requirements and the Programme Outcomes are compliant with the overarching Framework of Qualifications for the European Higher Education Area (EQF), adopted by the Bergen Conference of European Ministers responsible for Higher Education on 19-20 May 2005. The framework “comprises three cycles (including, within national contexts, the possibility of intermediate qualifications), generic descriptors for each cycle based on learning outcomes, and credit ranges in the first and second cycles”.

The overall result of the application of the EQF is a range of Bachelor and Master Degree programmes in engineering now offered in European Higher Education Institutions. These are described here in terms of the European Credit Transfer System as follows:

a) Fulltime Bachelor degree programmes in engineering are now of 180, 210 or 240 ECTS credits.

b) Fulltime Master degree programmes in engineering are of 60, 90 or 120 ECTS credits.

As established by the “Recommendation of the European Parliament and of the Council” of 23 April 2008, the descriptor for the first cycle in the Framework for Qualifications of the European Higher Education Area (Bologna process) corresponds to the learning outcomes for the EQF, level 6. The descriptor for the second cycle in the Framework for Qualifications of the European Higher Education Area corresponds to the learning outcomes for the EQF, level 7.

The Programme Outcomes are consistent with the provisions of the EQF.

The Programme Management requirements are consistent with the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG), adopted by the 2005 Bergen Conference of European Ministers responsible for Higher Education.

2.2 Student Workload Requirements

The workload requirements are described using ECTS credits.

ENAEE describes the Programme Outcomes for Bachelor and Master Degree programmes normally structured as follows:

- Bachelor Degree programmes, of a minimum of 180 ECTS credits.
- Master Degree programmes, of a minimum of 90 ECTS credits (60 in some educational systems).
- Master Degree programmes which are integrated and which, normally, do not include the award of a Bachelor Degree, should comprise ECTS credits consistent with the above: i.e. a minimum of 270 ECTS credits (240 in some education systems).

2.3 Programme Outcomes Framework

(a) Programme Outcomes describe the knowledge, understanding, skills and abilities which an accredited engineering degree programme must enable a graduate to demonstrate. The Programme Outcomes specified below apply to accredited programmes which are to be awarded a EUR-ACE label by an authorised agency. In this document, the term learning outcome is used only to describe the knowledge, understanding, skills and abilities which apply to individual course units/modules.
(b) The Programme Outcomes specified in this document are intended to be applicable to the full range of Bachelor and Master Degree programmes in engineering offered in European HEIs. They have to be considered as the ‘minimum threshold’ defined by the ENAEE community and to be fulfilled in order to assure the quality of engineering programmes.

(c) The Programme Outcomes can be used in both the design (by engineering academics) and the evaluation (by accreditation agencies) of programmes in all branches of engineering and for different profiles.

(d) The standards describe the Programme Outcomes that accredited programmes must meet, but do not prescribe how they are realised. Consequently, no restriction is implied or intended by the EAFSG in the design of programmes to meet the specified Programme Outcomes. HEIs retain the freedom to formulate programmes with an individual emphasis and character, including new and innovative programmes, and to prescribe conditions for entry into each programme.

(e) The Programme Outcomes are described here separately for both Bachelor and Master Degree programmes with reference to the following eight learning areas:

- Knowledge and understanding;
- Engineering Analysis;
- Engineering Design;
- Investigations;
- Engineering Practice;
- Making Judgements;
- Communication and Team-working;
- Lifelong Learning.

(f) The ENAEE/IEA Glossary of Terminology is used to verify terms used in this document.

**2.3.1 Programme Outcomes for Bachelor Degree Programmes**

**Knowledge and Understanding**

The learning process should enable Bachelor Degree graduates to demonstrate:

- knowledge and understanding of the mathematics and other basic sciences underlying their engineering specialisation, at a level necessary to achieve the other programme outcomes;
- knowledge and understanding of engineering disciplines underlying their specialisation, at a level necessary to achieve the other programme outcomes, including some awareness at their forefront;
- awareness of the wider multidisciplinary context of engineering.

**Engineering Analysis**

The learning process should enable Bachelor Degree graduates to demonstrate:

- ability to analyse complex engineering products, processes and systems in their field of study; to select and apply relevant methods from established analytical,
computational and experimental methods; to correctly interpret the outcomes of such analyses;
• ability to identify, formulate and solve engineering problems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; to recognise the importance of non-technical – societal, health and safety, environmental, economic and industrial - constraints.

Engineering Design
The learning process should enable Bachelor Degree graduates to demonstrate:

• ability to develop and design complex products (devices, artefacts, etc.), processes and systems in their field of study to meet established requirements, that can include an awareness of non-technical – societal, health and safety, environmental, economic and industrial– considerations; to select and apply relevant design methodologies;
• ability to design using some awareness of the forefront of their engineering specialisation.

Investigations
The learning process should enable Bachelor Degree graduates to demonstrate:

• ability to conduct searches of literature, to consult and to critically use scientific databases and other appropriate sources of information, to carry out simulation and analysis in order to pursue detailed investigations and research of technical issues in their field of study;
• ability to consult and apply codes of practice and safety regulations in their field of study;
• laboratory/workshop skills and ability to design and conduct experimental investigations, interpret data and draw conclusions in their field of study.

Engineering Practice
The learning process should enable Bachelor Degree graduates to demonstrate:

• understanding of applicable techniques and methods of analysis, design and investigation and of their limitations in their field of study;
• practical skills for solving complex problems, realising complex engineering designs and conducting investigations in their field of study;
• understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations in their field of study;
• ability to apply norms of engineering practice in their field of study;
• awareness of non-technical -societal, health and safety, environmental, economic and industrial - implications of engineering practice;
• awareness of economic, organisational and managerial issues (such as project management, risk and change management) in the industrial and business context.

Making Judgements
The learning process should enable Bachelor Degree graduates to demonstrate:

• ability to gather and interpret relevant data and handle complexity within their field of study, to inform judgements that include reflection on relevant social and ethical issues;
• ability to manage complex technical or professional activities or projects in their field of study, taking responsibility for decision making.
Communication and Team-working
The learning process should enable Bachelor Degree graduates to demonstrate:
• ability to communicate effectively information, ideas, problems and solutions with engineering community and society at large;
• ability to function effectively in a national and international context, as an individual and as a member of a team and to cooperate effectively with engineers and non-engineers.

Lifelong Learning
The learning process should enable Bachelor Degree graduates to demonstrate:
• ability to recognise the need for and to engage in independent life-long learning;
• ability to follow developments in science and technology.

2.3.2 Programme Outcomes for Master Degree Programmes

Knowledge and Understanding
The learning process should enable Master Degree graduates to demonstrate:
• in-depth knowledge and understanding of mathematics and sciences underlying their engineering specialisation, at a level necessary to achieve the other programme outcomes;
• in-depth knowledge and understanding of engineering disciplines underlying their specialisation, at a level necessary to achieve the other programme outcomes;
• critical awareness of the forefront of their specialisation;
• critical awareness of the wider multidisciplinary context of engineering and of knowledge issues at the interface between different fields.

Engineering Analysis
The learning process should enable Master Degree graduates to demonstrate:
• ability to analyse new and complex engineering products, processes and systems within broader or multidisciplinary contexts; to select and apply the most appropriate and relevant methods from established analytical, computational and experimental methods or new and innovative methods; to critically interpret the outcomes of such analyses;
• ability to conceptualise engineering products, processes and systems;
• ability to identify, formulate and solve unfamiliar complex engineering problems that are incompletely defined, have competing specifications, may involve considerations from outside their field of study and non-technical – societal, health and safety, environmental, economic and industrial – constraints; to select and apply the most appropriate and relevant methods from established analytical, computational and experimental methods or new and innovative methods in problem solving;
• ability to identify, formulate and solve complex problems in new and emerging areas of their specialisation.

Engineering Design
The learning process should enable Master Degree graduates to demonstrate:
• ability to develop, to design new and complex products (devices, artefacts, etc.), processes and systems, with specifications incompletely defined and/or competing, that require integration of knowledge from different fields and non-technical - societal, health and safety, environmental, economic and industrial commercial – constraints; to select and apply the most appropriate and relevant design methodologies or to use creativity to develop new and original design methodologies.
• ability to design using knowledge and understanding at the forefront of their engineering specialisation.

Investigations
The learning process should enable Master Degree graduates to demonstrate:

• ability to identify, locate and obtain required data;
• ability to conduct searches of literature, to consult and critically use databases and other sources of information, to carry out simulation in order to pursue detailed investigations and research of complex technical issues;
• ability to consult and apply codes of practice and safety regulations;
• advanced laboratory/workshop skills and ability to design and conduct experimental investigations, critically evaluate data and draw conclusions;
• ability to investigate the application of new and emerging technologies at the forefront of their engineering specialisation.

Engineering Practice
The learning process should enable Master Degree graduates to demonstrate:

• comprehensive understanding of applicable techniques and methods of analysis, design and investigation and of their limitations;
• practical skills, including the use of computer tools, for solving complex problems, realising complex engineering design, designing and conducting complex investigations;
• comprehensive understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations;
• ability to apply norms of engineering practice;
• knowledge and understanding of the non-technical – societal, health and safety, environmental, economic and industrial - implications of engineering practice;
• critical awareness of economic, organisational and managerial issues (such as project management, risk and change management)

Making Judgements
The learning process should enable Master Degree graduates to demonstrate:

• ability to integrate knowledge and handle complexity, to formulate judgements with incomplete or limited information, that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgement;
• ability to manage complex technical or professional activities or projects that can require new strategic approaches, taking responsibility for decision making.
Communication and Team-working
The learning process should enable **Master Degree graduates to demonstrate**:

- ability to use diverse methods to communicate clearly and unambiguously their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences in national and international contexts;
- ability to function effectively in national and international contexts, as a member or leader of a team, that may be composed of different disciplines and levels, and that may use virtual communication tools.

Lifelong Learning
The learning process should enable **Master Degree graduates to demonstrate**:

- ability to engage in independent life-long learning;
- ability to undertake further study autonomously.

2.4 Programme Management

(a) Accreditation agencies should confirm that engineering degree programmes, for which a HEI seeks accreditation, are managed to,

- achieve the programme aims;
- provide a teaching and learning process that enables students to demonstrate achievement of Programme Outcomes;
- provide adequate resources;
- monitor the rules for student admission, transfer, progression and graduation; and
- comply with internal quality assurance procedures.

b) The five standards below specify the key areas of programme management that must be evaluated if an agency is to be authorised to award the EUR-ACE® label. The guidelines that follow the standards are not prescriptive, but are intended to assist agencies and HEIs in meeting the standards. Programme managers are free to satisfy the standards in accordance with their own traditions and resources.

2.4.1 Programme Aims.

The aims of accredited programmes must reflect the needs of employers and other stakeholders. The programme outcomes must be demonstrably consistent with the aims.

The aims should take into account employment opportunities for graduates, potential developments in technology, the needs of employers, the wide range of applications of engineering, postgraduate opportunities for graduates, the mission of the university and the interests of students.
2.4.2 Teaching and Learning Process

The teaching and learning process must enable engineering graduates to demonstrate the knowledge, understanding, skills and abilities specified in the Programme Outcomes. The programme curriculum must specify how this is to be achieved.

The curriculum should give comprehensive information on all the modules in the degree programme, including the syllabus, the module learning outcomes, the methodology of teaching and learning, credit allocation, the method of module assessment, and any pre-requisite or co-requisite modules or other programme requirements. The curriculum should ensure that the module learning outcomes aggregate to the programme learning outcomes, including the effect of student choice of modules.

The learning process should be sufficiently flexible to accommodate different entry qualifications of students and different learning styles. If the programme includes time spent in industry or in another HEI, it should be assessed in the context of its contribution to the achievement of the Programme Outcomes.

The assessment of students should evaluate achievement of the specified module learning outcomes, and be both rigorous and fair. Wherever possible there should be second marking of student work or moderation of assessments. Students should have an opportunity to redeem work that is assessed as being below standard, provided this can be done without compromising output standards.

Independent and external scrutiny of the assessment of students, and of the decisions on progress and completion, are effective in ensuring that output standards are maintained. The arrangements for any such scrutiny should be documented.

2.4.3 Resources

The resources to deliver the programme must be sufficient to enable the students to demonstrate the knowledge, understanding, skills and abilities specified in the Programme Outcomes.

The number, qualifications and experience of the teaching staff should be adequate to teach the programme to the standard specified in the Programme Outcomes. The programme should be supported by an effective team of technical and administrative staff. There should be arrangements in place for ensuring that staff are updated to use and apply new technologies and receive training as and when required.

The laboratory, computing and workshop facilities should have the equipment necessary to support the programme; the arrangements for safe access by students should ensure appropriate opportunities for student practical activities, particularly to support project work.

Student support services, including but not limited to, tutoring, library and other information resources, assistance with external placements, should be readily accessible by students.

The resources necessary to deliver the programme should be supported by an adequate budget.
2.4.4 Student admission, transfer, progression and graduation

The criteria for student admission, transfer, progression and graduation must be clearly specified and published, and the results monitored.

Students should be informed of the qualifications necessary to enter the programme and of the regulations necessary to progress to completion. The criteria for students to transfer into later stages of the programme should be clearly specified.

Records of student achievement provide essential information for the review and development of programmes. There should be arrangements for monitoring the progress of students through the programme against their entry qualifications, so as to provide essential data for reviewing entry to the programme. In particular the number of, and reasons for, non-completions should be recorded. The overall performance of students in individual modules should be noted in order to identify assessment results that are significantly different from the norm.

2.4.5 Internal Quality Assurance

Accredited engineering degree programmes must be supported by effective quality assurance policies and procedures.

The programme should have quality assurance procedures that are consistent with the HEI quality assurance policy. It would be expected that there is a defined and documented procedure for reviewing the programme at regular intervals using all relevant data, including an evaluation of student achievement against the stated programme aims.

Feedback should be obtained in an agreed format from the students on an accredited programme on all taught modules in the programme, to enable the effectiveness of each module to be evaluated. There should be clearly understood arrangements for the day to day management of the programme to resolve any urgent and immediate problems.

Information about all aspects of the programme, including the quality assurance procedures, should be publicly available.

3. Standards and Guidelines for Accreditation Agencies

3.1 Introduction

(a) ENAEE requires quality assurance and accreditation agencies awarding the EUR-ACE® label to apply the standards described here. These standards apply to the effectiveness of the agency accreditation procedures in the evaluation of the learning process of the degree programme being accredited and its compliance with the Student Workload Requirements, Programme Outcomes and Programme Management specified above, for Bachelor and Master Degree programmes respectively.

(b) The seven standards specified below apply to the quality assurance of the internal processes of accreditation agencies. The standards are mandatory but the guidance is not intended to be prescriptive. It is recognised that agencies that accredit engineering programmes will have different histories and traditions, and will have established internal
organisation and accreditation processes that are tuned to the needs of their particular communities and relevant regulatory requirements. Nevertheless it would be expected that agencies will incorporate processes consistent with the standards that are accepted internationally as providing the basis for effective accreditation of engineering degree programmes. This guidance is intended to indicate methods that have gained general approval through widespread use, and to reflect a consensus of good practice.

An agency that uses methods and procedures differing from those indicated by the guidelines should provide evidence that its methods and procedures comply fully with the standards described here.

3.2. Programme Evaluation and Accreditation

3.2.1. Methods and Procedures

The methods and procedures of the agency must ensure that engineering degree programmes are accredited accurately in accordance with the agency’s established standards.

This standard is concerned with the processes used by the agency to establish, review and update its requirements of accredited programmes, of the infrastructure and resources of the HEI to deliver programmes and also of the agency procedures for evaluating programmes. Agencies need to be receptive to innovation in engineering technologies and teaching methods, to avoid accreditation inhibiting the introduction of new subjects and ways of teaching.

Established accreditation agencies will have a wide range of different arrangements for consulting all stakeholders to ensure that their accreditation processes are conducted efficiently and effectively. Whatever the arrangement, the agency procedures should ensure that its standards and methods of working are reviewed at regular intervals, and updated as required. The use of international accreditors is one way of ensuring that the agency standards and practices are consistent with international developments.

In addition to ensuring that the specified standards of engineering education are maintained, accreditation agencies can have an important role in the development of engineering programmes through, for example, sharing good practice.

3.2.2. Documentation

The accreditation standards and procedures must be publicly available in an accessible format.

The details of the accreditation standards and procedures should be widely available. A university applying for accreditation of a programme will require a clear statement of the standards and procedures that will be used to assess its application. It would be expected that agencies using web-based publishing have effective procedures for controlling changes to such documents.

Agencies have widely different publication practices, often arising from long-standing traditions that determine the format and number of publications, but the expectation would be
that all documents relevant to accreditation are publicly available, and contain explicit statements of the accreditation standards. The documentation should provide comprehensive information on the procedures used in evaluating programmes, including, but not limited to, format of self-assessment report, timetable of observation visit, membership of accreditation panels and other committees and a template for accreditation reports.

There should be an effective arrangement to ensure that changes in documentation arising from improvements in presentation and procedures are communicated to HEIs and other stakeholders. If the documentation is available on a website it should be properly signposted and readily downloaded.

3.2.3. Accreditation Process

The accreditation process must be effective in acquiring all the evidence necessary to make decisions.

The value of accreditation evaluations to universities, and to the wider engineering profession, is enhanced by a process designed to acquire the information necessary to make an informed decision. Agencies should ensure that the specification for the contents of the self-assessment report, and the agenda for the site visit by the accreditation panel are structured to obtain the required information. Accreditation evaluations are demanding of the time and resources of universities and therefore the process should not make unnecessary or excessive demands.

The timetable for the accreditation process should provide adequate time to enable the HEI to assemble the relevant information. The format, content and detail of the evidence to be provided in the self-assessment report submitted by the HEI should be clearly specified. The agency should list the supporting documentation that is to be provided either before or during the visit of the accreditation panel, such as minutes of meetings, examples of assessed student work, and quality assurance procedures.

The collective experience of agencies in many countries is that it is important to train the members of accreditation panels to assess evidence presented in different formats, ask relevant follow up questions, and make balanced judgements. The number and expertise of the panel membership should be determined by the nature of the programmes being assessed. Usual practice is that the accreditation panel consists of at least three persons, with appropriate representation from all relevant sectors of the engineering profession.

The self-assessment report and other specified information should, typically, be available to the accreditation panel about one month in advance of the site visit. The duration of the site visit will be determined by the need to collect the required evidence, and to investigate aspects of the self-assessment report. The agenda for the visit should be specified in advance by the agency, but may be changed by the accreditation panel depending on circumstances. It would be expected that the agenda would schedule an initial meeting of the panel to review the submitted evidence, and a programme of meetings as required with HEI management, teachers, students, graduates, and employers. There should also be an opportunity for the panel to inspect the teaching and other supporting facilities, and to evaluate assessed student work. In order that the time available during the visit is used efficiently, some agencies
request samples of assessed student work to be sent to the accreditation panel ahead of the visit, thereby enabling the work to be scrutinised more carefully.

If the agency uses a template for the report of the accreditation panel, it should be publicly available to ensure that the HEI is fully aware of the basis for accreditation decisions.

### 3.2.4 Decision-making

**Accreditation decisions must be demonstrably accurate, consistent and unbiased.**

The decisions of the agency need to be accepted by all stakeholders, if accreditation is to be accepted as evaluating the quality of engineering programmes. The agency should retain documented evidence of how decisions are reached.

Agency decisions on accreditation should be based on careful and unbiased evaluation of the evidence provided by the university, and in the report of the accreditation panel. The decisions should be made by a board appointed for that purpose, and composed of representatives from all sectors of the profession. The report (devoid of any recommendations) should have been cleared for factual accuracy by the university prior to consideration by the board, and it would be expected that one of the members of the accreditation panel would present the report to the board. Any member of the board who has (or has had) a connection of any sort with the university concerned should not be present during the decision making process.

It would be expected that the agency has documented procedures for appointing members to the board, and would maintain a balance of representation between all sectors of the profession. The terms of reference of the board, and its rules and procedures should be documented and publicly available. The board should have a range of possible decisions on accreditation to ensure that it can act constructively in the best interests of the profession.

The agency should have formal procedures for communicating decisions to HEIs, for recording decisions, for following up any actions required, and for any appeals against decisions.

### 3.2.5 Publication

**The agency must publish the outcome of the accreditation evaluation.**

Publication of the decision to accredit a programme, and the period for which the accreditation is valid, will contribute to maintaining the standard of engineering programmes.

The list of programmes accredited by the agency should be published including the period for which the accreditation is valid. The university should also be able to use accreditation of its programmes in publicity for prospective students. Agencies should also give consideration to publishing some parts of the report of the accreditation panel, subject to any limitations arising from confidentiality and other relevant considerations.
3.3 Quality Assurance of Accreditation Agency

3.3.1 Administration

The management, organisation, and administration of the agency must ensure that the accreditation functions of the agency are implemented accurately and reliably.

Agencies will have developed a wide range of different practices to administer its accreditation procedures, and will usually have arrangements that are well tried and understood. Nevertheless because an agency is making decisions on the quality of programmes on behalf of the engineering profession, it is important to review its practices from time to time, and to subject them to external scrutiny. Its organisation and processes should be open and transparent to ensure the efficiency and integrity of its accreditation decisions. The agency’s administrative arrangements, procedures and rules should be fully documented and publicly available. Such arrangements should include, but not be limited to, the procedures for membership of the decision making board and other relevant committees, for making accreditation decisions, and for selecting accreditation panels. It would be expected that the agency has quality assurance procedures to evaluate its activities. Such procedures should include a report at regular intervals, typically annually, to record and review its activities, and which should be independently, preferably externally, assessed.

3.3.2 Status and Resources

The agency must be independent of outside influences and have adequate resources to undertake accreditation.

The purpose of accreditation is to ensure the standard of engineering degree programmes. Therefore the agency should be recognised, formally or otherwise, by the engineering profession as having that responsibility. The standards should have been established collectively by the profession. Furthermore, it is essential that the agency is independent of all influences or conflicts of interest that might impact on the integrity of its decisions on accreditation. In order to preserve its independence it should have access to adequate financial resources and the technical expertise necessary to implement accreditation effectively.

The value of the accreditation of programmes requires that the engineering profession recognises the agency as the organisation with the specific responsibility for ensuring the quality of engineering programmes. Such recognition can be formal and legally validated, or informal and validated by wide representation of the profession on the agency board, committees and panels.

If the standards of an agency are substantially compliant with the requirements specified in the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG), then the agency is eligible to apply to be a member of ENQA (European Association for Quality Assurance in Higher Education), and to be listed in the European Quality Assurance Register (EQAR).
APPENDICES

The following appendices are provided as a guide to assist HEIs and accreditation and quality assurance agencies when these agencies are applying for authorisation to award the EUR-ACE® label. They are not intended to be prescriptive. They are an indication of what ENAEE would expect to form the basis of both the self-assessment review of an engineering degree programme by a HEI, and of the accreditation process of the agency, if the required standards are to be achieved.
### 1. Programme Aims

#### 1.1 Educational needs of the labour market and other stakeholders

**Documentation to be provided**

Relevant industry and labour market organisations and other stakeholders consulted, and methods and schedule of consultation.

Identified educational needs of the labour market and other stakeholders.

**Questions to be considered**

Were the relevant industry and labour market organisations and other stakeholders consulted? Was the methodology and schedule of consultation adequate in order to identify their educational needs?

Have the educational needs of these stakeholders been identified in a way which facilitates the definition of the programme aims and programme outcomes, i.e. in terms of professional profiles and/or functions/roles/activities expected of the graduates and associated required competences?

#### 1.2 Programme Aims

**Documentation to be provided**

Set of Programme Aims

**Questions to be considered**

Have the programme aims been developed in terms of professional profiles of the engineering graduates and/or roles/activities students are to be prepared for, and the associated competences to be developed and obtained by the students during the learning process?

Are the programme aims consistent with the mission of the institution that the programme belongs to and the identified educational needs of the labour market?

#### 1.3 Programme outcomes

**Documentation to be provided**

Set of programme outcomes.

**Questions to be considered**

Have the programme outcomes been established in terms of what students are expected to know, understand and/or be able to demonstrate after completion of the learning process?

Are the programme outcomes consistent with the relevant national qualifications framework, if any, with the EUR-ACE® Programme Outcomes for accreditation and with the established programme aims?

### 2. Teaching and Learning Process.
### 2.1 Teaching and Learning Process

**Documentation to be made available / to be required**

- Curriculum and description of its characteristics.
- Characteristics of the modules/course units (in particular: number of ECTS credits, learning outcomes, content, typologies of teaching activities, assessment of students’ learning, pre-requisites, didactic material).
- Documentation of the suitability of the curriculum to the achievement of the programme outcomes.

**Questions to be considered**

- Does the totality of the learning outcomes of the modules accumulate to constitute the programme outcomes?
- Is the curriculum formally approved by the HEI the programme belongs to?
- Does the curriculum embed a student-centred learning and teaching approach that enables flexible learning paths and encourages students to take an active role in co-creating the learning process?

### 2.2 Assessment of students’ learning

**Documentation to be provided**

*Note: The methods and criteria of assessment of the students’ learning should be included in the characteristics of the course units/modules.*

**Questions to be considered**

- Do the assessment methods and criteria provide evidence of their capacity to check the effective achievement of the intended course unit/module learning outcomes by the students and ensure trust that the level of achievement by the students is assessed in a credible way?

### 2.3 Planning of the learning process

**Documentation to be provided**

- Calendar and timetable of didactic activities and examinations.

**Questions to be considered**

- Has the development of the learning process been planned in order to enable students to achieve the programme outcomes in the expected time?

### 2.4 Management of the learning process

**Documentation to be provided**

- Description of how the teaching and learning process and student assessment are managed including a feedback loop in relation to the quality of the learning process and the assessment of students. This should include statistical analysis and documentation used.

**Questions to be considered**

- How does the management of the learning process assure achievement of the programme aims and the programme outcomes?
- Do the results of the quality control of the assessment tests attest their adequacy and appropriateness?
- Is the achievement of the learning outcomes of course units/modules adequately assessed?

### 3. Resources
### 3.1 Teaching staff

**Documentation to be provided**
- Curricula vitae of teaching staff.
- Teaching support staff.
- Recruitment policy in the selection of the teaching staff.
- Opportunities offered to the teaching staff to improve their teaching skills and the use of new technologies.

**Questions to be considered**
- Are the teaching staff appointed according to pre-defined recruitment criteria?
- Are the teaching staff quantitatively and qualitatively adequate for the achievement of the programme outcomes by students?
- Are the teaching support staff qualitatively adequate for the achievement of the established programme outcomes by students?
- Does the programme offer the teaching staff the opportunity to improve their teaching skills and the use of new technologies?

### 3.2 Facilities and support staff

**Documentation to be provided**
- Classrooms used by the programme, with the equipment available.
- Rooms for individual study used by the students of the programme, with the equipment available.
- Laboratories/workshops used by the programme, with the equipment and technical staff available.
- Libraries used by the students of the programme, with the equipment, services and library staff available.
- Other resources and special initiatives.

**Questions to be considered**
- Are the facilities at the disposal of the programme, with the associated equipment, quantitatively and qualitatively adequate for the development of the established programme aims as designed and planned, and enable the application of the established didactic methods?
- Is there adequate technical and library staff?

### 3.3 Financial resources

**Documentation to be provided**
- Needs and availability of financial resources.

**Questions to be considered**
- Are the financial resources available to the programme adequate for the development of the learning process as designed and planned?

### 3.4 Student support services

**Documentation to be provided**
- Organization, management and activities of student support (career advice, tutoring and assistance) services, and administrative staff available.
<table>
<thead>
<tr>
<th>Questions to be considered</th>
<th>3.5 Partnerships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the programme provide student support (career advice, tutoring and assistance) services relevant to the learning process and enable students’ learning and progression easier?</td>
<td>Does the programme provide student support (career advice, tutoring and assistance) services relevant to the learning process and enable students’ learning and progression easier?</td>
</tr>
<tr>
<td>Are the administrative staff quantitatively and qualitatively adequate for the effective management of the student support services?</td>
<td>Are the administrative staff quantitatively and qualitatively adequate for the effective management of the student support services?</td>
</tr>
</tbody>
</table>

**3.5 Partnerships**

**Documentation to be provided**
- Partnerships which enable training periods outside the university.
- Partnerships which enable international study mobility periods.

**Questions to be considered**
- Are the partnerships with public and/or private bodies for training periods outside the university adequate quantitatively and qualitatively to the achievement of the programme outcomes?
- Are the partnerships with foreign universities or other HEI’s for international mobility adequate quantitatively and qualitatively to the achievement of the programme outcomes?

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**4. Student Admission, transfer, progression and graduation**

**4.1 Rules governing the students’ academic career**

**Documentation to be provided**
- Qualifications and requirements for admission to the programme and methods of assessment of their possession by the students.
- Regulations for the recognition of higher education qualifications, periods of study and prior learning.
- Criteria for the management of the students’ progression in their studies.
- Certification of students’ studies successfully completed.

**Questions to be considered**
- Does the programme provide student support (career advice, tutoring and assistance) services relevant to the learning process and enable students’ learning and progression easier?
- Are the administrative staff quantitatively and qualitatively adequate for the effective management of the student support services?

**4.2 Entrance students**

**Documentation to be provided**
- Results of the assessment of the possession of the admission requirements.
- Results of the examination performance in the first year.

**Questions to be considered**
- Do the results of the student examination performance in first year provide evidence of the programme attractiveness and the adequacy of the entrance requirements?
- Is the first year curriculum designed to motivate students towards studying engineering?

**4.3 Student assessment**

**Documentation to be provided**
- Result of the assessment of the students’ learning in each module and each year.

**Questions to be considered**
- Do the results of the monitoring of the students’ achievement of the learning outcomes provide evidence of the effectiveness of the learning process in the course units/modules?
| **4.4 Student progression** | **Documentation to be provided**  
Results of the monitoring of student progression in the different course years. Results of the monitoring of dropouts.  
Results of the monitoring of the credits acquired by the students who pass from one course year to the next one. Results of the monitoring of the duration of studies leading to graduation. | **Questions to be considered**  
Do the results of the monitoring of students’ progression in their studies provide evidence of the effectiveness of the learning process? |
| **5. Internal Quality Assurance** | **5.1 Policy and processes for the quality assurance of programmes**  
Policy for the quality assurance of programmes of the HEI.  
Organizational structure for the quality assurance of programmes and decision-making processes of the HEI. | **Questions to be considered**  
Does the HEI conform to public policy for the quality assurance of programmes?  
Has the HEI an effective management system and effective decision-making processes for the quality assurance of programmes? |
| **5.2 Management system of the programme** | **Documentation to be provided**  
Quality assurance policies and procedures relevant to the programme. | **Questions to be considered**  
Does the programme participate satisfactorily in the HEI quality assurance processes and implement relevant findings? |
| **5.3 Programme review and development** | **Documentation to be provided**  
Policies and procedures for programme review and development.  
Results of most recent programmatic review. | **Questions to be considered**  
Does the programme periodically review needs and objectives, learning process, resources, results and management system, in order to guarantee their continuing relevance and effectiveness? Does it promote the improvement of the effectiveness of the processes of programme management and of the associated results? |
| **5.4 Student feedback on the learning process** | **Documentation to be provided**  
Students’ opinion on the quality of course units/modules.  
Students’ opinion on the training periods outside the university.  
Students’ opinion on the periods of international mobility.  
Opinion of the final year students on the learning process and support services. |
<table>
<thead>
<tr>
<th>Questions to be considered</th>
<th>5.5 Engineering graduates’ placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the monitoring of student opinion adequate in relation to completeness of information gathered and response rate?</td>
<td><strong>Documentation to be provided</strong></td>
</tr>
<tr>
<td>Do the results of the monitoring of student opinion on the learning process provide evidence of the adequacy and effectiveness of the learning process and of student support services?</td>
<td>Results of the monitoring of the graduates’ job placement.</td>
</tr>
<tr>
<td>Do the results of the monitoring of student opinion on the learning process provide evidence of the adequacy and effectiveness of the learning process and of student support services?</td>
<td>Results of the monitoring of student progression to Master programmes (only for Bachelor programmes).</td>
</tr>
<tr>
<td>Do the results of the monitoring of student opinion on the learning process provide evidence of the adequacy and effectiveness of the learning process and of student support services?</td>
<td>Results of the monitoring of student progression to Doctoral studies (only for Master programmes).</td>
</tr>
<tr>
<td>Do the results of the monitoring of student opinion on the learning process provide evidence of the adequacy and effectiveness of the learning process and of student support services?</td>
<td>Results of the monitoring of employed graduates’ opinions on the education received.</td>
</tr>
<tr>
<td>Do the results of the monitoring of student opinion on the learning process provide evidence of the adequacy and effectiveness of the learning process and of student support services?</td>
<td>Results of the monitoring of employers’ opinion on the graduates’ education</td>
</tr>
<tr>
<td>Do the results of the monitoring of student opinion on the learning process provide evidence of the adequacy and effectiveness of the learning process and of student support services?</td>
<td><strong>Questions to be considered</strong></td>
</tr>
<tr>
<td>Do the results of the monitoring of the engineering graduates’ job placement and of the employed graduates’ and employers’ opinions on the graduates’ education provide evidence of the qualification's value, of the appropriateness of the programme aims and the programme outcomes to the educational needs of the labour market?</td>
<td><strong>Documentation to be provided</strong></td>
</tr>
<tr>
<td>Do the results of the monitoring of the engineering graduates’ job placement and of the employed graduates’ and employers’ opinions on the graduates’ education provide evidence of the qualification's value, of the appropriateness of the programme aims and the programme outcomes to the educational needs of the labour market?</td>
<td>Documentation in relation to the quality assurance of the programme as publicly provided.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions to be considered</th>
<th>5.6 Public availability of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the programme make publicly available full, up to date, easily accessed information, both quantitative and qualitative, on its objectives, learning process, resources, results and management system?</td>
<td><strong>Documentation to be provided</strong></td>
</tr>
<tr>
<td>Does the programme make publicly available full, up to date, easily accessed information, both quantitative and qualitative, on its objectives, learning process, resources, results and management system?</td>
<td><strong>Questions to be considered</strong></td>
</tr>
<tr>
<td>Does the programme make publicly available full, up to date, easily accessed information, both quantitative and qualitative, on its objectives, learning process, resources, results and management system?</td>
<td>Does the programme make publicly available full, up to date, easily accessed information, both quantitative and qualitative, on its objectives, learning process, resources, results and management system?</td>
</tr>
</tbody>
</table>
Appendix 2 – Guidelines on Programme Accreditation Process

1. Application

The accreditation procedure should start with the application for accreditation by the HEI. The self-assessment report should consider all the questions set out in Appendix 1, and submit relevant documentation at least one month before the visit of the accreditation team.

2. Composition of the Accreditation Panel

The accreditation process is based on principles of peer review and normally the members of the accreditation panel should be from the national jurisdiction of the HEI concerned. The accreditation panel should consist of at least three persons, preferably more, including a student. At least one member of the accreditation panel should be an academic and at least one a practising engineering professional. All members of the accreditation panel should be sufficiently trained to enable them to participate expertly in the accreditation process and their curricula vitae should be publicly available. Accreditation agencies should promote short training courses for potential members of accreditation panels.

To facilitate the dissemination of good practice in accreditation, the accreditation agency should consider including external observers from outside the jurisdiction.

From each member of the accreditation panel, a statement should be received indicating that a conflict of interest does not exist between the member and the HEI at which one or several programmes are being accredited. This statement should be received prior to any documentation being distributed.

3. Duration of Site Visit

The site visit should last at least two days, including any preliminary meetings to evaluate the documentation and the visit to the HEI.

4. Agenda for Site Visit

The site visit should include:
- preliminary meeting of the accreditation panel prior to the visit to identify what information is to be obtained during the visit;
- meeting with head of department / university;
- meeting with academic and support staff members;
- meetings with current and former students;
- meeting with employers / industry / professional engineering organisations representatives;
- visits to facilities (libraries, laboratories, etc.);
- review of project work, final examination papers and other assessed work (with regards to the standard and modes of assessment as well as to the learning achievements of the students);
- feedback to the HEI at the end of the visit.

5. Programme Evaluation

a) Good practice arising from experience would indicate that the evaluation of programmes can be classified effectively using the judgements described below.
The following three points at least, should be considered:

(i) Acceptable without reservation;
(ii) Acceptable with prescriptions/conditions;
(iii) Unacceptable.

The judgment “acceptable” should be awarded to programmes where all requirements have been fully met, even if improvements are still possible.
The judgment “acceptable with prescription” should be awarded to programmes where requirements have not been fully met, but are judged to be resolvable within a reasonable period of time (as a rule no longer than half the regular full period of accreditation).
The judgment “unacceptable” should be awarded to programmes where requirements have not been met or fully met, and are judged not to be resolvable within a reasonable period of time.

c) The members of the accreditation panel prepare an accreditation report. The accreditation report, without the recommendation, is then submitted to the HEI to check for factual errors and to submit a statement on the report. The statement of the HEI is transmitted to the members of the accreditation panel for review of the accreditation report and the finalisation of the recommendation concerning the accreditation decision.

6. Final Recommendation

In accordance with Section 5 above the following final recommendations should be used. It is recognised that individual agencies may add other types of recommendation, for example, where partial accreditation will result in the cancelation of a degree programme.

6.1 “Accreditation without reservation”, with possible specification of recommendations for the improvement of the programme, should be awarded to programmes for which all the requirements are judged to be acceptable. In this case accreditation should be awarded for the full period of accreditation (which should not exceed six years).

6.2 “Accreditation with prescriptions/conditions” and the time in which prescriptions/conditions must be carried out, should be awarded if one or several requirements are judged to be acceptable but with prescriptions/conditions. In such cases accreditation must be awarded for a shorter period of time after which compliance with the prescriptions/conditions must be verified.

6.3 The judgment “unacceptable” should be awarded to programmes where requirements have not been met or fully met, and are judged not to be resolvable within a reasonable period of time. In this case the accreditation panel can recommend that accreditation be withheld.
SUSTAINABILITY IN ENGINEERING EDUCATION AND THE PROPOSED ABET REQUIREMENTS

Dr. J.P. Mohsen, Vice Chair WFEO-CEIE, Professor and Chair at University of Louisville, KY - USA

Abstract

Sustainability principles have long been considered by design engineers in terms of allocation of resources and serviceability of systems. However, it is only rather recently that sustainability related principles have become part of the course offerings in engineering educational programs. The most recent modifications to ABET students learning outcomes require each civil engineering program seeking accreditation to show evidence that the students graduating from the program have an understanding of sustainability principles and provide evidence that they indeed can incorporate them in design. The details of the impending requirements and proposed methods with which these new requirements can be met will be discussed and shared.

Examples of how various engineering programs currently meet these criteria will be given. Additionally, the available resources developed to assist in preparation for the proposed requirements will be discussed.
ETHICS AND PROFESSIONAL CONDUCTS-KEY PREREQUISITES FOR SUSTAINABILITY

Author: Kamel Ayadi, Chairman of Global Infrastructure Anti-corruption Centre for MENA Region Past President of WFEO, and founding chairman of its standing committee on Anti-corruption (2007-2013)

Abstract:
In this paper the author will analyze the other ways to achieve sustainability, through the focus on ethics and professional conducts. This paper will demonstrate how endemic corruption retards economic growth, hinders social stability and damages environment and therefore undermines the main pillars of sustainability. Corruption and sustainability cannot coexist together. A Number of empirical studies have demonstrated the existence of significant relationship between corruption and environment sustainability. These studies are mainly based on reconciliation between two aggregated indexes, the Corruption Perception Index (CPI) promoted by TI and the Environment Sustainability Index (ESI) of the WEF. CPI is based on perception of corruption, mainly among business people. CPI offer a global ranking. ESI is an assessment of a number of variables that influence the environmental health of economies. There are similarities and parallel in the assessment of the environment situation and the corruption within a country. Significant Correlation exists between both factors:
1/ Both Corruption and environment are transnational
2/ Both CPI and ESI are positively related to GDP per capita
3/ There is a direct effect between corruption and sustainable environment, in the sense that corruption interferes with law enforcement, monitoring, rule of law.
ABSTRACT
Engineering ethics and sustainability are important components of engineering education and professional practice. Both are included in the International Engineering Agreements Graduate Attributes and Competencies that are the basis for accreditation under the Washington Accord. The purpose of this paper is to review where we are in infusing sustainability ethics into engineering education focusing on Washington Accord signatory countries and to briefly describe an expanded U.S. National Academy of Engineering Online Ethics Center that should be a valuable resource for programs infusing ethics and sustainability into engineering curricula.

KEY WORDS: accreditation, ethics, sustainability

1. Introduction
The purpose of this paper is to review ethics and sustainability in engineering education from a top down global to local perspective. The focus is on the World Federation of Engineering Organizations (WFEO) and the International Engineering Alliance (IEA). The IEA and WFEO recently signed a MOU and are currently developing an agreement to work together on engineering accreditation. The U.S. National Academy of Engineering (NAE) is expanding its Online Ethics Center (OEC) and with increased global coverage should be a valuable resource for teaching and learning the ethics of sustainability in engineering practice. Codes of ethics have been important drivers of sustainability and sustainable development in engineering and the ethical aspects of sustainability and sustainable development are receiving increasing attention by academics and practitioners.

2. Knowledge Expectation
Ethics and sustainability are prominent in the UNESCO report on Engineering; see for examples articles by Bugliarello, Ridley, Didier and others. Byrne et al reviewed sustainability expectations for engineering graduates in the context of codes of ethics for most of the Washington Accord signatories. This paper builds on the most recent Byrne paper.

2.1 WFEO Ethics and Sustainability
Sustainability is explicitly included in the WFEO Model Code of Ethics under Canon 4 protection of the natural and built environment. The WFEO Model Code of Practice for Sustainable Development and Environmental Stewardship provides a comprehensive approach to sustainability in engineering practice. The WFEO is working with the IEA to develop a MOA to work together to mentor countries wanting to join the IEA.
2.2 IEA Ethics and Sustainability

The IEA Graduate Attributes and Competences are the foundation for accreditation of engineering programs under the Washington Accord (WA). To be recognized under the Washington Accord, the accreditation process must ensure that the attributes of graduates of a signatory’s programs are substantially equivalent to the IEA graduate attribute exemplars. Graduates are expected to be able to demonstrate both knowledge and competencies.

*WK7: Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability*

According to the IEA Glossary of Terms, comprehension is synonymous with understanding.² The American Society of Civil Engineers Body of Knowledge (2nd edition) uses Bloom’s taxonomy with comprehension being level 2 and application level 3.⁹ Engineering graduates from all programs accredited under the IEA Washington Accord can be expected to have an understanding of both ethics and sustainability in the context of engineering practice in their field.

Table A1 summarizes some of the phrases in accreditation criteria that reflect this requirement. Most of the statements use understanding for comprehension.

At the Professional Level, practicing engineers are expected to

*WA7: Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts. (WK7)*

This is a level 4 or 5 Bloom outcome building on the knowledge base from formal education. The key word here is complex; an appreciation of complexity will only be acquired with practice. Evaluate is reserved for level 6 in the ASCE BOK2.

*WA8: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. (WK7)*

This attribute can be interpreted as a level three. The proposed program criteria for ABET accredited civil engineering programs would require level three for both sustainability and ethics; graduates must be prepared to include principles of sustainability in design and to analyze issues in professional ethics.¹⁰ However, program criteria are curriculum requirements not outcomes so the content must be there but there is no expected assessment of student understanding or comprehension.

At this point, the expectation for most WA engineering graduates is level 2 - comprehension - but there may be other requirements for specific fields similar to the ASCE program requirements.

3. Educational Approaches

In this paper, we are particularly interested in how ethics and sustainability are being integrated in engineering education. Klbert and coauthors do this in a book that could be used as a textbook or reference for practitioners.¹¹ It could also be a text for a full course in sustainability ethics. Both sustainability and ethics could be included as modules in courses throughout a program from an introductory course to a culminating design courses and there are many examples of this being done. Mulling et al. described their experience with a sustainable design project in a first-year course. Reported student feedback indicated that ethics and sustainable design were effectively combined.¹² Dawish et al
describe their efforts to integrate sustainability and environmental ethics in a construction engineering program. Robinson and Sutterer describe their approach to integrating sustainability into a civil engineering program. They start with a discussion of sustainable development in the ASCE Code of Ethics in an introduction to civil engineering course. Veeraghanta and Frost describe their experience integrating sustainability and ethics in a first year course at the University of Utah. There is no shortage of resources for teaching sustainability and ethics. Engineering ethics case histories developed by the UK CETL are available on their web site and include sustainable development. The CETL case study on sustainability ethics deals with heritage sites and is on a Leeds University site. Ashley discusses the role of the civil engineer in: engineering ethics and major projects in the context of the sustainability challenge from Prince Charles. The ICE has an Ethics Toolkit for practitioners and academics.

In Australia, engineering ethics and sustainable development have been addressed in engineering education for more than 20 years, see for example the 1995 paper by Beder. The work of Byrne and his colleagues in Ireland has already been mentioned. Byrne describes his experience at University College Cork with ethics and sustainability in a first year introductory module in chemical engineering.

Reid in a doctoral thesis provides a comprehensive review of the evolution of ethics and sustainability engineering education in New Zealand engineering education as background for designing an undergraduate module at the University of Auckland.

Masud et al discuss generally what is needed to introduce sustainability into engineering education in Malaysia.

The challenge may not be so much resources but how to teach ethics and to a lesser extent sustainability. Ethics and to some extent sustainability require that instructors not rely exclusively on lectures - still the predominant mode of instruction in engineering.

4. The U.S. National Academy of Engineering Online Ethics Center

The NAE Online Ethics Center recently (2014) began an expansion project funded by the U.S. National Science Foundation (NSF) to become the “go to” place for engineering ethics. The coverage goes beyond engineering ethics but engineering ethics is already a strong component of the OEC and this component will be strengthened particular the international coverage with the expansion. The goal is to incorporate a more comprehensive international component in the center resources. This effort is seeking to identify a cohort of international collaborators to contribute to the center.

During fall 2014, the OEC surveyed faculty to determine what is most important in teaching ethics to science and engineering students. There was a strong response from engineering faculty including members of the American Society for Engineering Education (ASEE) Engineering Ethics Division. The Engineering Ethics Division is one of the largest Divisions in ASEE with over 1100 members. For faculty members that have taught ethics and those that have not, the most important resource for teaching ethics is case histories. A number of the case histories on the OEC are detailed including instructor notes and can be described as off the shelf and ready to use. More are needed and there are relatively few that deal with sustainability.
Summary

Sustainability and sustainable development are prominent in the WFEO Model Code of Ethics and the codes of ethics of many of the IEA members. Graduates of programs recognized under the Washington Accord are expected to have at least an understanding of professional ethics and sustainability in the context of engineering practice in their field. Although there is no lack of resources for teaching and learning sustainability ethics, these resources, with some exceptions, are not easily accessible for faculty needing a module for a particular course or topics. The U.S. National Academy Online Ethics Center aspires to be the go to place for engineering ethics and if successful could greatly improve accessibility and usability. The WFEO Committee on Education in Engineering could help by assisting the OEC in reaching out broadly to WFEO members to share resources on teaching and learning sustainability ethics and to solicit a broad range of case histories that illustrate engineering practice globally.

APPENDIX

Table A1 Comparison of Knowledge Outcomes IEA Signatories

<table>
<thead>
<tr>
<th>IEA</th>
<th>WK7: Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia <a href="#">Engineers Australia</a></td>
<td>Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline.</td>
</tr>
<tr>
<td>Canada <a href="#">Engineers Canada</a></td>
<td>Impact of engineering on society and the environment: An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interaction</td>
</tr>
<tr>
<td>China Taipei <a href="#">IEET</a></td>
<td>understanding of professional ethics and social responsibility</td>
</tr>
<tr>
<td>Hong Kong <a href="#">The Hong Kong Institute of Engineers</a></td>
<td>a knowledge of the impact of engineering technology solutions in a societal and global context with particular reference to the environment and sustainable development</td>
</tr>
<tr>
<td>India <a href="#">NBA</a></td>
<td>Understand the impact of the professional engineering solutions in societal and</td>
</tr>
</tbody>
</table>
environmental contexts, and demonstrate the knowledge of need for sustainable development.

<table>
<thead>
<tr>
<th>Country</th>
<th>Organization</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>Engineers Ireland</td>
<td>Understanding of the need for high ethical standards in the practice of engineering, including the responsibilities of the engineering profession towards people and the environment.</td>
</tr>
<tr>
<td>Japan JABEE</td>
<td></td>
<td>Understanding of the effects and impact of engineering on society and nature, and of engineers’ social responsibility (engineering ethics).</td>
</tr>
<tr>
<td>Korea ABEEK</td>
<td></td>
<td>a broad understanding of the impact of engineering solutions in economic, environmental, and societal context</td>
</tr>
<tr>
<td>Malaysia</td>
<td></td>
<td>Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development; Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice;</td>
</tr>
<tr>
<td>New Zealand Engineers New Zealand</td>
<td></td>
<td>Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability</td>
</tr>
<tr>
<td>Russia</td>
<td></td>
<td>Studies in humanities and socioeconomic sciences must provide graduates with the appropriate knowledge in social, economic, legal issues and professional ethics, foster commitment for sustainable development, health and safety issues.</td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td>Demonstrate critical awareness of the sustainability and impact of engineering activity on the social, industrial and physical environment. Demonstrate critical awareness of the need to act professionally and ethically and to exercise judgment and take responsibility within own limits of competence.</td>
</tr>
<tr>
<td>Singapore</td>
<td></td>
<td>understand the impact of engineering solutions in a societal context and to be able to respond effectively to the needs for sustainable</td>
</tr>
<tr>
<td>Country</td>
<td>Body</td>
<td>Text</td>
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</tr>
<tr>
<td>Sri Lanka</td>
<td></td>
<td>It must be ensured that the students are made aware of the role and responsibilities of the professional engineer in society by exposing them to ethics, equity, public and worker safety, and concepts of sustainable development.</td>
</tr>
<tr>
<td>UK - JAB</td>
<td></td>
<td>The engineering subjects should be taught in the context of design (see Annex B – Design in Degree Programmes), with appropriate account of issues of sustainability (see Annex C – Sustainable Development in Degree Programmes) and construction, so that each forms a continuous and integrating thread running through the programme. Programmes should expose students to a thorough mixture of analysis, synthesis and conceptual design, and – through contact with other issues – they should be stretched to ensure development of their capabilities to operate at a high intellectual level, including the exercise of judgement.</td>
</tr>
<tr>
<td>USA ABET</td>
<td></td>
<td>an understanding of professional and ethical responsibility</td>
</tr>
</tbody>
</table>

**References**


OEC Request for Faculty Feedback on Teaching Ethics in Science and Engineering,
WAYS OF INNOVATING IN EDUCATION FOR SUSTAINABLE DESIGN PRINCIPLES

Osama Omar¹, Marwan Halabi²

¹ Assistant Professor, Faculty of Architectural Engineering, Beirut Arab University
² Assistant Professor, Faculty of Architectural Engineering, Beirut Arab University

Abstract:

In the field of contemporary architectural thinking, students are usually taking the terminology “Sustainable Design” as a theme in their projects. However, due to their lack of awareness concerning the principles behind it, the expression ends up being a baseless word that affects directly their project evaluation. In order to avoid the misuse of such a social impacting ideology, students must be conscious of several principles and guidelines for reaching sustainable design ideas. A definition of a series of criteria of sustainable design must be introduced to students as parameters for their design.

This paper discusses some ways to provide awareness of sustainable design principles by emphasizing the basic approach considerations. They are mainly based on building awareness about sustainable education for a later survey to support the design principle. By such action, a definition of a series of parameters can be clearly defined during the design process, and later the data can be inserted in simulation tools to evaluate environmental performance of the design according to sustainable principles. In the end, a series of measurements will be shown as criteria to evaluate projects to support the designers’ decision in addition to increasing awareness when conceiving sustainable design.

Keywords:

Sustainable, Architecture, Design, Education, Innovation

1. Introduction:

In 1987, the World Commission on Environment and Development Report for Our Common Future (also known as the Brundtland Report) provided an early, and still much-used, authoritative definition of what constitutes sustainable development. According to the Brundtland Report, “Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.” Sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and the institutional changes are made consistent with future as well as present needs (WCED 1990: 8).
This definition of sustainable development contains two crucial points. First, it accepts the concept of ‘needs’, in particular those basic needs of the world’s poor, such as food, clothing and shelter essential for human life, but also other ‘needs’ to allow a reasonably comfortable way of life. Second, it accepts the concept of ‘making consistent’ the resource demands of technology and social organizations with the environment’s ability to meet present and future needs. This includes both local and global concerns and has a political dimension, embracing issues of resource control and the inequities that exist between developed and developing nations (Terry [1]). Also, Sustainable Design can be defined as a method of designing and constructing a building that minimizes burdens on natural resources and environment.

2. Sustainable Design Approaches and Principles:

Sustainable Design has three main approaches defined as environmental, social, and economic. The environmental approach is divided into five principles:

1- Sustainable Site Planning.
2- Safeguarding Water and Water Efficiency.
3- Energy Efficiency and Renewable Energy.
4- Conservation of Material and Resources.
5- Indoor Environmental Quality (Giles [2])

Figures 1 and 2: Overlapping spheres of economic, environmental, and social sustainability. In the figure on the left, the action represented by the darkest area does not show significant consideration of all spheres. In the figure on the right, the action taken has met the needs of much of each sphere, representing a more sustainable choice (Johanna [3]).
3. Problem:

In the academic field of architecture, many students, especially the ones in the first years have a lack of awareness of the principles behind the terminology “Sustainable Design”. Once in the advanced levels, they already misuse the terminology with greater inconsistency. One of the reasons behind this is the fact that information acquired in elective courses is not always applied in design projects, thus showing that there is a certain lack of connectivity between what is taken in theoretical courses and what should be applied in practical ones. Also, many students usually do not go deep in sustainable design approaches when reading basic information in order to have a good background in the theory so later apply such parameters in the project design process.

Another weak point detected is the lack of awareness from students concerning the importance of sustainable design as a solution to environmental problems. Several countries try to solve this problem by creating systems like Leadership in Energy and Environmental Design (LEED) Rating System in the USA or Rating System in UK (BREAB) to make sure that all new buildings are constructed in a sustainable way and to help protect the environment.

4. Why is Sustainable Design Important?

From the many issues to taken into consideration when elaborating sustainability values, most of them are based on the fact that:

- Buildings consume more than two-thirds of the total electricity consumed annually.
- No matter what the source is, using energy carries a burden. This burden can be from mining and extraction of fossil fuels, air pollutants released in the burning of these fuels, or the production and disposal of nuclear materials.
• Saving energy minimizes a wide range of environmental impacts and potential health risks.
• Sometimes the price is political. Our need for energy resources has caused political turmoil, and ensuring continued access to these resources will long continue to carry strong economic consequences.
• Sustainable buildings have benefits far beyond reducing national dependence on fossil fuels. Occupants of sustainable buildings are more productive, more creative, and in general, healthier.

5. Methodology:

After all of that, from expertise as teaching architecture in design studios and based on scientific methods, there are several ways to raise student awareness such as:

5.1. Proper Flow of Information among Courses

Since all sources of information are important in the academic field, it is crucial to link all elective courses given in a faculty, be them theoretical or practical, to design studio courses. By making each assignment in relevance with design projects in design studio like Sustainable, Environment, or Indoor environmental controls courses, themes can be directly integrated in the design process as part of practical applications in architecture.

5.2. Rating System Application

It is important to expose students to real problems directly affecting design and building. Environmental issues are a good source that exposes great design challenges and at the same provides many parameters to be taken into consideration as part of solutions. Students should get used to designing their projects during design studio courses by taking into consideration sustainable systems. References like LEED, BREAM or any other reliable environmental system is important to be applied in order to make sure that they understand international Rating system well enough to engage sustainable features in their design projects.

5.3. Design Contests

Being exposed to conditions where competition among designers is needed is a good source to test students to apply advanced knowledge in order to motivate them to first apply information acquired in the academic field and show them the impact that it can cause in the real world can be considered a good learning strategy. Such an environment can be found in design competitions. For instance, when dealing with existing built conditions, students are exposed to a real situation where they have to first understand the building itself, the surrounding context affecting the building, and the natural and artificial conditions affecting the building.
In the case of the last student competition held in Lebanon regarding the rehabilitation of an iconic office building located in Hamra, the conditions affecting the building and its surroundings were analyzed by students in very similar ways, even though the outcomes were of a great variety. Having studied all the architectural aspects related to the building, many students realized that the potential for a winning project was in the plaza level located in front of the building and which could be related to the Hamra Street in a stronger way. In addition, they would be tackling a very important issue concerning environmental aspects in the urban context which is related to open areas in the city. Therefore the approach was to maintain the building intact, as they figured out that the building was of a historical value, and the intervention would affect the context and its relation to the building. In the end, 71 individual proposals were presented and with the help of professors within the group of students requested to participate in the competition, 20 projects were selected and recommendations were made in order to improve their proposals.

The experiment was of great success since by the end of the design stage, 12 proposals were presented in the competition. Out of 120 registered participants from all universities of Lebanon, 50 were selected in the first stage. Out of the 50 proposals, all of the 12 proposals from the original group were included in the selection. In the later stage, 7 proposals were selected as part of the top 10 best projects. To complete the great success of the experiment realized, students from the group requested to participate in the competition received 3 of the four prizes set at the competition, including the winning prize.

Figure 4: Winner project proposal of the building rehabilitation competition where the idea was to stress on the value of the plaza for contextual and environmental reasons
5.4. Information Technology Use

The use of simulation software in the initial stages of the design process to reduce the energy consumption of new buildings and use of renewable energy can be easily studied thanks to advances in information technology. It is more than crucial for students to be aware of environmental aspects during the design process. In this sense, technology has been providing a wide series of tools in order for students and professionals to perform a wide range of tests during the design process. However, this awareness should be exposed in the academic level in order to have the new trends related to environmental issues an important and crucial parameter in the design process. Even the prototype softwares should be used by students in order to first become familiar with them and second to forecast their future needs so that progress is constantly achieved.

In the field of 3D design, besides experiencing the basic architectural aspects of the project such as proportion, aesthetics, and functionality, students can add to their criteria issues such as material performance, thermal effects on building, shade and shadow quality, and ventilation, among others. Thanks to systems such as parametric design, many of the studies can be directly linked to the design criteria in such a way that changing for instance a size of a window can be defined according to the amount of light needed to enter the room containing it. Therefore, all design parameters can be automated in such a way that environmental parameters can be easily integrated in the design process to the desired designer’s point, up to the level that they can be the decision makers of many of the issues within the design.

Such environmental parameters should be transmitted to students as a part of the design process rather than the design concept. It is quite common these days to hear from students that their conceptual idea is to do something environmental friendly. However, in order to do so there must be a clear set of criteria and after that a clear approach and design strategy where environmental parameters would then fit and play an important role in the design process.

5.5. Design, Environmental Analysis and Fabrication Labs

There is no doubt that technology is directly influencing our lives today. Not only does it simplify and accelerate our way of life, but it also plays a key part in the contemporary and future development of professional fields. For instance, in the field of digital architectural design, machines are allowing us to do almost everything we want, and arguably, any designer can draw anything and send it to a 3d printer right next to his laptop. This is positively affecting creativity and allowing us to appreciate the physical result of the design by using a tool which is becoming hugely popular. The same goes for CNC machines and robots, which if given the right task, can do almost anything. This is contaminating many professional fields related to design including architecture. For instance, in the process of design and production of models or prototypes, the digital media lab and digital fabrication lab are spaces that help students and professionals to explore innovative design ideas and processes of construction. With the help of advanced softwares, design can be easily visualized and
analyzed, thus providing greater possibility to innovate for both aesthetic and sustainable solutions. And with the help of Computer Aided Manufacturing systems (CAM) such as 3D printers or computer numerically controlled machines, components of different forms, scales, and materials can be fabricated. Therefore technology can be crucial in many stages of the architectural design and construction, be it in the conceptual, design, or execution steps.

Building special labs in the faculty to support the environmental and simulation studies is a step being applied at many educational institutions. In this sense, the Faculty of Architectural Engineering at Beirut Arab University is actually providing students with an environmental, a 3D modeling, and a fabrication lab to support all types of student research for further application during the design process.

6. Conclusion:

In the architectural academic field, there is a great urge to provide students with consciousness related to sustainable issues. Misunderstanding and misusing principles can lead to weak design ideas, while misleading approaches can lead to weak project results. The environmental field is a trend that should be taken into consideration with great care since it is shaping not only contemporary buildings, but it is also defining the quality of life that should be prepared for the generations to come. And in order to create effective results, students must be familiarized with principles and tools that help in the creation of sustainable buildings.

Design tools, materials and machines can be the main workforce of the process. However, without a solid set of criteria related to sustainability, it is impossible to reach maximum performance in buildings. Technology, information and solid criteria should go along in parallel during all the stages of architectural design and construction. But in order to reach success with the system in a professional level, such methodology should be socially spread, and in order to do so, the first step is to aware students and expose them to ideas and principles related to the field so that they become responsive, and later develop systems in an established and well organized ways with the intention of maximizing building performance.
References:


[3] Johanna Sands, *Sustainable Library Design*, This material has been created by Johanna Sands, AIA and provided through the Libris Design Project, supported by the U.S. Institute of Museum and Library Services under the provisions of the Library Services and Technology Act, administered in California by the State Librarian.
Sustainability and Engineers: a perspective to future generation and society

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Abstract

During the past decades, societies have evolved tremendously in terms of lifestyles, needs, exploitation of resources, practices without limitations while at the same there are people on the planet who are missing the basic necessities to live with their dignities. These trends cannot be sustained indefinitely without depleting earth resources, placing at risk the life of future generations, polluting our environment and harming ourselves. Therefore, another way of thinking is required to allow our lives to be sustained. Consequently, all concerned parties (universities, industries, companies, societies, governments, etc...) should approach the problem and cooperate effectively in order to have sustainable societies. In this work, the issue is addressed mainly from the university perspective. That is, universities, particularly Engineering Faculties, should revisit their curricula in order to address the challenges that are faced when the issue of sustainability is incorporated. In other words, students should learn several crucial and vital principles to attain sustainability and some of these principles are introduced in this paper such as understanding the problem and its impacts, critical thinking, ability to make sound decisions, communication with colleagues who are knowledgeable about the issue at different levels (such as environmental, economical, societal, technological).

1. Introduction

The issue of sustainable engineering was first addressed by the world commission of the United Nations on environment and development in its report during its plenary meeting that was held in December 1987 [1]. In that report, the term sustainable development is defined as "a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Also, it identifies the environment, the economy and the society as the three levels which are addressed by a sustainable approach. Others researchers have provided a similar definition which is defined as being a process that can lead to a balance between the environment issue, the social issue and the cultural issue [2]. This definition entails the fact that a compromise should be achieved between them. Consequently, the design of a system, a component or a process should not favor one issue over another.

The issue of sustainability and sustainable development have been gaining a big momentum over the past years. The universities are modifying, particularly, their engineering programs in order to include this component and to provide the needed skills and expertise which engineering students should acquire during the span of their university years. In this context, sustainability is an ABET (Accreditation Board for Engineering Technology) student outcome that engineering students should possess at the time of their graduations. It is clearly stated that the student
should have "an ability to design a system, component, or process to meet the desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturing and sustainability" [3]. Thus, it becomes clear that the activities and the actions that are taken by engineers to fulfill a set of specifications embed certain interdependence between the various factors.

The planet earth is not just to fulfill our needs and support our way of life. It was there in the past and it should remain for future generations. Humans currently take advantage of its vast resources (energy, water, sea, air, vegetation, animals, plants…). Humans are in great need of fresh air to breath. Therefore, they should not pollute the clean air by various damaging emissions that will result from cars, factories, electrical generation plants, motors etc..... For example, it is needless to say that currently the generation of electricity is mostly based on oil that is extracted from underneath i.e. under the land and the sea. Thus, a particular neighborhood will be polluted with particles that are hazardous to the life of the inhabitants by a source that is not a renewable form of energy. Besides, the source could be depleted and will not exist for future generations. The hazardous emission is not limited to a particular region i.e. a border does stop the movement of air from one region to another or from one country to another. Also, emitted particles will return to earth as acid rain that can damage greatly the forests and all types of plants and vegetations. Subsequently, it may reach the wells underneath (particularly, drinking water) and will be dropped over the seas and its richness might be affected. Several issues are at stake from the point of view of sustainability. First, if the generation of electricity is achieved using a source of renewable energy such as the sun, the electricity is provided in a sustainable manner. The energy is provided without any pollution and consequently without any health hazard. Also, the environment will benefit from such approach and will be preserved to future generations. Besides, the approach entails a moral and an ethical issue to (at least) human beings i.e. health and the life's quality of the inhabitants. Therefore, this will stress the importance to modify the current laws and develop a new legal platform to encourage the use of such renewable energy. This will improve the economical status of the inhabitants, the region and the country on the long run because the electricity is generated without spending money on the purchase of oils. Needless to say, that the society (its inhabitants) by taking such sound decisions, will ripe great benefits for themselves and their children (health, economic,..). Also, this will encourage companies to develop such systems and to extend their use to other applications. This simple example highlights the fragility of our planet and its ecosystem, how all the various issues are interconnected and the importance to fulfill the needs of the current societies without compromising the needs of future generations. This also emphasizes the big challenges that are facing engineers in practicing sustainability.
2. Approach

The sustainable development, particularly in the engineering field, is mainly characterized by the activities and actions that are taken by engineers. However, this does not mean that the companies, industries or the people requesting the product are not responsible at all. Unlike the university, the industry is in the business to make profits which may lead to overcome the objectives of producing a sustainable product, design, project or process for the benefits of the society. Therefore, it should be highlighted that sustainable development is not mainly the responsibility only of engineers. The responsibility should cover all interested groups and societies.

In this context, the university should play its valuable role in order to prepare the new engineers to design systems (simple, complex…) according to given specifications requested by customers, employers and stakeholders without damaging the environment, depleting the natural resources and putting at risks the inhabitants. Even though, the objective is to satisfy the needs of the current societies, the student should be equipped with skills and abilities to provide a sustainable solution for future generations. They should have the ability to analyze the system and understand its economic impact, environment impact, cost impact, the risks involved, the long-term effect, the short term effect, the ability to minimize all negative effects and to maximize the benefits to the environment and to the societies.

2.1 Problem Understanding and Impacts

A vital step to provide a solution to a particular engineering problem (or any problem in a particular field and discipline) is to understand "very well" what is needed to be accomplished from all perspectives. That may lead to a solution in which certain activities, actions and/or tasks are implemented. However, the most important is to associate with the recommended decisions their effects and impacts (positive as well negative) on the societies at different levels (such as the health of the inhabitants, economical and so on) and the environment. Consequently, this understanding will help further the "designer" or the engineer to perform further improvement in order to minimize the negative effects and to maximize the positive effects under certain constraints which can be technological, social, etc... Besides, the engineer should look beyond the current days and provide a solution that is sustainable in the future. Furthermore, his vision should not be limited to his society. It should be extended to all societies around the globe. For example, assume that a product is manufactured and is satisfactory according to the rules and regulations of today. The product consists of a certain number of components which may deteriorate over time. Consequently, the environment and the health of people might be affected. Therefore, the dilemma becomes the following: can such product be manufactured even though the quality of inhabitants' lives will be at risk? Is it wise to design a system and/or to perform actions or activities that could lead to unsustainable development at the local, regional and/or global levels? Consequently, is it an objective and good practices to place more pressure on various depleted resources in order to create more environmental problems, to introduce more social problems, to induce more negative effects and to put at risk future generations?
Thus, this aspect is of great interest and value to universities, especially one of its objectives is the preparation of engineering students to be easily employed and to have successful professional lives. Besides, sustainability is an outcome required by accreditation agencies and professional societies. In his context, ABET requires sustainability for the accreditation of an engineering program i.e. “the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context (outcome (h))” [3].

2.2. Critical Thinking

The university should equip the future engineers with the ability of critical thinking. It is among one of vital characteristics that help students to have a bright and successful carriers. Even it should be acquired before a student reaches the university i.e. during his high school years. In other words, engineers (among other capabilities) should be resourceful, innovated and have the ability to create and devise new solutions and new approaches to address the problem at hand. There is no unique solution to such problem in which sustainability is incorporated. The problem is not simple and is usually complex due to the interconnectivity between the various issue i.e. economical, health, technological, social, design, conception, environmental etc.... Students should not re-iterate what already exists i.e. provide an existing solution. Thus, this will emphasize the fact that the university should prepare students with the ability of problem solving, critical thinking and leadership. Besides, it is not enough for engineers to provide an acceptable solution and to satisfy all the involved parties. That is, the technology, the research, the knowledge and the information are evolving and are changing from one day to another at a fast pace. This change may lead tomorrow to a better solution. Also, engineers cannot predict the future performance of the selected solutions. Therefore, their design should be flexible enough to incorporate such changes and to embed easily the modifications into the recommended solutions. Needless to say, that the current solutions are provided based on the current state-of art technology, knowledge, information, tools, skills, expertise and resources which might be different in the days to come.

2.3 Compromise

As stated earlier, the problem is usually complex and the solution might not be at all trivial. To achieve sustainable development, several issues should be addressed simultaneously i.e. technologically, economically, environmentally, socially, availability of knowledge. Consequently, several solutions that fulfill the given specifications should be developed and presented and each solution is a compromise among all the stated issues. Then, the most appropriate solution will be selected. In other words, the developed solution should be balanced among these various issues. For example, can an engineer design a system such that all the various issues can be achieved with a 100 percent of satisfaction? If not, a compromise should be attained and consequently a balanced solution will be more appropriate. This factor can be elaborated as follows: if the current state of technology does not allow the development of a
system (or a device) that does not purify water from all possible contaminations, does it mean that such system which purifies the maximum possible contaminations should not be devised even though the water is drinkable without any hazardous effects? If it is too expensive to be commercially available and consequently, cannot be afforded by the inhabitants by all inhabitants (cost), does it signify that the engineer should not build such filter so that it will available to municipalities? From these couple questions, it becomes clear that a compromise is in accordance. It should be highlighted that the solution should lead to certain gains in all aspects i.e. social environment, economic, heath, future, etc....The emphasis on the use of renewable resources is another example.

2.4 Team Work & Communication

Sustainable development requires that the involved parties have the abilities to take a sound and well-thought decisions from the various alternative solutions which are devised. As already stated, this will emphasize the fact that the problem should be well understood and its impacts/effects (Pros and Cons) on the various entities (such as societies, the environment and the economy) should be well defined so that the appropriate approaches that can yield a balanced and acceptable solutions are developed. Also, the legal framework in the country (if the problem is local) or in the countries (if the problem is regional or international) must be addressed i.e. the manufacturer of a particular product should be aware of the local laws or foreign laws governing the manufacturing and selling of such product locally, regionally or internationally. Therefore, a good and practical solution requires the effective involvement of the various actors in making sound decisions and choosing a solution that is sustainable i.e. the importance of the work in a team [4]. That is, a group of professionals (engineers, stakeholders, developer, designer, business marketing, system design, programmer, technical ...) should be created and should bring all their skills, knowledge and information to produce a sustainable product or process. Furthermore, each member of the group should be actively (not passively) participating in achieving the intended objective. Therefore, all members should discuss the given problem from different views and perspectives to identify the appropriate tools, approaches, knowledge and skills that are required to develop the sustainable solution.

The team consists of members and professionals from different disciplines and fields highlights the added value of communication. Therefore, the members are not all engineers and consequently, it is not anymore enough to speak the same "technological language". They should have the ability to “listen” to each other and be receptive to the various point of views. That is, the communication is much more demanding than discussing an issue technically with a professional having the same background. Thus, the university should prepare engineers to acquire such skills namely; communication and team work, and to possess the ability to work in Multi-disciplinary settings. Besides, the team work and communication skills will lead to a better exchange of information and a better understanding of the interconnections among the various factors (such as, the economy, the technology, the environment, the society..) which are embedded in the design of a sustainable product or process to fulfill the required needs. Finally,
it is needless to state that these skills are required by accreditation agencies and professional societies i.e. for example, ABET requires the student to acquire "an ability to communicate effectively (outcome (g))" and "an ability to function on Multi-disciplinary team (outcome (d))"
[3].

3. Conclusion

Today, sustainability and sustainable development are becoming a vital issue to be addressed by universities and to equip engineering students with the corresponding skills. It is increasingly becoming of great and valuable importance at the local, regional, and international levels. The sustainability requires the effective involvement and the active participation of all actors: engineers, universities, industries, governments, people and societies at large. The technical skills, tools and expertise which engineering students acquire are not enough to fulfill the needs of current societies and future generations. They should take into consideration other aspects such as environmental and social issues in their design, professional activities and actions. Thus, they should understand the problem under consideration and the corresponding positive and negative impacts in order to reach a compromised solution that will satisfy the current needs and keep the possibility for improvement or modifications in the coming future. They should be equipped with the knowledge and abilities to weight the various alternative solutions and to select the best decisions that minimize the risks to future generations.

References


SUSTAINABLE DEVELOPMENT WITHIN SUBURBS AS A MODEL FOR MANAGING URBAN GROWTH: A CASE STUDY FROM Palestine

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Abstract

Urbanization is accelerating globally; in developing countries it exceeds 60%, impacting urban centers and surrounding natural resources. Recently, Ramallah a prominent Palestinian city has been considered as a central hub in the West Bank. It is known as the main center for commercial, educational, and cultural activities as well as the center for all political activities. Consequently, demands for residential and commercial projects have been increasing enormously. Scattered development is taking place within city periphery outside city growth boundary regardless landcover and land use. The city attracts people from surrounding villages and rural areas searching for services and work, while these villages lack the proper services and in bad need for development and upgrading.

A challenge of how to protect and manage agricultural lands is the core of this study, taking into consideration, the protection of the valuable agricultural land in the periphery as a source for food. The study aims at formulating a conceptual framework on how to manage agricultural land and high quality lands as a means to sustainable development within the scope of urban development.

Key words: Palestine, suburban development, GIS, urban planning, landscape assessment

1- Introduction

Urbanization has been accelerating around the world for the past few decades. Statistics show that more than half of the world’s 6.6 billion people live in urban areas, crowded into 3 percent of the earth’s land area [1]. The proportion of the world’s population living in urban areas, which was less than 5 percent in 1800 increased to 47 percent in 2000 and is expected to reach 65 percent in 2030 [1;2].

Cities in the developing countries face a rapid growth due to the high increase in population density. The rise in urban population in developing countries is caused by the rapid overall natural population growth, the rural-to-urban migration, and the classification of rural areas as urban[3;4].

Since automobile invention, urban growth took the form of suburbs established in the fringes of cities [5;6]. On a wide scale, cities have been growing fast, stretching into countryside, putting more stress on environment and productive lands as a resource [7].

Population growth and immigration to urban centers were behind the rapid spread of suburbs across rural, agricultural lands and natural landscape. Searching for better services was
one of the major factors behind urban densely populated areas [8]. Sprawl was one of the forms of urban expansion where scattered development and low densely populated areas encroached into the countryside, resulted in socio-economic impacts—fragmented development, rise in commuting cost, infrastructure cost, impacting natural resources and open landscapes [9].

The West Bank is the home of 2.5 million inhabitants distributed in three categories: urban 46.6%, rural 46.9% and refugee camps 6.5% [10]. Population growth rate is 3.18% [11]. Major urban centers are considered as the district/county seat where services are gathered and centralized.

Migrations to urban centers in addition to population natural growth are adding more pressure on these centers. Urbanization is escalating in the West Bank as it is the norm globally. Geo-political factors are playing a major role in land availability for urban expansion especially in the study area of Ramallah, where land is limited and urban expansion is delineated by surrounding Jewish colonies. After Oslo Accords1, land in the West Bank was classified into three categories (A, B and C).

Land classifications (A, B and C) put more pressure on Palestinian urban development and expansion. As a result there is no space for cities to expand beyond their administrative boundaries (Area A) unless getting approval from the Israeli authority, which normally takes a long time. Due to these facts cities became more crowded and there is no room for new neighborhoods within the master plan. During the last decade, new neighborhoods were constructed in the outskirts of major cities in order to provide the inhabitants with the needed residential spaces. In addition new residential blocks were constructed in the surrounding villages, where most of these villages became as dormitory towns. Other development took the shape of ribbon (linear development) style connecting surrounding villages with the main city center. All mentioned earlier have been impacting natural resources as agricultural lands, where the periphery of the study area is mainly planted with olive trees and high biodiversity areas [12].

Palestinian cities growth was affected by the Israeli actions and policy. Vast areas were confiscated for military purposes and colony activities. Infill planning was the main urban development trend within Palestinian cities. Urban planning mechanism outside cities and towns’ boundaries is still in the hands of the occupying power/Israel; this resulted in deforming urban growth pattern and transforming the available agricultural lands into shelters. In the absence of a strong planning intervention at the regional and local level, further urban sprawl will consume more agricultural lands [13;14].

In the West Bank, high percentage of people is living in few urban centers, while the rest are scattered in a large number of small rural communities. This resulted in a high concentration of public facilities/services in large urban centers to serve their population and the surrounding

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1 In 1993, Israel and the Palestine Liberation Organization (PLO), agreed to initiate peace in the area. In order to transfer power to the Palestinians, land was divided into three categories: area A to become under Palestinian jurisdiction, Area B just civil affairs to be under Palestinian jurisdiction, and area C under full Israeli control. Area A & B is 38% of the West Bank, Area C is 62%. 
rural communities. There is a profound defecincy in spatial system hierarchies of centers and subcenters at regional and sub regional levels [15].

The focus of this study is to set a conceptual framework for sub-urban development with the least impact on natural resources and mainly on the agricultural lands as a source of food. This will enforce surrounding villages/suburbs on one hand and alleviate pressure on the major city (Ramallah city as a case study) on the other hand.

2- Study area

Ramallah Governorate lies in the central part of the West Bank, covers an area of 848.828 km², and home of 297,330 Palestinians (Fig, 1). In 2007, the population density of Ramallah Governorate was 327 person/km² while in 1997 it was 217 person/km² [10]. According to Oslo Agreement 101.731 km² lies in area A, 210.738 km² in area B and 536.359 km² in area C. Since 1967, 30 illegal Israeli colonies have been constructed on lands of the Governorate occupying an area of 30.673km². In addition the Apartheid Wall isolated 99.069 km² of Palestinian lands behind its path [16]. All of these actions have been impacting the area; more Palestinians (who lost their lands) are forced to migrate to other areas (mainly to the central city), severe damages to the agricultural sector, rise in land price, increased urbanization and higher population density, and loss of open spaces and natural landscapes.

Figure 1: Study Site

Ramallah city is adjacent to Al Bireh city where they form twin cities with 62,000 inhabitants, and considered as the center of the Governorate. Since 1996, Ramallah has been the center for the Palestinian authority where most services, including; health, financial, education, governmental and commercial are located in this center [11]. A rapid urban development took
place to accommodate officers in different institutions, international organizations, governmental, diplomatic missions, and for local companies. And parallel to that, there was a high demand for residential buildings to accommodate employees working in governmental and private sector.

The city attracts people from all the surrounding cities, towns, villages and refugee camps either to work or to get services. There are about 80 localities completely dependent on Ramallah city which is considered as a central hub with a busy core and dormant periphery. The centralized activities in the city caused an exponential growth pattern. In the past few decades, the spatial planning of the city was shaped to serve the sequential mandate and Israeli occupation forces, and not the locals’ interest [14]. Lately, the condition of the city underwent a prevailing disorder and disorganization due to several reasons; the un-planned city growth, geopolitical setting, and inefficient power to manage the dynamic process of urban development.

Ramallah urban expansion and sprawl is heading to the north to reach the adjacent villages in a ribbon (linear development) style. These villages are dormitory communities with minimum services, lack of public facilities and infrastructure, and on the overall scale, sprawl is impacting surrounding natural and manmade landscape (figure 2).

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2 Alamari, Qadora, Aljalzoon, Qalandya refugee camps

3 Ottoman till 1917, British till 1948, Jordanian till 1967, and Israeli

4 The villages of Surda, Abu Qash and Birzeit.
Ramallah built-up area and the surrounding villages form a radial agglomeration with Ramallah as its focal point. On a geopolitical side, Ramallah built-up area is blocked from the south by Israeli colonies (Giv'at Ze'ev, Atarot and Kokhav Ya’kov), the wall\(^5\) and the gate\(^6\) to Jerusalem and from the east by Israeli colonies (Beit-Eil and Psagot) and “area C”. From the west it is bounded by a series of Israeli colonies (Nahaleil, Talmon, Dolev, Bet Horon) and “area C” [17] (IPCC, 2007). The built-up area of Ramallah expanded during the period of (1989-1994) with a percentage of 16.1%, which is approximately 397 donums\(^7\) per year, and it increased with the percentage of 24.5% during (1994-2000) with 585 donums per year. This indicates that Ramallah has transformed rapidly to a major center to cope with the increasing needs for dwellings and offices (figure 3). So urban development is taking place on areas assigned for future development regardless its value and sensitivity.

![Figure 3: Geo-political context](image)

Rapid growth and increasing demand on dwellings and offices in addition to high land prices encouraged people/investors to move to the outskirts. Since a decade, few developmental projects (mainly residential) were constructed in the periphery. These projects were implemented according to investors’ visions and perspective (revenue). Lack of regional plans and governmental vision for “protected areas” and “developing areas” beyond cities’ boundaries, as well as land classifications (A, B and C) were behind the absence of a comprehensive plan for development. This resulted in fragmentation of urban fabric, sprawl, and scattered development in the outer ring of Ramallah city, which impacted natural settings and agricultural lands around.

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\(^5\) Israeli apartheid wall

\(^6\) The wall has gates as crossing points even between Palestinian cities and communities (here I refer to Qalandia crossing point)

\(^7\) One Donum= 1000m\(^2\)
The study is trying to incorporate all mentioned above challenges: geo-spatial settings, urban segregation and fragmented development around central city (Ramallah), service hierarchy centers, and environment.

3- Methodology and Analysis

The study used spatial analyses in order to find the most suitable village to be assigned as a suburban center within the periphery of Ramallah city. The study analyzed spatial public services structure and hierarchies for the surrounding villages, within a radius of 10 km from city center in order to find the best location for a suburban center that can absorb a portion of the flux of people commuting to the city center. People’s perception was incorporated in this study. Then the study used GIS application for landscape/landcover assessment within the boundary of the proposed suburban center for better allocation of future development.

According to the publications made by the Ministry of planning [18] in 1998, Birzeit Town was addressed to be a candidate site to be developed to work as suburban centers. Another study[15] which investigated services distribution between communities, addressed Birzeit to be developed to work as a suburban center. So, the study is going to consider Birzeit as the suburban center which needs upgrading and development.
Landscape/landcover assessment was conducted in order to allocate future development in the right direction, taking natural settings and agricultural lands into consideration. In order to find where to allocate developmental area within Birzeit context, GIS was used to assess the surrounding areas of Birzeit master plan. A rectangle of 5km surrounding Birzeit master plan was assigned. The periphery area was divided into 7 zones according to land topography and road network (figure 5). Each zone was then assessed in order to find the most proper zone for future development.

Figure 5: Birzeit context

Shape files were prepared consisting of: built-up, olive trees, rock areas, agricultural lands, shrub land, quarries and biodiversity areas (figure 8). Land assessment was conducted according to land value and sensitivity:

- **Protected land**: Agricultural lands, biodiversity areas, and fields with olive trees were considered as protected land where development is prohibited.
- **Development land**: rock area and fields with shrubs were considered as development areas where development is encouraged in order to sustain protected areas.
- **Improvement areas**: lands containing quarries, and built up areas were considered as improvement areas.

Areas (size) and percentages for each type of land cover were calculated (table 1). From table (1) it is clear that zone number 5 has 39% as rock lands, 41% as shrub lands, 3% as quarries, 0% biodiversity 3% as olive trees areas, and 9% as agricultural land.
Table (1): areas of different land cover

So zone number 5 is going to be the best location for future development in the area with minimal impact on nature. This area is adjacent to the master plan boundary of Birzeit and close to Birzeit University campus (BZU) (figure 7).
4- Discussion and Conclusion:

Long term financial mortgage, automobile loans [19] and high price of lands within city boundary, forced people from middle class to move to outskirts for better living conditions. As a result, several residential projects were constructed to accommodate these people. Scattered development, fragmented neighborhoods and low dense urban expansion is taking place since Oslo peace accords.

On the national level, Ministry of planning and International cooperation [18] in 1998 published the regional development plan for the West Bank, where one of the sectors of development was urban expansion models. One of the scenarios for development was to enforce and improve sub-urban centers to attract population from moving to the main cities.

This research is in line with the strategy of developing sub-center to alleviate pressure on major centers and to develop these sub-centers to coop with population growth. As a result of the analysis Birzeit town was selected according to the assigned criteria, one of the site potentials is
Birzeit University. Birzeit University is located within the municipal boundary of Birzeit town, with 10,000 students. The university is considered as one of the important educational institutions in the West Bank. The town is considered as a university town, where dormitories and other services are located. The town is located on one of the major roads connecting south of the West Bank with the north. The survey showed that people from Birzeit and the surrounding localities commute to Ramallah for several needs: services, education, shopping, residences and work.

As a result Birzeit got the consensus for developing a sub-urban center where residence and students can find the needed services they used to get from the city center of Ramallah. In addition spatial analysis lead to the same result of considering Birzeit as a potential site to be developed as a suburban center.

As a conclusion, if urban expansion is left in the hands of investors’ and without comprehensive national and regional planning guide lines, urbanization in the West Bank will accelerate and dense urban centers will be the dominant trend. Geopolitical settings are playing a major role in urban planning, if master plans were not updated to include more lands (in Area C), urbanization will accelerate and more stress will be exerted on nature.

Without proper planning on the regional scale, more marginalized villages and rural areas will emerge, more dense urban centers will dominate urban structure, services will be centralized which will add more pressure on centers and will add more cost on commuters.

This study proposed a methodology where spatial analysis and peoples’ perception were incorporated in order to come up with a mechanism for future development around city centers.

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References


AN APPROACH FOR INTRODUCING SUSTAINABILITY IN ENGINEERING EDUCATION

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Abstract

The world is suffering from overpopulation that is causing an increase of impervious surfaces in urban areas, depletion of natural resources, and degradation of the environment. Therefore, the principle of sustainable development, or sustainability, has been introduced into communities as a possible solution to these problems. Since engineers play an important role in the welfare of communities, they are increasingly being asked to address such problems in design and implementation of projects. On an academic level, this entails that engineering graduates possess the knowledge and understanding of sustainable concepts and methods for their adoption and implementation. However, the main challenge remains in integrating sustainability concepts into a curriculum that is already packed with courses and modules. The aim of this paper is to present an instructional methodology that can serves as a road map for academic institutions to integrate principles of sustainability into engineering education. The paper presents steps followed in establishing and implementing such methodology along with examples at the Department of Civil and Environmental Engineering at AUB.

Keywords: Sustainability, Instructional methodology, Engineering Education, Civil Engineering

1. Introduction

Since 1950, the world has witnessed an increase in its population by approximately three times [1], causing dramatic social changes, depletion of natural resources, and degradation of the environment. It is globally recognized that basic needs such as drinking water, clean air, energy and others cannot be sustained indefinitely [2]; therefore, it is the role of engineers to recognize these constraints and seek approaches to reconcile human needs with the world’s capacity to sustain these needs. According to the National Society of Professional Engineers, it is the responsibility of the engineers to “dedicate their professional knowledge and skill to the advancement and betterment of human welfare” [3]. This responsibility being established, engineers have been seeking ideas and methods to drive down the adverse environmental, social and economic aspects of engineered products and infrastructure, to improve their environmental performance, and most importantly to shift the society towards adoption of what is often referred to as “sustainable development”.

“Sustainable development” or “sustainability” are relatively new concepts that have emerged as a solution to the challenges that our world is facing. The debate around the meaning of sustainability has not been settled [4]; however, a classic and accurate
definition describes it as “development which meets the needs of the present without compromising the ability of future generations to meet their own needs” [5]. In the past, societies had identified development as pure economic growth to attain high levels of wealth [5]. However, after realizing the need to live within constraints and limitations, sustainable development has come through to ensure that economic development that meets the needs of the societies does not do so at the expense of depletion of natural resources, and socio-environmental degradation. By recognizing the importance of a sustainable lifestyle and embracing it, one main challenge remains in equipping the society with professionals who are able to address such challenges [6].

Many leaders in the engineering community have been opting to integrate sustainability thinking in engineering education because engineers are increasingly being asked to address such issues in their workplace [7]. However, integrating new concepts and materials into a curriculum that is already packed with courses, modules, and projects on covering a wide breadth of topics is a challenge by itself. One solution lies in implementing a transition from the current curriculum to another one that accommodates sustainable thinking and knowledge; however, reassessment of what is important and relevant for the students in a changing world, redesign of the curriculum and some of its courses, and its implementation, is a complex and lengthy process and such transition can take years. Therefore, until such process is carried out in its entirety, it is necessary to explore other venues for introducing sustainability in the engineering education in the immediate time frame.

The aim of this paper is to present an instructional methodology which covers sustainability in the discipline of infrastructure. This methodology can be considered as a road map for integrating sustainability thinking in the engineering education. It comprises of the individual involvement of the professor whereby it is his/her responsibility to initiate and adopt a teaching process that promotes sustainable thinking. It also aims at engaging the students into a continuing learning process that starts at the undergraduate level and continues all the way to graduate levels. The paper presents examples and case studies that have been implemented at the Department of Civil and Environmental Engineering (CEE) at the American University of Beirut.

2. Integrating Sustainability Concepts

This section discusses first three innovative and sustainable infrastructure practices that are being researched and implemented by CEE at AUB. Then, the steps followed in establishing a road map for integrating the associated principles in the curriculum are discussed.

2.1 Sustainability in Infrastructure

Geothermal pavements, use of construction and demolition waste (CDW), and pervious pavements are sustainable practices that have been researched extensively at AUB and implemented in pilot projects. Below is a brief description of these concepts:

1. Geothermal pavements, also known as energy harvesting pavements, are asphaltic pavement structures incorporating embedded pipe networks in their asphalt
surface layer. In warm to hot climates, asphalt absorbs high amounts of energy due to its black color, and thus heats up significantly (reaching 70°C in summer in Lebanon, and 85°C in the Gulf). As water circulates in the pipes, its temperature rises due to the heat exchange thus lead to the cooling of the asphalt pavement. There are several benefits of such systems: reducing air temperature on top of pavement, urban heat island effect, reducing the energy needed to heat water, and increasing the life span of the pavement by reducing the risk of permanent deformation under the tires. In very cold conditions, the pavement could act as a snow/ice melting system by running warm temperatures in the pipe network.

2. CDW, construction and demolition waste, are materials that consist of the waste from debris generated during construction, renovation, or demolition of buildings, roads, and infrastructure. CDW can be any type of materials such as concrete, wood, metals, etc. Reducing and recycling CDW is important as it conserves landfill space, reduces the environmental harm of illegal dumping, and reduces the depletion of natural resources.

3. Pervious pavements are characterized by a highly porous structure that allows rainwater to penetrate through them and percolate to the soil layers. Surface layer of such pavements can be of two types: asphalt or concrete. They have been widely used in Japan, Europe, and the United States of America because of their various advantages: controlling storm water runoff, reducing surface water pollution, reducing roadway noise, and, most importantly recharging underground aquifers or collecting rainwater.

These concepts will be used in section 0 as examples of sustainability projects applied by CEE at AUB as part of the teaching process.

2.2 Sustainability Concepts in Education

In this paper, the presented methodology for integration of sustainability thinking in the engineering education consists of four steps.

Figure 1 presents the sequence of the steps of the path followed as part of a case study conducted at the CEE Department.
Figure 1: Sequence of steps followed in the instructional methodology implemented at AUB

The first step consists of informing the students about the general concept of sustainability. In this phase, students are considered to be in a passive phase that consists of acquiring and grasping information for use in later stages. The characteristics of this step are:

1. Happens during the first and second years of the undergraduate level.
2. Initiated by the professor since he/she possesses the required knowledge and it is his/her duty to promote sustainable thinking in the class.
3. The professor can provide the students with published articles, which students have to read and present in interactive sessions.
4. An example consists of introducing the students to the definition, importance, and current practices of CDW in a Construction Materials and Technology course. Another example involves introducing in a Highway Engineering course a glimpse of the practices and applications of geothermal and pervious pavements.

The second step aims at encouraging the students to participate in community service activities that are organized by students based societies such as the American Society of Civil Engineers. The purpose of such activities is to first promote the sense of responsibility in the student body, allow them to learn through collaborative work, and provide them with real life experience of a specific sustainable project. An example is a summer camp that is yearly organized by the ASCE Student Chapter at AUB, the aim of
which is to employ the capabilities of the undergraduate students in serving rural and needy communities in different Lebanese regions. “Pervious Sidewalk in Lala” is one amongst the several achievements of the camp (Figure 2).

The teaching process continues in the third step where the students witness a transition from being an audience to a more engaged and active knowledge seekers. The characteristics of this step are as follows:

1. Spans over one academic year where students in their senior level are required to go in depth into the understanding, applications, and challenges of specific sustainable concepts such as geothermal pavements, pervious pavements and CDW.

2. This can be achieved in their Final Year Project (FYP), where each group of students have an advisor, and it remains the duty of the advisor to promote and propose sustainable research ideas. Moreover, it is his/her duty to supervise, guide, and evaluate the work being done.

3. At the end of the academic year, students are required to present the work done during the year along with the knowledge and experience acquired. The work will be evaluated by their professor judges.

4. To date, three groups of five students each have completed their FYPs on experimental and numerical studies of geothermal pavements and application of pervious pavements.

The last step is carried at the graduate level where special research topics are provided to graduate students based on their demand and orientation. These types of courses require the students to read, understand, and present for the class chapters of the specified book. Students are also required to conduct projects of their interests within the scope of the class.

3. A Success Story: Pervious Concrete

Pervious Concrete Pavements has been the interest of students at different levels (undergraduate and graduate) as it presents a possible solution for the water shortage problem in the Lebanese regions. Students have focused on this concept from exploration to implementation, and its success presents a validation for the instructional methodology proposed in this paper.

3.1 Pervious Sidewalk: Lala village

The Student ASCE chapter at AUB organizes a yearly summer camp in rural and needy Lebanese regions. As part of community service activities, students have proposed to design a pervious concrete sidewalk that is 65 m in length for a school in Lala village in West Bekaa. The idea was feasible since pervious pavements are pavements that allow water to drain through it, and thus school students won’t get wet while waiting for the bus during the winter season.
This project has created a collaborative environment as students from different engineering majors have participated in this project under the supervision and the guidance of the professors. Moreover, students were exposed to the different aspects of this project ranging from structural design of the sidewalk to its construction and operation. Figure 2 shows the site before and after the construction of the pervious sidewalk, while Figure 3 presents the intermediate steps implemented in the construction of the sidewalk.

Figure 2: Before and After Completion of the Project
3.2 Pervious Parking: AREC

The Agricultural Research and Education Centre (AREC) is a facility owned by AUB in the Northern Bekaa region. It consists of vast areas of agricultural land and various other facilities. It is situated in an arid climate and suffers from water shortage. At times, it either relies on wells, or buys water from external sources to irrigate its gardens and crops. As part of the Final Year Project, a group of five students took the task to design...
and build a pervious area in the major parking lot of the farm. During winter season, rain water will drain through the pervious area and the water will be directed through the pipes to a buried storage tank underneath the parking lot. The stored water can then be used for irrigation purposes. Figure 4 presents the steps undertaken in the construction of the pervious parking area.
3.3 Pervious Concrete: Research and Innovation

Three graduate students who had participated in the previous mentioned activities (except for FYP) and have been part of this continuous learning process have showed extreme interest in pervious concrete pavements. These students have detected the lack and absence of universal methods and codes according to which the structural design and the performance of such pavements can be measured and evaluated. Therefore, by attending special topics classes such as CIVE 798: Experimental Design in Civil Eng’g Porous Media, students have researched and explored venues to develop a mix design methodology for pervious concrete. The work of the students is of high quality as it is being submitted to top notch conferences and journals in the civil engineering discipline. Figure 5 shows laboratory testing for the permeability of a pervious concrete sample done as part of the graduate students’ work.

4. Conclusion

This paper focuses on an instructional methodology that has been implemented at AUB as part of a case study. Implementing pervious concrete into two different villages in the Bekaa region is a proof of the effectiveness of this methodology. This methodology can be adopted by universities as it is simple and does not require changing the curriculum. However, the initiator is the professor and thus it is his/her duty to promote, stimulate and encourage sustainable thinking.

5. REFERENCES


ACHIEVING SUSTAINABLE ADAPTIVE REUSE 
IN ARCHITECTURAL DESIGN STUDIO 
USING ENVIRONMENTAL SIMULATION

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Abstract

Education for sustainability must go beyond teaching sustainable strategies in design methodologies. It must give students practical skills that enable them to continue learning after they graduate.

This paper addresses the integration of sustainable design process as a pedagogical approach in the architectural studio which is applied on an adaptive reuse project. It aims to explore the use of building simulation as a tool to evaluate different sustainable solutions, to highlight on the significance of design decisions and to emphasize on improving building performance indicators. It also investigates Blooms taxonomy as a benchmark of student's learning domains, linking it to the environmental simulation in design Studio by developing this methodology of learning architectural design.

An assessment of several projects carried out within design studio course using Design Builder; a simulation software in the design process will be compared with the conventional design method that is based on functional and aesthetic criteria only. The challenge of limiting the design within the constraints of an existing building reveal that site selection impacts the sustainable approach through the design process.

The result shows the significance of this quantitative experiment that can support students in testing different alternatives from the early stage of the design process and manipulate their design based on informed and reliable results to optimize building performance.

Keywords: adaptive reuse, design studio, simulation, sustainability, design builder

1 Introduction

Over the past decades, the built environment is increasingly responsible for the deterioration of the natural environment. The depletion of energy, materials, waste and pollution dispersion are all problems that result not only from the construction phase but during the entire building life cycle and after demolition. Though there is an increase in awareness of global warming in different domains, sustainable policies are still weakly applied especially in the developing countries (1)

In response to that, the UN decade of Education for sustainability 2005 -2014 launched a program which aims to ensure that all higher education establishments are integrating principles, and practices of sustainable development (2). Furthermore, in their second report UNESCO focused on processes and learning in the context of Education for Sustainable Development that have the potential to be catalysts for innovation in education(3). In relation to this, architectural schools like many higher educational institutions accord recently high priority to sustainability by integrating green concepts in their curricula.

However, academics are still facing lacks on how to bridge the gap between the theoretical knowledge and the application of environmental design. According to (Altomonte 2009), the formation of building practitioners needs to inaugurate amendments that support the successful achievement of awareness of environmental concerns in the practice of architecture. The study also highlighted that "University curricula have shown to be relatively
ineffective in methodically integrating sustainable environmental design in the education of students of architecture" (4).

2 The Architectural Design Studio and the emergence of simulation tools

An architectural project is a result of complex interactions between different design parameters that should not only provide the comfort and well-being of the inhabitants of the internal space but should also minimize the impact of the building on the surrounding environment(5). The conventional teaching method in the design studio is concerned with the visual appearance of the mass and functional purpose. Even modern architects like Le Corbusier, Walter Gropius and Mies van der Rohe adopted “form follows function” as design principles(6). Nevertheless, architectural education should not be limited to physical building design but it should also integrate value system, sustainability and technologies. Limited by the conventional analytical tools, the traditional discipline neglected building performance concerns related to comfort, lighting, acoustics and other associated aspects. Hence, there was a disconnection between applying the design parameters and building sciences. As stated in (Papamichael K, Pal V 2002), "Design studios and building science courses have been conducted independent of each other, mainly due to a lack of tools that allow quick and easy consideration of building science criteria, such as comfort and energy requirements, during the design process". (7)

The emergence of simulation tools can integrate sustainable principles within the architectural education and accordingly link the theory with practice within the studio. A number of simulation programs have been recently developed. The listed top rated free software capable of whole building simulation are “Energy Plus” and “Open Studio”(8). “Design Builder” is an “EnergyPlus” graphical user interface appropriate to inform design through performance based decisions. “EnergyPlus” is "a whole building energy simulation program that engineers, architects, and researchers use to model energy and water use in buildings."(9). “Energy plus” comprises "a core 3-D modeler and 9 modules which work together to provide in-depth analysis of energy use, consumption and commitment for any building" (10). It ensures that the designs meet performance targets early in the design process. It also enables compliance with the building rating systems requirements such as LEED, BREEAM.

2.1 Early integration of sustainability in the design process
Simulation tools not only facilitate decision making within the complexity of the design process but also engages students in multidisciplinary approaches. These methods are capable of broadening the knowledge of sustainable design as a multidimensional discipline encompassing many levels to be integrated in the design studio. On the other hand, building energy modeling could be an effective game based learning versus the traditional method(11). The incorporation of these methods within the design process have a potential to provide students an effective path to understand the principles of sustainability in a holistic manner and with measurable reliable results allowing a science based approach.

2.2 Using environmental simulation in relationships to Blooms taxonomy
The modeling procedure expands student's skills in association with different levels in the cognitive domain of Blooms taxonomy. The cognitive domain taxonomy (Blooms, 1956) classified by an educational committee is widely accepted in many fields and has been identified as, “arguably one of the most influential education monographs of the past half century.” In the table below, Bloom's domains (1956) are compared with Lukman (2013) and
the new methodology of using simulation programs integrated within the design process. These additional skills are based on the observation of our students during their design process.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Level 1</td>
<td>Knowing the design requirement</td>
<td>Comprehend the main goal to achieve the most sustainable design</td>
<td>- Theoretical Knowledge of building performance parameters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Adequate simulation software skills</td>
</tr>
<tr>
<td>Comprehension Level 2</td>
<td>Understanding the objective of the design requirements</td>
<td>Identifying the Parameters that can influence the building’s performance</td>
<td>- Data Collection of the existing building (Base Case Scenario)</td>
</tr>
<tr>
<td>Application Level 3</td>
<td>Using the information to execute design or to solve the design problem</td>
<td>Application and comparison between several alternatives</td>
<td>- Input Parameters Modeling (Building the geometry)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Running the simulation</td>
</tr>
<tr>
<td>Analysis Level 4</td>
<td>Critical thinking: identifying/analyzing the effectiveness of design components; making design decisions based on facts</td>
<td>Linking the theoretical modules to the design module</td>
<td>- Analysis of the Output Parameters</td>
</tr>
<tr>
<td>Synthesis Level 5</td>
<td>Proposing new and original design solutions without borrowing literally from precedents</td>
<td>Targeting the Performance Criteria: Energy Consumption, Daylighting, IAQ</td>
<td>- Visualizations of Results</td>
</tr>
<tr>
<td>Evaluation Level 6</td>
<td>Evaluating the merit of the proposed design solution</td>
<td>Quantitative evaluation rather than purely aesthetic and functional needs</td>
<td>- Interpretations of Results</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compliances with building rating systems</td>
<td>- Selecting the optimum Solution</td>
</tr>
</tbody>
</table>

Table 1 Additional learning skills that Design Builder can add to the Blooms Taxonomy based on the conducted project relative to the conventional Design Studio

3 Methodology

3.1 Adaptive reuse as a challenging context
In a study on research design education for adaptive reuse, (Eyüce, 2010) discussed that "Context concerns itself not only with relationships between built forms, natural and manmade environment but also expands over a vast area of interpretations ranging from a simple single feature to such interrelated conditions like social, cultural, economic, and environmental factors" (14). Adaptive reuse of an existing building refers to the process of reusing an old site or building for a purpose other than which it was built or designed for.

Students at Beirut Arab University (BAU), faculty of Architectural Engineering were assigned a design project as a group work of 4 to 6 students during the spring semester 2014-2015. This opportunity to work as a team was challenging but valuable in terms of
interaction engagement between the students. Each group is required to select an abandoned building in Lebanon so that multiple options are addressed and thus different responses will be taken. The aim is to reuse an old neglected building through an eco-friendly approach and creative solutions. It therefore decreases the consumption of materials and reduces the impact of Building life-cycle by improving the environmental and economic performances. Adaptive reuse is considered as part of the known sustainable strategies. In LEED v4 for Neighborhood Development, two credits can be earned with the building reuse and adaptive reuse. The requirement is to "Incorporate into the project the reuse of one building that maintains at least 50% (based on surface area) of the existing building structure (including structural floor and roof decking) and envelope (including exterior skin and framing, and excluding window assemblies and non-structural roofing material)." (15) The simulation strategy in this project was done as a process of the adaptive reuse of the old building to make it functional for the new use, hence the methodology integrated the simulation tools as a part of the adaptive reuse.

### 3.2 The simulation tool: Design builder

A comparison between different simulation programs and graphical interfaces using Energy Plus such as COMFEN, Design Builder, DIVA for Rhino, Open Studio and Simergy(16) shows that they are all similar in description however Design Builder is easy to learn and is considered as a standalone software that can integrate CFD and radiance daylighting simulation. The selection of this software as a tool in this design project was also based on its user friendly interface in addition to its precision. It also allows designers to evaluate energy efficiency and carbon performance during early stage design. It enables the visualization of solar shading and the comparison of alternatives to maximize comfort, daylighting and natural ventilation. It also helps students in quantitative evaluation of various designs in order to assess the impact of design parameters on building performance and to identify the ultimate solution.

### 4 Analysis and Synthesis

Students are required to apply their theoretical knowledge and simulation skills into practice. On the basis of taken lectures during the semester, students should have attained an adequate knowledge of how several parameters can influence the building’s performance including; building orientation, window opening area, glazing type, shading devices and its positions. The design parameters evaluated emphasized that each building design has its own context which dictates the design. This indicates that implementing any solution must be based on quantitative analysis and on a simulation process. For example, in the early decisions, the additional blocks should be based on using the simulation software as a tool to investigate the effectiveness for the optimum design solutions of comfortable and energy efficient buildings. It is important to specify certain questions and conditional statements in order to support the finally reached results. Assessment of performance includes several design parameters such as designing shading devices, orientation and therefore cooling load reductions to reach comfort zones. Once having applied the previous criteria, students become able to develop the critical thinking by considering the simulation process as a vital part of evaluating the new building design in comparison with the initial condition as a part of the adaptive reuse project.

In their design project, students specify the geographical location during the modeling procedure and accordingly the weather conditions (temperature, humidity, wind speed) of the region are used for simulation.
After completing the project, a questionnaire was circulated to the majority of students in this course to evaluate their feedback on the first experience with this methodology in design.

**Figure 1** Different scenarios and daylighting according to different wall to window ratio.

**Table 2** Parameters variations for alternatives and analysis of results.

<table>
<thead>
<tr>
<th>Base Case Scenario</th>
<th>Wall to window ratio</th>
<th>Glazing</th>
<th>Shading</th>
<th>Cooling Loads (Kwh)</th>
<th>Daylighting</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6% openings</td>
<td>Single Cl 6mm</td>
<td>Local shading, 1m overhang</td>
<td>65.9 Kwh</td>
<td>Min: 0.003 lux Ave: 3.649 lux Max: 37.947 lux</td>
<td>627.72 U.S.D</td>
<td></td>
</tr>
<tr>
<td>-10% openings</td>
<td>Double LoE Cl 6mm/13mm Arg</td>
<td>Local shading, 1m overhang</td>
<td>60.27 Kwh</td>
<td>Min: 0.016 lux Ave: 3.472 lux Max: 32.735 lux</td>
<td>620.259 U.S.D</td>
<td></td>
</tr>
<tr>
<td>-40% openings -5% 10%</td>
<td>Triple LoE Cl 3mm/13mm Arg</td>
<td>Hurricane</td>
<td>58 KW</td>
<td>Min: 0.007 lux Ave: 2.416 lux Max: 14.872 lux</td>
<td>635.704 U.S.D</td>
<td></td>
</tr>
<tr>
<td>-5% wall openings</td>
<td>Double LoE Tint 6mm/13mm Arg</td>
<td>-4 skylights -Local shading, 2m overhang</td>
<td>57.05KW</td>
<td>Min: 0.007 lux Ave: 3.831 lux Max: 11.428 lux</td>
<td>620.363 U.S.D</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2** Numerical Comparison between different alternatives in terms of internal gains (Kwh) and humidity (%).
(appendix 1). After reviewing the results of the questionnaire and summarizing them, we found out that conducting the design processing simulation software in the design process was rated between quiet easy and reasonable in the level of difficulty of each phase in the modeling procedure compared to the conventional methodology of design in addition to being so helpful in measuring the building sustainable performance discussed previously which improved their design development in achieving a more sustainable architecture, despite the occurrence of some technical challenges regarding the usage of the proposed software. And as a final comment the students were eager to explore more software packages in the domain of sustainable simulation.

**Figure 3** Students feedback on Modeling Procedure through Design Builder
Figure 4 Design Builder compared with the conventional methodology of design

Figure 5 Performing indicators contribution to the final design decision

5 Conclusion
This exercise aimed at effectively employing quantitative methods in analysis as a part of the adaptive reuse projects and to be a base for further studies in the field. It encourages the integration of building energy simulation in the design process. This simulation tool in calculating the whole building energy simulation measures expected energy use based on the building’s geometry, climate, building type, envelope properties, and active systems.
The importance of the combination of the core modules in the design studio is essential to understand sustainable theoretical lectures and simulation application tools. The evaluation of different alternatives facilitates the design decisions in a science based approach. More training and explanation for students should be given on the reading of technical data visualization, running the simulation, and evaluating the design alternatives. Further investigation of other simulation software is necessary in order to recommend the most suitable one for architects.

6 References


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**Appendix I**

**Questionnaire on the use of Building Energy Simulation Software in the Design Process**

This survey is designated to assess students’ feedback on the use of building simulation as a tool during the architectural design education.

We would be very grateful if you could complete the enclosed questionnaire. Your response will be combined with other students to form an overall picture, so please respond only if you have taken ARCH 339 - Environmental Design Course Spring Semester 2014/2015.

1. Please indicate your level at the faculty of architectural engineering for the Spring Semester 2014/2015 (double click on the box and select checked).
   - Level Two □ 1
   - Level Three □ 2
   - Level Four □ 3
   - Level Five □ 4
   - MArch □ 5

2. During the design process, how would you rate the difficulty of each phase in the modelling procedure? Please tick one box on each line (double click on the box and select checked).

<table>
<thead>
<tr>
<th></th>
<th>Too easy</th>
<th>Quite Easy</th>
<th>Reasonable</th>
<th>Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case scenario</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>(Data Collection)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Parameters</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Modeling (Building</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>the geometry)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Running the simulation</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Analysis of the</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Output Parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visualizations of</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpretations of</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design recommendations</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

3. Compared with the conventional methodology of design, please indicate how helpful was using simulation software in the design process

<table>
<thead>
<tr>
<th></th>
<th>Very Helpful</th>
<th>Helpful</th>
<th>Neutral</th>
<th>Not very Helpful</th>
</tr>
</thead>
<tbody>
<tr>
<td>To measure building performance</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>rather than to focus only on aesthetic and functional values</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To predict the use of energy from</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>the building</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To integrate temporal variations</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>(extreme weather conditions during</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>winter and summer)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To integrate building location</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>(geographical)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To evaluate reliable numerical</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>results in tabular and graphical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>format</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To identify and prioritize</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>alternatives to optimize the design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. **How would you rate the difficulties of Design Builder in the design process?**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is easy to learn (user interface)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has limits in Modeling complicated geometrical shape</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand high specification for computer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compatible with other software (Sketchup, CAD..) to export and import files</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. **Selecting an adaptive reuse building support the concept of sustainability in your project**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. **In your project, evaluate how much would you say each of the following performing indicators contributed to your final design decision.**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>A great deal</th>
<th>Quite a lot</th>
<th>A little</th>
<th>Not a factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Consumption (KW/m²/year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Envelope heat transfer (U value)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Emission (kgCO₂/year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling/ Heating Loads (BTU)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost ($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Comfort</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewable energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting Quality (lux)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. **In your opinion, gaining new skills is essential in Education for professional practice?**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. **Is there any other issue related to the use of building simulation in the design process on which you would like to comment? Please feel free to comment.**
ABSTRACT
Throughout history, civil engineers have contributed enormously to the development of society and to the huge improvements in the standards of living. Their activities have certainly made some negative impacts on the surrounding environment, society and affected natural resources preservation. Civil engineers, being part of the problem can also be part of the solution, by contributing to sustainable development and green design issues. They have faced many challenges in the past and this is another challenge they have to address. There are many approaches that will help the civil engineers of tomorrow be the leaders of sustainability efforts. This paper focuses on the role of, and need for, universities to create and promote a holistic approach in engineering education. The role of professional societies, as a key part of developing sustainability literacy among future engineers, is also addressed. The paper also looks at local challenges and efforts in the country of Lebanon to promote awareness of sustainability development. Recommendations are made on embedding sustainability principles in civil engineering programs.

Key words: Sustainability, Education, Civil Engineering, Programs

1. Introduction: Sustainability Defined.

In 1972, one hundred and thirteen countries gathered at the United Nations conference on the “Human Environment” in Stockholm, Sweden [1]. The conference was the start of global efforts aiming to address environmental problems. In 1983, United Nations appointed the Bruntland Commission charged with addressing the growing concerns about the accelerating deterioration of the human environment and natural resources and its consequences on economic and social development. The Report of the Bruntland Commission “Our Common Future” was published in 1987. It included the following definition of sustainability: “Sustainability is the state of the global system, which includes environmental, social and economic subsystems, in which the needs of the present are met without compromising the ability of future generations to meet their own needs”. The report suggested that international governments should meet to look at how to best reduce the impact of human activities on the surrounding environment for the welfare of future generations. These basic efforts led to other meetings and conferences, most importantly was the first Earth Summit, held in Rio, Brazil in 1992 and Kyoto conference (1997); where the issue of global warming and emissions of gases were discussed. Ten years later, a conference in Johannesburg met to review progress towards sustainable development. Other meetings were held to discuss the climate changes in 2007 and 2009. Several tools have been developed to assess and mitigate the impacts of human actions on the environment, such as Environment Impact Assessment (EIA) and Strategic Environmental Assessment (SEA). Both tools are reactive measures while sustainable construction is a proactive approach [1].

The most appropriate definition of civil engineering is Tredgold’s [2] definition which is “Civil engineering is the art of directing the great sources of power in nature for the use and convenience of man”. The relation between sustainability development and civil engineering is
hence obvious and this implies that the civil engineers are key factor in sustainable development and are decision makers about how to best use natural resources: material, energy, water…etc. An argument could be poised on whether civil engineers are ready to lead in sustainability efforts. Are they committed to implement required measures in their projects? Do future engineers acquire the necessary knowledge that helps them face the current challenges?

This paper suggests some solutions to improve the role of civil engineers in sustainability by developing a new approach to civil engineering education; fostering the importance of and identification of leadership and role models; promoting a shift in local policy and education programs for civil engineers in particular and engineering in general.

2. How can sustainability be achieved?

Previous researchers [1, 3, 4, 5, 6] have highlighted many guiding principles for achieving sustainability as a process in which our planet can be well-preserved. From the perspective of civil engineering as a profession, there are many challenges: the first is how to make choosing the sustainability option easier and cheaper for clients and contractors; then there is how to build the capacity of teachers and trainers to integrate sustainability into courses, how to make specifying for sustainability criteria in materials and processes an effective tool for change and finally how to embed sustainability thinking and practices into the culture of organizations and across different professional groupings. This paper will focus on the roles of universities and professional societies.

2.1 Role of Universities

Sustainability should have a well-defined identity of its own, with a solid scientific basis and significant perspective for growth. Major academic institutions offer graduate programs that focus on this very broad subject. However, regardless of the fact that single institutions have developed and implemented their own know-how, it is important to have a constant exchange of information and experiences in international conferences and symposia. In the inquiry report of the 21st Century Engineer [3], a group of young engineers conducted a survey targeting universities and colleges in UK. Their findings were summarized in the form of top ten recommendations related to leadership, universities, government and planners as far as sustainability is concerned. Here is the part of their results that is related to education:

- **Sustainable development was only a first degree third year or postgraduate option.**
- **The subject was an optional, rather than a mandatory module or course.**
- **Sustainable development was not integrated into engineering courses as a whole.**
- **Audit procedures for assessing the standard of the sustainable development modules or courses were weak.**
- **There was general apathy and lack of awareness concerning the value of introducing sustainability into engineering courses, amongst teaching staff and students.**

Though these findings may apply to many universities, suggesting that more plans are desperately needed in programs, it is quiet certain that the majority did not yet play their role in
sustainability development. As a starting step the university can make plans for staff training by offering lectures that enhance their understanding of sustainability development. They can benefit from the Visiting Professor schemes who can advise on the inclusion of sustainability concepts in teaching and also on structure and staff skills. Revision of undergraduate and postgraduate programs is a major step to incorporate sustainability concepts and drive critical thinking among engineering students. Some examples can be quoted here:

**Imperial College experience**

At the Imperial College - London, a Centre for Doctoral Training (CDT) in Sustainable Civil Engineering was established. The Centre produces civil engineering doctoral graduates with interdisciplinary skills and research experience to contribute to multi-faceted and complex infrastructure projects, with training delivered through highly innovative industry-linked research. CDT adopts the widest possible definition of sustainability, covering the effective whole life design and performance of major civil engineering infrastructure. The Centre addresses key engineering challenges of: fit for purpose, economic viability, environmental impact, resilience, infrastructure inter-dependence and durability. It also considers the impacts of changes in population, urbanization, available natural resources, technology and societal expectations. This requires a broad-based approach to research training, effectively integrated across the wide range of civil engineering disciplines. Very few academic institutions are capable of providing in-depth training across this range of subjects. However, the Civil and Environmental Engineering Department at Imperial College, recently ranked number one in the world against its competitor departments (QS 2013), is uniquely placed within the UK to achieve exactly this. The Centre offers a Grand Challenge Project to address a major problem for the nation. Examples of 2015-16 Grand Challenge Projects:

- Multiple Use Infrastructure
- Low Carbon Civil Engineering
- Urban Resilience

The example of Imperial College can be thought of as an option for universities that offer doctoral degrees. The type of projects presented will of course vary depending on local needs. In the country of Lebanon, civil engineers face the challenge of limited natural resources. Considering reinforced concrete construction as an example, there is a huge consumption of natural aggregates. The number of allowable quarries is only sixteen according to the Ministry of Environment, while the estimated number of existing quarries is about one thousand endangering the whole country environment. Studies showed that quarries can annually reduce an estimated surrounding lands value by anywhere from 16 to 71%. Therefore, there is an urgent need to face such challenges and future engineers must be prepared and educated accordingly.

**Strathclyde University**

Strathclyde University established a working group to decide how sustainability could be introduced into both undergraduate and postgraduate engineering studies and into further academic research.

**University of Balamand**

University of Balamand offers graduate course on Sustainability and Green Buildings as an elective course for fourth year students. The University also offers Master of Science in civil engineering – Environmental option in which many electives are offered dealing with issues
related to pollution and waste management. Some research projects leading to Master degree or Ph.D. degree focuses on innovative issues related to concrete and asphalt technology and on the industrial processes that contribute to extensive energy use and pollution. Examples of such topics are:

- “Recycled concrete as coarse aggregates for structural concrete production”
- “Improvement of asphalt for aging by using crumb rubber tires”.

Based on the above, it sounds like a sensible starting point wherein each university forms a task group whose duty is to identify possible ways of incorporating sustainability and green solutions into offered courses at undergraduate and post-graduate levels.

Civil engineers’ understanding of sustainability requires them to have knowledge in biological and social sciences. They do not need not to be experts in other professions but rather be able to be good team members.

Another way of integrating sustainability into education is to make course accreditation dependent on the inclusion of sustainability in teaching and marking. The ministry of higher education should formulate measures to assess the knowledge of sustainability as a prerequisite to issuing any license to be given to an engineering institution.

2.2 Role of Professional Societies

Professional engineering societies provide guidance, resources, Codes of practice and programs for engineers in order to improve the practice of the profession. Hence, they can help engineers to lead as sustainable and innovative problem solvers. The American Society of Civil Engineers (ASCE), for example has formally recognized civil engineers’ obligation to practice sustainability by making it part of its Code of Ethics [7]. It also demonstrates its commitment to sustainable practice through public policy statements, technical codes and standards and contributes to organizations such as World Federation of Engineering Organizations.

ASCE defines sustainability as: A set of environmental, economic and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality or availability of natural, economic, and social resources.

The same policy statement further states that civil engineers will “have a significant role in planning, designing, building and maintaining a sustainable future. Engineers provide the bridge between science and technology. In this role, engineers must participate in interdisciplinary teams with ecologists, economists, sociologists and professionals from other disciplines, in applying technology to issues and challenges that require environmentally sustainable strategies and solutions” (ASCE 2001) [7].

US Green Building Council (USGBC) has developed a Green Building Rating System known as Leadership in Energy and Environmental Design, LEED certification. LEED provides independent, third-party verification that building project meet the highest green building and performance measures. There is a checklist which ensures that all aspects of sustainability are covered in the design and implementation of the project. USBCG has published two guiding documents [8, 9] and made them available for professors threading sustainability into their courses.
The above statements serve as examples of what professional societies’ responsibilities may include towards their role in bridging the gap that may exist between engineers and arising needs and help them face new challenges.

3. Conclusions and Recommendations

Based on the above discussion, the following remarks can be concluded and recommended for application:

- Civil engineering students need to be taught to consider the limited resources constraints, learn how to evaluate alternative resources, recycling and understand global sustainability.

- Changes are recommended to curricula and program content and context to teach undergraduates the complexity of sustainability. In particular, the civil engineering curriculum should incorporate sustainability and green design courses and promote problem solving thinking.

- Policy on accreditation of professional engineering programs should include the following two generic attributes: “Understanding of the social, cultural, global and environmental responsibilities of the professional engineer” and “Understanding of the principles of sustainable design and development”.

- Government should include incentives for sustainability, green building design projects and implement taxes on landfills and construction waste disposal.

- Orders of engineers are invited to clear their positions on sustainability. New publications on this issue are called for. This may include an annual report on “state of the Profession’s Contribution to Sustainable Development”. Engineers and contractors must be more engaged with sustainability concepts through workshops, conferences, training...

- Value Engineering techniques should be used to look beyond the technical challenge to ethical and value issues [3].

4. References


VIRTUAL ELECTRONICS LABORATORY FOR EFFECTIVE ON-LINE EDUCATION IN ELECTRICAL ENGINEERING

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Abstract

A current trend in higher-education is on-line education. This mode of instruction is utilized extensively and has been found to be effective in a multitude of subject areas, including engineering education. However, for on-line education to be fully effective in engineering education, a means must be developed to provide on-line students with laboratory experiences that achieve the same learning outcomes as face-to-face laboratories. To address this need, a pilot computer program, Project VELVET (Virtual Electronics Laboratory for Visualized Education and Training), for a virtual electronics laboratory is being developed. VELVET operates on Windows-based computers in a real-time environment. It presents to its user a virtual breadboard into which components may be inserted. A dc power supply and a signal generator are available to supply energy and signals to circuits, and measurements may be made with a virtual multimeters and a virtual oscilloscope. Actions by the user are immediately reflected in the output from the circuits under test. To the greatest extent possible, laboratory conditions have been replicated including component to component variation and powered-on instruments. The theory of VELVET and sample screen images of the program is presented in this paper.

Keywords

Virtual Laboratories, Electronics Laboratories, Engineering Education, Learning Research, On-line Education, Distance Education

1 Introduction

On-line courses, hybrid courses, and massively open on-line courses (MOOCs) are becoming more common. Such courses offer advantages for students in that they do not necessarily need to come to campus to attend classes. This is particularly beneficial to students who cannot attend traditional classes due to inconvenient travel or conflicting work schedules. Such courses are easily implemented and are effective in replacing lectures in many fields of study. However, there are unique challenges for courses that involve a laboratory.

Many engineering courses fall into the latter category as they often contain a laboratory. Some of these laboratories may be suitable for implementation as software-based virtual laboratories while others may involve physical experiments that can be controlled remotely. Other laboratories require physical testing and experimentation methods that cannot be conducted remotely. The first type might include circuit laboratories like VELVET; materials laboratories would be examples of the third type. Mechatronics laboratories would be examples of second type (a physical laboratory suitable for remote manipulation). Laboratories which can be virtualized or made suitable for remote operation, allow more engineering courses to be offered through distance education, thereby increasing the availability of engineering education. The focus of this paper is a virtualized electronics laboratory aimed at undergraduate electrical engineering education.

2 Requirements of a virtual laboratory

To be effective in undergraduate education, a virtual laboratory must provide at least the same level of learning as does a physical laboratory. That raises a very important question: in engineering education, is the goal to teach design and applications, or is it to teach the techniques of physical
construction such as soldering or welding? In the context of current engineering education, the answer appears to be the former: teaching design principles and application of those principles, including system analysis and diagnosis. If one accepts that premise, provided that the necessary learning outcomes can be achieved, some laboratories can be virtualized, and can be effective in undergraduate education.

To be effective, a virtual laboratory must:

a) Allow students to make measurements in the virtual environment utilizing the same kinds diagnostic tools found in a physical laboratory (e.g., digital multimeter, oscilloscope).

b) Provide realistic virtual representations of the same components used in the physical laboratory.

c) Have “manufacturing tolerances” in virtual components that are of the same order as their physical counterparts; and

d) Enable achievement of the necessary student learning outcomes.

Project VELVET aims to address all of these requirements.

The software developed for implementation of the virtual laboratory must have a graphical user interface that is intuitive to an undergraduate engineering student. The learning curve must be minimal so that students spend their time in learning concepts rather than tools. The virtual breadboard circuit needs to resemble an actual breadboard with realistic components. The software must also be robust so that errors which may occur are trapped and feedback is provided to the student in much the same manner as a physical laboratory, for example, a component that is subjected to excessive power dissipation may burn out. Errors that may occur when solving a system of equations (such may occur when the values of matrix elements span many orders of magnitude) need to be dealt with in a rational manner.

3 Previous works

Many papers have been published related to the subject of virtual laboratories, applicable to diverse areas such as process engineering, electrical machinery, physics, and chemistry. For instance, Shaheed et al [1] describe a remote laboratory for the process control and automation. Tanyildizi and Orhan [2] describe a virtual laboratory for electrical machines and have developed a virtual laboratory for synchronous machinery, using Hyper Text Markup Language (HTML), Active Server pages (ASP) and Borland C++ Builder.

Ben et al [4] detail other virtual laboratory applications such as a web-based virtual oscilloscope laboratory experiment. Basher et al [3] outline a virtual laboratory for an introductory course on circuit analysis in an Electrical Engineering Technology program. They discuss the integration of LabVIEW with a PC laboratory, in which users are able to enter the parameters to be processed by means of a LabVIEW program, and data are taken with myDAQ (National Instruments, Austin TX).

4 Development of VELVET mathematical model

Figure 1 depicts of virtual breadboard and connection of resistors. This example virtual breadboard has eight connection strips for leads of components. In the left-hand of figure 1 resistor R5 has been connected between breadboard connection 1 and breadboard connection 5. The first insertion is made to breadboard connection 1; electrical node 1 (represented by the circle number 1) is assigned to this connection. The second lead insertion is made to breadboard connection 5, which is assigned to electrical node 2. The current in this component is designated $i_1$, flowing into R5 at the first lead (node 1) and leaving R5 at the second lead (node 2). Similarly the next component R1 is connected between breadboard connections 5 and 8. The connection of R1 to breadboard connection 5 does not require designation of an electrical node since connection 5 is already associated with electrical node 2. The connection of the second lead of R1 to breadboard connection 8 causes connection 8 to be mapped to electrical node 3. The current $i_2$ in R1 flows from node 2 to node 3.
Network equations are assembled as the circuit is built. Figure 2 shows the flowchart of proposed algorithm. Matrices A1, A2, A4 and S are explained in detail in below given example.

5. Validation of the Algorithm

The above algorithm is validated with the help of the following example. By following the procedure given in the mathematical model, network equations are assembled from circuit topology, and the unknown values (node voltages and branch currents) are computed.
5.1 Circuit diagram

Figure 3 is a simple example circuit consisting of three meshes involving six resistors and a dc voltage source. Numbers adjacent to the schematic indicate the assumed node numbers. There is no ground node shown in the circuit diagram; VELVET develops the network equations for all nodes and then modifies those equations after one of the nodes is selected as the reference (ground) node. Arrows indicate flow of currents in respective branches.

![Circuit diagram of example circuit](image)

From the circuit, based on Kirchhoff’s current law (KCL), node equations are formulated as:

At node 1:  
\[ i_1 - i_5 = 0 \]

At node 2:  
\[ -i_1 + i_2 + i_4 = 0 \]

At node 3:  
\[ -i_2 + i_3 + i_6 = 0 \]

At node 4:  
\[ -i_5 - i_4 - i_3 - i_7 = 0 \]

At node 5:  
\[ -i_6 + i_7 = 0 \]

From the circuit constitutive equations are formulated as follows:

For branch with R5:  
\[ \frac{v_1 - v_2}{R_5} - i_1 = 0 \]

For branch with R1:  
\[ \frac{v_2 - v_3}{R_1} - i_2 = 0 \]

For branch with R3:  
\[ \frac{v_3 - v_4}{R_3} - i_3 = 0 \]

For branch with R4:  
\[ \frac{v_2 - v_4}{R_4} - i_4 = 0 \]

For branch with R6:  
\[ \frac{v_1 - v_4}{R_6} - i_5 = 0 \]

For branch with R2 resistor:  
\[ \frac{v_3 - v_5}{R_2} - i_6 = 0 \]

For branch with voltage source:  
\[ v_5 - v_4 = \text{potential of source } V1 \ (12 \text{V in Fig.3}) \]

Using both Kirchhoff and constitutive equations we form both a square coefficient matrix \( A \) representing the left-hand sides of the equations and a column vector of known values representing the right-hand sides. The dimensions of matrix \( A \) are \( (N_{\text{nodes}} + N_{\text{branches}}) \) by \( (N_{\text{nodes}} + N_{\text{branches}}) \) where \( N_{\text{nodes}} \) is the number of nodes and \( N_{\text{branches}} \) is total number of branches. The matrix \( A \) is subdivided into four sub matrices (designated as \( A_1, A_2, A_3 \) and \( A_4 \) for the purpose of construction. A column vector of sources \( S \) and a column vector of zeroes \( Y \) are also formed and concatenated to form column vector of known values with \( (N_{\text{nodes}} + N_{\text{branches}}) \) elements. From the above equations, sub-matrices, \( A_1, A_2, A_3 \) and \( A_4 \) and vectors \( S \) and \( Y \) can be formed as:
The combined matrix formulation can be represented as:

\[
\begin{bmatrix}
A_1 & A_2 \\
A_3 & A_4
\end{bmatrix}
\begin{bmatrix}
S \\
Y
\end{bmatrix}
= \begin{bmatrix}
V \\
I
\end{bmatrix}
\]

S1 = \begin{bmatrix}
\mathbf{S}
\end{bmatrix}

When these equations are solved, vector \( V \) contains node voltages and vector \( I \) contains branch currents. Matrices \( A_3, A_4 \) and \( Y \) represent KCL and matrices \( A_1, A_2 \) and \( S \) are derived from constitutive relations.

Once the network equations are formulated, VELVET chooses a ground node based upon the circuit topology. The rules are selecting ground node follow a hierarchy. If a dc power supply is connected to the circuit, the node connected to the common terminal power supply is designated as ground. If no dc power supply is present, VELVET checks for the presence of the signal generator. If the signal generator is present, the node connected to generator reference terminal is designated as ground. If neither the power supply nor the signal generator are present, VELVET checks for the presence of the oscilloscope and/or the digital multimeter (DMM).If one of these test instruments is present, ground is assigned to the node connected to the reference lead of the instrument.(If both are present, ground is determined by the reference lead of the oscilloscope probe).

Once the ground node is determined, the column of coefficients in Matrix \( A \) corresponding to voltage at the ground node is deleted and the row representing the KCL equation at the ground node is also deleted. In the circuit of figure 3, the common lead of the dc power supply is connected to node 4, and node 4 is thus designated as ground. This designation causes the modification of matrices \( A \) and \( Y \) to form new matrices \( A' \) and \( Y' \). These new matrices are given below with deleted elements of the original matrices shown in cyan.
The values of branch currents and non-ground node voltages are computed as:

\[
\begin{bmatrix}
V' \\
I
\end{bmatrix} = A^{-1} \begin{bmatrix}
S \\
Y'
\end{bmatrix}
\]

Where \( V' \) represents node voltages and \( I \) represent branch currents. For the circuit of figure 3, the computed node voltages and branch currents are:

\[
X = \begin{bmatrix}
v_1 \\
v_2 \\
v_3 \\
v_5 \\
i_1 \\
i_2 \\
i_3 \\
i_4 \\
i_5 \\
i_6 \\
i_7
\end{bmatrix} = \begin{bmatrix}
1.165 \\
1.5534 \\
3.30 \\
12 \\
-0.00019 \\
-0.00058 \\
0.00066 \\
0.00038 \\
0.00019 \\
-0.00124 \\
-0.00124
\end{bmatrix}
\]

The network equations are re-formulated whenever there is a change in the circuit topology. This allows students to re-configure their circuits “on the fly” as occurs when a circuit element is added to or removed.

6. Sample Implementation Screens

Figure 4 shown below is the main screen of VELVET. It has breadboard and connections to a dual-output virtual power supply on the right of the screen; to the left are a virtual multimeter, an oscilloscope and the power supply. Figure 5 shows an example screen the user sees when selecting a resistor. In this case, the user has chosen a 20Ω resistor. The virtual component is shown, including a display of both its nominal and actual values.
7. Conclusion

In this paper we have outlined the preliminary development of a virtual laboratory tool for introductory circuit analysis courses. Further development is in progress; we are currently developing the methodology for incorporating reactive elements and controlled sources and activation of failure modes due to excessive power dissipation. We have included randomized component to component variability as encountered in realistic labs. We anticipate future reports as development proceeds.

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8 References


EFFICIENCY OF ASSIGNMENTS IN THE EVALUATION PROCEDURE
AT THE SCHOOL OF ENGINEERING OF THE LEBANESE
INTERNATIONAL UNIVERSITY

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Abstract
Properly evaluating students has always been an important task for university faculty members. Academic organizations continuously seek improvements in the assessment strategies at their faculties in order to keep up with the constant changes and alterations of societies, students’ backgrounds, technology advancements and curricula. A correct evaluation strategy is the one that gives students the opportunity to test their skills in the chosen domain. Furthermore, it should motivate the students for enhancing their performance while studying and conducting research. Most importantly, evaluation methods need to be well understood, accepted and respected by students. Today, assignments are considered as one of several evaluation practices conducted by engineering departments. In our study, we focus on this evaluation strategy that has always been underestimated by students and keeps being under evaluated. In this paper, we will be investigating the opinion of engineering students from different majors and levels towards assignments given to them. We will be examining the reasons that make them plagiarize their copies or ignoring them and we will be proposing different practical and constructive solutions that help overcome this issue.

Keywords – Engineering, Assignments, Plagiarism, Motivation, Evaluation

1. Introduction
Teaching, learning and evaluation are the three pillars of educational systems. These three processes are highly correlated. Their interaction and the way they are associated and applied is what distinguishes efficient and un-efficient universities educational systems. Nowadays, university faculty members employ evaluation within their curriculum in order to verify that students have learned what they were supposed to learn or not [1].

Evaluation is one of the most important steps a university student has to go through during his learning track. Even before he starts his university career, a student goes through a series of tests. These evaluations often include language proficiency level assessment for those students that have a native language different than the main teaching language of the university. In addition to language related evaluations, a student undergoes a number of general knowledge evaluations in many fields like such as mathematics and science for engineering students. This assessment allows university principals to take a decision concerning the eligibility of the student in their university. Based on assessments results, decisions vary from requesting the student to take more
language courses such as French and English – in the case where the student is not up to the
to the language level required by the university, school or department to which he is applying, or to
forbidding certain majors when the student lacks the basic knowledge needed for this major.

Once enrolled in the chosen major, the student is continuously evaluated by the mean of diverse
evaluation methods. The efficiency and value of these assessment methods is a major point for
discussion. In this paper, we will be studying the efficiency of assignments as part of the current
evaluation strategy that students go through during their academic journey. We will be
investigating students’ opinions about assignments and what forces them to underestimate their
due assignments.

To present our contribution, this paper is structured as follows: In the following section, we will
present the three different major categories of evaluation procedures and we will illustrate their
importance. In Section 3, we define assignments and present the assignment based evaluation
approach followed by the faculty of engineering at the Lebanese International University (LIU),
where the actual research is conducted. We then illustrate the goals of our study in Section 4 and
present in Sections 5 and 6 the research methodology we conducted, the results and their
analysis. Finally, we conclude and present our future work in Section 6.

2. Diagnostic, formative and summative evaluation

As soon as the student chooses his major and starts his training and learning, he goes through a
number of evaluations specific to each course he is enrolled in. These evaluations can take on
many aspects: assignments, tests, quizzes, exams, oral presentations, projects, etc. They can be
done individually, in groups or in tandem. They can also be done in class or prepared in advance
at home. These different forms of evaluation can also be grouped according to their purpose,
whether diagnostic, formative or summative.

2.1. Diagnostic Evaluation

The diagnostic evaluation is the first category to be conducted. At the beginning of the semester
or of a lesson, a diagnostic evaluation usually allow the professor to determine the capacity of his
students according to initially fixed prerequisites, and therefore adapting his teaching to their
level [2]. This evaluation is often made orally and subtly for students on an individual basis or by
group of students. This evaluation is also important in order to help students recall previously
acquired material and hence, make it easier for them to handle the newly learned topics. This
diagnostic evaluation may be repeated throughout a semester each time a new notion or topic is
addressed by the professor.

2.2. Formative Evaluation

Throughout the semester or lesson, another type of assessments are usually conducted by the
professor. These assessments called formative evaluation, allow the professor to assess the
current understanding of the students and the adequacy between their current level and the fixed
objectives of topics covered so far [3]. This evaluation is rarely graded and is used for the only
purpose of taking a decision about proceeding with the lesson as planned or rolling back to a
previous period and repeating few objectives and topics that were not clear enough to some or most of the students. This formative evaluation is usually done orally or through ungraded assignments given to students.

2.3. Summative Evaluation

The last and most renowned type of assessment is the summative evaluation. It is usually completed throughout the semester, at the end of a lesson and a course. This type of assessment is graded and done on an individual basis. Conducting this evaluation throughout the semester is essential for both students and professors. It helps students during the semester to keep track of how much they are knowledgeable in the material given in class [4]. It motivates them to study harder or change the approach in which they are reviewing the material. However, in addition to its advantage, this evaluation may have an unconstructive effect on some students, especially those who are putting much efforts for learning the material but who are not capable of providing good results in these evaluations.

In addition to its role towards students, this evaluation also provides faculty members with valuable information about the real progress of each student. Moreover, it gives them the ability to estimate the status of acquaintance of the overall class with respect to the taught material. This progressive evaluation also helps the professor take a decision concerning the upcoming academic status of the student. This decision varies from whether the student can pass the course or fails it. In the majority of engineering schools and departments, several assessment methods are usually employed in order to ensure this progressive summative evaluation procedure. The mostly utilized ones are Quizzes, Projects and Assignments. These methods are considered to be complementary to both midterm and final exams.

Although this type of assessment leads to important decision making, it has often raised questions about its efficiency, its adaptability to students and its applicability. Students often complain about a certain professor who grades harshly, or about a test that was too difficult to solve, or another that was too different from what they have learned in class. Students also criticize frequently the number and length of quizzes and assignments conducted throughout the semester. In our study, we will focus on the assignments task, in the purpose of studying their effectiveness at the university level, as well as their application, and the students’ view of them.

3. Assignments

3.1. Defining Assignment

Assignment is by definition a work related to a course that is done outside of the classroom. Its main purpose is to give students more possibilities of applying the learned concepts and knowledge without wasting class time. Assignments can have two main objectives. They are corrected by professors in the purpose of showing the students their mistakes. When necessary, they are followed by remedial sessions where the professor repeats the most common mistakes observed. In addition, since assignments fall within the summative evaluation procedure, they are corrected in the purpose of grading the students’ work. The mistakes in this case do not have a remedial value anymore but make students lose grades.
The effectiveness and the utility of assignments have been questioned throughout the years. Should the students be given assignments or not? Should the assignments be graded on a regular basis? Should they be viewed as an educational tool that has a remedial purpose, other than grades? [5]. In a study conducted in schools by Hill et al. [6] assignment is proved to improve students’ knowledge and understanding. It is considered to be a convenient way to improve students’ performance without changing the curriculum, adding more professors, or creating any other support system. The same results are shown by a study conducted by Cooper et al. [7].

On the other hand, several research work focuses on the downside of assignments. Despite their positive outcomes, assignments tend to enlarge the gap between students from high and low socioeconomic backgrounds. In fact, the latter rarely have the time or an appropriate place to do their assignments at home [8]. In the same context, Bennett et al. [9] argue that assignment is harmful for students’ health, especially when given without considering the students’ other occupations, which include family and socialization time.

While the research work showing both positive and negative outcomes of assignments at a school level, few research is actually conducted at a university level. This is one of the main motivations that encouraged us to conduct our study at a university level, especially in the engineering department where the application of the learned concepts and knowledge is fundamental.

3.2 Assignments in the Faculty of Engineering

In order to study the effectiveness of the assignment methods used by LIU, we must first examine the system followed. The overall system is determined by the dean and the council of the Faculty of Engineering which includes chairpersons and associate chairpersons: Assignments should be done throughout the semester and the average grade of these assignments will be counted in the final grade of the course. The weight of the assignments is determined by the coordinator of the course. It varies between 5% and 10% depending on the course. In addition, the number and frequency of assignments per course also varies which is also determined by the course coordinator. It usually varies between five to six assignments per course per semester. Coordinators and professors specify when each assignment will be given to students and the deadline to hand it in. Each assignment is directly related to one or several topics of the course that has been discussed during recent lectures. Their objectives is to give students material for practicing and analyzing their capabilities and consequently give them grades. This gives assignments a double objective. On one hand, they give professors the opportunity to grade students. On the other hand, they will help professors adapt their teachings to the difficulties they observed while correcting the assignments and allow students to review their mistakes and ask the professors for more clarifications.

4. Purpose of this Study

By continuously monitoring the academic performance of our engineering students, we noticed that the assignments evaluation strategy is not having the expected effect. Some students keep copying assignments, others are not handing them on time or even not turning them in at all. Therefore, we believe that it is of high importance to analyze the reasons behind this lack of
interest in assignments in order to find new methodologies that would help engineering students better understand the significance of course assignments.

The aim of our research is to find new ways and innovative methodologies for motivating students throughout their university educational journey. To be more specific, our research focuses on measuring the efficiency of assignments as an evaluation mean and analyzing the motivation of engineering students towards doing assignments in the current system. We measure the impact and correlation of this evaluation procedure with their grades and their overall seriousness towards the evaluation through assignments. We will also be investigating the reasons that make engineering students turn their interests of solving assignments into plagiarizing them. We also aim to study their opinion about four possible future changes in the assignment evaluation method. The purpose of these adjustments is to motivate students to give more interest to assignments and consequently devote more effort and time for studying and practicing their course materials. As mentioned in section 3.1, solving the courses’ assignments is one of the most important ways to improve the overall knowledge of the material, and therefore a good way to improve grades.

Usually, students highly value their grades and their GPA. Although they have to hand-in five to six assignments per course, as mentioned in section 3.2, their work and efforts only count for 5 or 10% of the general grade. This might discourage students to do the assignments, at the risk of losing this little percentage, and concentrate more on parts that give them more grades such as exams, quizzes or projects. One way to solve this problem is to give assignments more weight in the overall average, through two methods. The first method consists of extracting quizzes from previously corrected assignments. This approach gives students the possibility of achieving better grades on the quizzes. The second method involves in-class solving of an assignment where the professor allows students to solve parts of it on the board and get extra grades in return.

A third method in motivating students is related to another problem they evoke when it comes to assignments. They often claim that they don’t have enough time to solve them due to the large load of courses they have and that assignments are usually too long and take too much time. In order to solve this issue, we propose that the professor and coordinator specify the time needed for solving each assignment. This will allow them and the department’s chairperson to control the load of work given to students. In addition, students will be able to monitor their performance by controlling the time of solving as well as manage their workload. We also suggest posting assignments online as a fourth method. This e-approach may be appealing for students since it uses modern technology.

5. Research Methodology

In order to collect information about how students consider assignments given, we created a survey and submitted it anonymously to 75 students from the faculty of engineering. The students were randomly selected from those enrolled in the faculty, on both Bachelor of Science (BS) and Masters of Science (MS) levels. The students were following three different curricula:
CCE (Computer and Communication Engineering), MENG (Mechanical Engineering) and EENG (Electrical Engineering).

The survey included closed questions. These questions aimed to identify the opinions of the students about the current assignment procedure and their motivation towards this form of evaluation as well as their opinions towards the three changes that we suggested in the purpose of motivating them.

6. Results and Analysis

In this section we will be presenting the results of the survey we conducted. First we show some generalities about the students that took this survey like their gender, major, academic level and Grade Point Average (GPA).

6.1. Population generalities

![Figure 1 Students Grouping by Gender](image1)

![Figure 2 Students Grouping by Major](image2)

![Figure 3 Students Grouping by Level](image3)

![Figure 4 Students Grouping by GPA](image4)

Although students were selected randomly, we can clearly see that most of them (75%) are males (see Figure 1). This is mainly due to the prejudice about engineering being unsuitable for female students and that is still influencing their choice of major. The students are distributed on three majors as follows: 37% Mechanical Engineering (MENG), 29% Computer and Communication Engineering (CCE), and 34% Electrical Engineering (EENG) (as shown in Figure 2). 67% of the students are at the BS level and 33% at the MS level (as shown in Figure 3). More than half of them (54%) have a GPA between 2 and 3 out of 4 while few have lower (11%) or higher (35%) GPAs (as shown in Figure 4).

6.2. Plagiarizing assignments

As we mentioned in section 4, the main purpose of our research is to study the attitude of students towards assignments. Figure 5 and Figure 6 show that for both MS and BS students only few (32%) never plagiarize their assignments from their classmates while 68% of them do copy them.
Even though assignments aim to allow students to practice their acquired knowledge, an important portion of them are ignoring its importance by simply copying the solutions. By analyzing the average GPA of the students grouped by their frequency of plagiarizing assignments, we can notice that those who often plagiarize have a lower GPA than those who don’t (see Figure 7).

In our survey, we also studied the interest of students in re-solving assignments after plagiarizing them. As assignments are being graded, some students prefer to hand in copied assignments – which will ensure a good grade – and later try to solve the exercises on their own, without fearing that any mistake will affect their grades. Figure 8 shows that 40% of BS students who copy their assignments are not involved in attempting to resolve them while 29% occasionally try to. These results show that BS students may be lacking motivation and are not fully aware of the importance of spending time solving exercises and assignments at home. As for MS students, Figure 9 shows that only 10% do not re-solve their assignments while 53% make sure to resolve them. This difference between MS and BS students may be linked to the academic maturity of those who are in MS and their understanding of the importance of assignments.
These previously mentioned results, help us rise a new important question: What are the reasons that make engineering students overlook their assignments?

In Figure 10, we can see that engineering students may need help in improving their time management capabilities especially MS students, since the lack of time seems to be the main reason for plagiarizing. This may be due to several reasons such as their heavy course load, their inability to understand the material in a limited time or any other external conditions like their entourage or their jobs. We also think that our BS students are in need of better motivation for studying and solving problems whether this motivation is provided by faculty members or their families.

Figure 11 shows statistics about time students are dedicating to study the material of one course per week. We can see that majority of students who often plagiarize their assignments are dedicating less than one hour per week to study the material of one course. In engineering majors, dedicating less than one hour cannot be considered as enough for efficiently studying a course’s material.

We also questioned the students about their self-satisfaction as engineering students about the time they spend weekly for studying. In Figure 12 we can clearly notice that most of the students who often plagiarize their assignments are not self-satisfied. Hence, these students are aware that they need to devote more time for studying. Therefore, new measures and approaches should be analyzed for improving the motivation of these students.
6.3. Motivation to do assignments

Since most students lack motivation to do their assignments, we tried to find some ways to motivate them. Figure 13 shows that 55% of students think that posting assignments online would give them better motivation for studying and solving assignments while 45% believe that it is an inefficient approach for being motivated.

Figure 14 and Figure 15 give clear solutions about what may motivate the students to accomplish their assignments. Students are highly motivated to solve assignments when there is some kind of a trustworthy reward. Linking assignments to quizzes may be one solution. 83% of students answered positively for extracting exercises from assignments and inserting them into quizzes. Only 17% think that this approach will not help them being better motivated.

Another solution would be asking students to solve extracted parts of assignments in class for extra points. 76% consider that this approach will help them improve their desire to take assignments seriously and practice them at home, while 24% consider this approach inefficient.
Figure 16 shows the students’ level of interest if time was linked with assignments exercises. In other words, we asked the students if they would be better motivated when professors specify the approximate time needed to solve assignments. This solution will help them manage their time and will allow them to control their performance while solving the assignment. Like the two previous solutions, this one showed good appeal from the students: 77% think it would help them get motivated to do their assignments and would help them evaluate the time needed to solve problems while only 23% of students said that it would not help.

7. Conclusion & Future Work

In this paper, we investigated an important evaluation issue that most engineering schools face. We studied the reasons that make engineering students plagiarize their assignment and what pushes them to underestimate this evaluation practice. We conclude that an important number of the students copy or neglect their assignments. Their lack of time and motivation, and their high interest in grades pushes them to plagiarism. Of the possible approaches we suggested as solutions, three held the attention of the students. Specifying the time needed to solve an assignment seems to interest the students. This method will help them monitor their performance as well as motivate them to practice more often. Extracting quizzes from assignments helps students get better grades and therefore motivates them to solve the assignment on their own. A similar approach also found appealing by the students is offering extra grades for solving parts of the assignment in class. This study shows that the assignment system followed by the Faculty of Engineering does not adhere to the students’ interests and needs revising and adjusting in order to better fit its purpose.

This study opens up broad opportunities for future work. We will apply these new proposed strategies and analyze their efficiency in improving the performance of students. As an expansion to this study, we will be analyzing the influence of the students’ social background on their academic performance and on their motivation to learn.

References
Abstract: Generally, students have different attitudes about learning and have different learning styles which affect their comprehension and processing of information. Engineering instructors should take these facts into consideration by choosing the optimal teaching strategies. Educational researchers proved that active learning strategies encourage a deeper comprehension of the learning material covered in a class; this is due to the fact that these teaching strategies involve the students in the learning process. This article explores the different learning styles and teaching strategies. However, this research also highlights the benefits of combining different methods in order to optimize learning efficiency and to promote the teaching reform while achieving diversification of teaching Techniques.

Keywords: engineering education, learning styles, teaching strategies, teaching Techniques.

1. Introduction

What have really changed in most engineering classrooms today? In a normal class, a professor stands in front of the students, near the board, maybe using an overhead projector, writes his notes while lecturing. Passively, the students copy or read the notes, complete another course’s homework, play with their smartphones or just relax and dream. Every now and then, the professor asks a question related to the material being taught; the answer may come or may not, mostly from the students in the front row. So what does this classic scene reflects: Is it the incompetence of the professor or the nonchalance of the students?

Generally, there are some mismatches between common learning styles of engineering students and traditional teaching strategies which may affect the performance of students in class, tests or projects. In recent years, new teaching approaches have been introduced to the engineering education to promote the participation of students in the classrooms; Professors begun to feel more adequate to adopt these new techniques with the increasing necessity of changing the way they teach. The question resides in adapting the teaching strategies to the diversification of learning styles. This paper will present an overview of the different learning styles and teaching strategies and will offer a potential proposition for combining those two in order to optimize learning efficiency.
2. Learning Styles

How much a given student learns in a class is related to the student’s ability and motivation but also by his adaptability of his learning style and the instructor’s teaching strategies. When designing a course material, it is mandatory to understand the individual learning styles of students in order to accommodate the best teaching practices and methods. Each student has his own attitude, interests, levels of motivation and capacity. Some students might adapt easily with a math course, its complex concepts and its abstract theories others might be more interested with concrete material and practical hands-on experiments. McLoughlin (1999) defined learning style as “adopting a habitual and distinct mode of acquiring knowledge” which affects the comprehension and the processing of information. [1]

Carl Jung was the first to define the learning style theory when he described the differences in the way people perceived information via their intuition or sensation, how did they take decisions using their logical thinking or their feelings and the way they interact being introverted or extraverted. [2] Later on in 1977, Isabel Briggs Myers and her mother Katharine Cook Briggs implemented Jung’s ideas and added her own insights; eventually they created the Myers-Briggs Type Indicator (MTBI). [3] This test was used to assess personality type which meant to help people realize their "best fit type". Isabel and Katharine added to Jung’s typology a fourth pair, Judging and Perceiving. Furthermore, several learning style models have been developed and applied to engineering education. [4][5][6][7][8]

Each learning-style theorist has his own interpretation of personality, but almost all the models have two things in common: [9]

- **A focus on Process**: all models should be concerned with the process of learning which describes how people absorb information, think about it and evaluate the results.
- **An emphasis on personality**: learning is generally a result of a personal, individualized act of thought and feeling.

Almost all learning-style theorists defined four basic styles. Silver, Strong and Perini described the following four styles related relatively to Jung’s theory: [10]

- **Mastery or Sensing-Thinking**: The learner absorbs information concretely and sequentially and evaluates the value of learning in terms of its practicality. Students thoroughly learn all material they are studying and do not progress on to learning new material until they have mastered current material. This gives them a feeling of control. Mastery students want to appear competent, able to complete the work assigned better than other students in their classrooms.
• **Understanding or Intuitive-Thinking**: The learner learns through a process of questioning, reasoning, and testing using abstractions. He evaluates learning by logic. Students understand a mathematical concept if one can solve problems using it, especially problems that are not similar to what one has seen before. They are motivated largely by a need to understand and question what they learn.

• **Self-Expressive or Intuitive-Feeling**: The learner uses feelings and emotions to construct new ideas and looks for representations and images in the information. He evaluates learning according to its originality and its surprising aspect. Students use hunch and guessing to organize the world into shifting patterns of possibility. Their feelings and emotions turn these patterns into concrete images so they can use to understand what they are learning.

• **Interpersonal or Sensing-Feeling**: Close to the Mastery learner, prefers to learn socially and focuses on the physical-concrete nature of the world. He evaluates learning in terms of its potential use in helping others. But, unlike Mastery learners who transform the data into separate details, Interpersonal learners extend these concrete sensations into images and emotions related to their personal experience. Interpersonal students believe that they are part of a team or cooperative group and are strongly motivated by their relationships to the teacher, to the other students.

Silver and strong defined approximately the percentage of people with strengths in each style as follows: Mastery 35 %, Understanding 18%, Self-Expressive 12 % and Interpersonal 35 %. [9]

Felder and Silverman defined 5 dimensions of learning styles: Sensing/intuitive; Visual/auditory (verbal); Inductive/deductive; Active/Reflective; Sequential/Global. In each dimension, most students are in both poles, but they tend to favor one over the other. [11]

### 2.1 Sensing / Intuitive learners

A dimension in Jung's theory of psychological types related to the perception of information. [12] **Sensory** (external): sights, sounds, physical sensations or **intuitive** (internal): possibilities, insights, hunches. **Sensing learners** are more concrete, practical, oriented toward facts, careful but may be slow, patient with detail but do not like complications. **Intuitive learners** use speculation, imagination in grasping new concepts; they are conceptual, innovative, oriented toward theories, quick but may be careless, bored by detail and welcome complications. In timed tests, sensors and intuitors may do poorly due to different reasons; learners frequently run out of time because they must read questions several times before answering. However intuitors
are impatient with details which may induce them to answer carelessly before reading thoroughly the questions.

2.2 Visual / auditory (verbal) learners
A dimension formulated by Dunn et al. related to the input of information. [13] Visual: pictures, diagrams, graphs, demonstrations or auditory: words, sounds. Visual learners prefer visual representations of presented material like pictures, diagrams and flow charts, time lines, films, demonstrations. They tend to remember what they see more than what is said to them as they will probably forget it. Verbal learners prefer written and spoken explanations. They tend to remember much of what they hear and more of what they hear and then say. They favor verbal explanation and learn effectively by explaining things to others. A study concludes that students retain 10 percent of what they read, 26 percent of what they hear, 30 percent of what they see, 50 percent of what they see and hear, 70 percent of what they say, and 90 percent of what they say as they do something. [14]

2.3 Inductive / deductive learners
A dimension from the model of Guild and Garger related to the organization of information. [15] Inductive: principles (governing rules, laws, theories) are inferred from the given facts (observations, measurements and data) or deductive: principles are given then the consequences and applications are deduced. Induction is the natural human learning style. Most of what we learn comes from our experience in a real life situation not from a principal. Deduction is the natural current human teaching style. It begins with stating the general principles then presenting the applications. Inductive learners need some motivation to promote their learning process. Similarly to the sensing learners they need to see the concrete application before understanding the governing theory. So they will not appreciate the need of such theories if there aren’t enough applications.

2.4 Active / Reflective learners
A component of a learning style model developed by Kolb and related to the input of information. [16] Actively (extravert): through engagement in a physical activity (experiment), in a discussion or by trying things out. Reflectively (introvert): through Introspection by thinking individually (observation) and by working alone. Active learners do not adapt to passive situations, such in most lectures. They need to do something in class like discussing, arguing and brainstorming other than passively watching or listening. Reflective learners do not adapt to contexts that doesn’t provide any chance to think about the material being taught, such in most lectures. Consequently, they tend to be theoreticians and modelers. Reflective learners can define the problems and simulate the possible solutions while active experimenters
design and execute the working ideas as decision-makers. Generally, engineers tend to be more likely active than reflective learners, and they are both needed as engineers.\textsuperscript{[13]}

2.5 Global / Sequential learners

Defined by Pask as Holist and Serialist. These two dimensions are related to the understanding of information.\textsuperscript{[17]} Globally (Holist): tend to learn in large jumps, known as system thinkers. Sequentially (Serialist): tend to learn in incremental, ordered and continual steps. Global learners learn in layers and they prefer to have an overview of the material being taught before going into the detailed complex process. They prefer having like a concept map that shows the whole picture of what they are working toward. Generally they are uncomfortable with step-by-step instructions as they tend to over generalize. They require a certain preference for considerable freedom to explore. Sequential learners learn whatever they are shown immediately as they prefer to proceed step-by-step, in an ordered way, to the end result. They might not be able to see the whole picture of the material like the global learners. They follow linear reasoning processes when solving problems and require a preference for an equitable degree of structure and guidance.\textsuperscript{[18]}

Eventually, engineering instructors who try to globe both poles of these dimensions in their teaching strategies might provide an optimal learning environment for all students in their class. However, most engineering students are visual, sensing, inductive and active while most engineering education is auditory, abstract (intuitive), deductive, passive and sequential.\textsuperscript{[10]} These mismatches may cause a lack in students' performance. So before presenting the potential solution to this situation, the next section will offer a resume of the teaching strategies.

3. Combining Teaching strategies

Previous studies have pointed the effect of applied teaching strategies on the teaching quality by using methods that adapt to their learning styles preferences.\textsuperscript{[19][20][21]} The following table presents the relationships between students learning styles with its correspondent teaching strategy.

<table>
<thead>
<tr>
<th>Learning Styles</th>
<th>Sensing</th>
<th>Intuitive</th>
<th>Visual</th>
<th>Auditory</th>
<th>Active</th>
<th>Reflective</th>
<th>Sequential</th>
<th>Global</th>
<th>Inductive</th>
<th>Deductive</th>
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<tr>
<td>Lecture</td>
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<td></td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td></td>
<td>✓</td>
</tr>
<tr>
<td>Presentation</td>
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<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Discussion Panel and debate</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 1. Relationship between learning styles and teaching strategies
### Learning Styles

<table>
<thead>
<tr>
<th>Role playing</th>
<th>Sensing</th>
<th>Intuitive</th>
<th>Visual</th>
<th>Auditory</th>
<th>Active</th>
<th>Reflective</th>
<th>Sequential</th>
<th>Global</th>
<th>Inductive</th>
<th>Deductive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case study</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Brainstorming</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Games and simulation</td>
<td>✔</td>
<td>✔</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Questioning</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Problem based learning</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Project based learning</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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</tr>
<tr>
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<td>✔</td>
<td>✔</td>
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</tr>
<tr>
<td>Demonstration</td>
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<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
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</tr>
<tr>
<td>Group project</td>
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<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
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<tr>
<td>Individual project</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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</tbody>
</table>

This table should allow the engineering instructor to determine the appropriate teaching strategy related to the students’ learning styles. In order to achieve such a solution, the instructor should define the different learning styles in class, and then apply a combination of teaching strategies accordingly. Instructors confronted with these teaching techniques might feel uncomfortable and anxious about doing all of this in one course and still cover the syllabus. However, the instructor should try some of these techniques and evaluate their efficiency compared to the availability of resources and to the performance of students.

### 4. Conclusion

Learning styles are not permanent for individuals; it develops and changes as the person grows. Most students practice a mixture of learning styles throughout their life as they learn; these styles might change and adapt to various situations or teaching contexts. On the other hand, teaching strategies should consider the diversification of learning styles while remaining effective for the engineering students and comfortable for instructors.

### 5. References


FLIPPING AN ENGINEERING COURSE: IMPLEMENTATION AND RESULTS

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Abstract: Recent technological advances gave rise to online and blended classrooms. At the center of blended learning is the flipped (or inverted) classroom, in which the lecture is usually watched on a video outside the classroom while practicing problem solving, group work and discussions inside the classroom. This article compared the efficiency of flipped classroom versus a traditional classroom in a senior Mechanical Engineering course at the Lebanese American University. Two sections of the Control Systems course were delivered simultaneously, one in the traditional format and the other in the flipped format. The encouraging results demonstrated significant improvement in student performance on exams, and approximately 90% of the students that experienced the flipped pedagogy preferred it over the traditional format and would like to see it implemented in other courses.

1 Introduction
According to the National Academy of Engineering (NAE)’s Engineer of 2020, there is a pressing need to redesign engineering education. The change should be toward making it more effective, relevant, and appealing to students [1]. Flipped classroom is a form of blended learning approach that intentionally interchanges lectures, content and asynchronous activities into an online learning environment such as videos. While instructors will use classroom time for solving problems and performing group-based activities that increase student engagement, deepen understanding of concepts and improve mastery of skills [2-5].

Most of the studies in this area demonstrated that flipping the classroom is effective in engineering education [6-8]. It shifts the learning process from one that is instructor centered toward an engaged and student centered educational process. Flipped classrooms take the better from two worlds: online and face-to-face learning. Online learning is convenient, cost effective, and teaches the student to be a more effective time manager. However, classical face-to-face experience is known to provide a more effective student-instructor and student-student interactions, better motivation, and student mentoring and support. Most importantly, a Flipped classroom offers the convenience to students while freeing classroom time for adding more effective learner centered and highly interactive activities [9]. On the other hand, fewer studies were not as favorable to the flipped format as they did not show significant improvements in student learning outcomes, while they cited increased studying load for students and heavy preparation time for faculty members [10-11].

This study is part of exploring the various uses of technology in the classroom and the direction in which technology should be heading at the Lebanese American University. It compares the effectiveness of the Flipped classroom versus the traditional classroom in Control Systems which is a senior Mechanical Engineering course. This study is especially interesting since it compares these two learning pedagogies in an engineering class with majority students from the Middle East, however learning in an American style university. Specifically, the main objective was to highlight the findings with regard to the connection between the classroom configuration and students' learning attitude, perception and
achievement. The first section elaborates the Methodology implemented, next the results are presented and analyzed, and finally a conclusion is drawn.

2 Methodology

This study took place in two sections of the MEE445 Control Systems courses taught at the Lebanese American University during the Fall 2014 semester. The three credit course is required for all senior Mechanical Engineering Students. The course is usually registered along with a 1 credit laboratory applied control sessions. The semester is 14 weeks long and the courses was delivered on Monday, Wednesday, and Friday (50min long sessions). The course is the first exposure of students to the theory of Control Systems. The covered topics are system modeling, review of Laplace Methods, Root Locus Analysis, Bode plots, Nyquist Plots, and design of PID and Lead Lag controllers using either Root locus or frequency methods. The adopted textbook for both section is “Modern Control Systems” (10th Edition) by Richard C. Dorf and Robert H. Bishop. The accompanying Lab course covers Real-time coding using LabVIEW on NI myRIO FPGA systems, performing identification and modeling of a DC motor, and controlling the position and velocity of the DC motor using PID designs (hardware developed by Quanser [12]).

One section of the course was delivered in the traditional lecture format, while the second was delivered using the flipped format. The numbers of students enrolled in the flipped and traditional sections were 34 and 44 respectively. The courses were taught by the same instructor in consequent time slots (10am and 11am). The students in both sections took the same exams at the same time during after-hours. The mixed exams of both sections were corrected simultaneously, one problem at a time, in order to avoid any bias.

2.1 Traditional Classroom

The first section of the Control Systems course was taught using traditional lecture method. The class composed of 44 students out of which 6 were females and 38 were males. Most of the students were senior students. The course material was delivered with the aid of PowerPoint slides, which guide the lecture and contain the main part of the course material. Some parts of the slides, like the problem solving examples and some equations that are derived in class are left blank in order to promote student engagement. All students had access to the PowerPoint slides to print and use in class.

The instructor has been delivering this course in the traditional configuration for the past 8 years. Approximately 75% of the class sessions were lectures, 20% text-book like problem solving, and the remaining 5% were MATLAB tutorial/simulations sessions. Pop quizzes were performed in class on average one each two weeks, Homework assignments from the text-book were given to the students from the beginning of the semester. The Homework assignments were not graded nor collected. Apart from quizzes most of the problems were solved by the instructor in class. The course was assessed through the quizzes (5%), Exam 1 and Exam 2 (55%) and a Final Exam (40%). The MATLAB tutorials demonstrated to students on how to design and simulate the response of a PID controller using either the Root Locus or Bode Plot methods.

2.2 Flipped Classroom

The second section of the course was taught using the Flipped configuration. The class composed of 33 students out of which 5 were females and 28 were males. Most of the students were also senior students.

The lectures were entirely recorded on video and provided to the students at least 48 hours prior to each session. The total length of the video for one session (50 minutes in traditional format) was approximately 20 minutes. Usually the lecture was usually split into two movies in order to optimize toward the attention
span of the student and have it elaborate only one topic. The length of these movies varied from 5 to 15 minutes depending on the topics covered. Some of the movies provided examples of problem solving. The movies displayed the video of the instructor explaining the material along with the original PowerPoint Slides marked live using a Wacom tablet pen. Camtasia software was also used to screen capture, record the instructor’s lecture and later edit and compile the movie. The movies were disseminated using LAU’s Learning Management System which was Blackboard Learn. Each session’s worth of videos took approximately one and half hours to record and 3 hours to edit, compile, and upload. The students were also expected to solve the same Homework assignments as in the Traditional section. They also had access to the PowerPoint slides, and are expected to have the textbook and read through it before the class sessions.

Class time started with a 5 minutes quick review of material covered in the videos, many times it was followed by a quiz, and the remaining time was assigned to either problem solving, MATLAB simulations, or group-work case studies or design problems. Approximately 24 quizzes were performed, only 10 were collected and graded. The quizzes were all performed while the students were not informed whether they will be graded or not. This is done to save the time needed to correct quizzes while making sure the students are taking them seriously. Another method implemented was to collect only the ones that got the correct answer after a quick scan by the instructor. This had the advantage of pushing students to obtain complete answers by the time allocated. The major disadvantage was that low performing students ended giving up without attempting the quizzes.

The problems that were solved are similar to text-book problems and very similar to those assigned as Homework. For this session the assigned Homework problems were there for students to reinforce their knowledge. The major difference as compared to the traditional section, is that the students would solve the problems either individually or in groups and later one of them will go to the board to present the solution. The instructor answered questions as he moved around class, monitored the progress of the students, engaged with the low performing students and helped them in sharpening their problem solving skills. However for complicated problems, the students will attempt as usual, while the instructor will solve on the board. A photo of typical group work taking place in the Flipped Section is shown in Figure 1.

![Figure 1 Students solving problems in the Flipped Classroom](image)

The Flipped section had at least twice more MATLAB sessions. The Traditional section had 2 MATLAB sessions, while the Flipped section had approximately 6 MATLAB sessions. Both sections learned the
basics of designing and simulating controllers while the Flipped section practiced using MATLAB to perform design and simulation of controllers in a more complex setting. Furthermore, MATLAB was used in the Flipped section to demonstrate the theoretical relations between root locus and response.

3 Results
The success of the Flipped classrooms compared to that of the Traditional classroom was evaluated by the content coverage, student performance on Exam 1 and Exam 2, and a survey on student perception that was conducted twice.

3.1 Content Coverage
The Control Systems course was well covered and there was no need to expand the content coverage. All topics stated in the course description and the course syllabus were properly covered. However during the group discussions in the flipped classroom, new concepts were elaborated. Furthermore, more sophisticated problems were covered in the flipped classroom. This happened naturally when all the regular problems were solved and the instructor had to fill class time. The extra MATLAB sessions also elaborated more content such as using Simulink to simulate the response of controlled systems. According to the instructor only few new topics were introduced, while all the material delivered was more complex and better elaborated.

3.2 Student Performance
To eliminate bias in the student performance level between the two sections; the classes were informed about the flipped format on the first day of the semester, and the low enrolled section was selected to be flipped. As mentioned earlier, the section that was selected to be Traditional was already full with 44 students. Hence, students could not run away from the Flipped section, which was not initially attractive due to the fact it was implemented for the first time.

The student performance is determined using the grades of Exam 1 and Exam 2, while eliminating the data of the quizzes and the Final exam. The quizzes cannot be delivered simultaneously, therefore different quizzes were given to each section. The result of the Final exam proved to be an outlier to the data of Exam 1 and Exam 2, despite the fact that these exams covers more than 95% of the material. After investigations with students, it turned out that the top performing students did not need to score high on the Final Exam to secure a good grade, hence they focused on other courses.

Table 1 Statistical summary of the grades of Exam 1 and Exam 2 for the Flipped and the Traditional Sections.

<table>
<thead>
<tr>
<th></th>
<th>Flipped</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>34</td>
<td>44</td>
</tr>
<tr>
<td>Minimum</td>
<td>30</td>
<td>17</td>
</tr>
<tr>
<td>Average</td>
<td>61.62</td>
<td>58.23</td>
</tr>
<tr>
<td>Maximum</td>
<td>93</td>
<td>90</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>18.12</td>
<td>18.01</td>
</tr>
<tr>
<td>Exam 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>33</td>
<td>44</td>
</tr>
<tr>
<td>Minimum</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>Average</td>
<td>85.27</td>
<td>79.98</td>
</tr>
<tr>
<td>Maximum</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>10.67</td>
<td>18.02</td>
</tr>
</tbody>
</table>
The histogram of the grades of Exam 1 and Exam 2 are shown in Figure 2, while the summary of the statistics are shown in Table 1. The statistics show a clear outperformance of the students in the flipped section compared to those in the traditional section. For instance, on Exam 1 there is 3.39 point increase on the average which corresponds to 5.8%. While on Exam 2 there is 5.29 point increase which corresponds to 6.6% increase. Furthermore, looking at the histograms, it could be noticed that low performing students did not score as low as in the traditional section. This trend was further emphasized in Exam 2.
A survey on student perception of the effectiveness and appreciation of the Flipped classroom was conducted. The survey asked 6 question on how much they like the Flipped format and if they like to see it implemented in other courses. It also asked about their preference of problem solving in class and how much time they are spending in preparing for the course. The questions and chart representation of the results are shown in Figure 3. The first time the survey was conducted was in week 5 which happened to
be one week before Exam 1. The same survey was also conducted in the last week of class. The same questions were asked at the same time for both sections.

The results from the survey indicate that approximately 94% of the students enrolled in the Flipped section preferred the Flipped format as compared to the traditional format. This number did not change between the first and second survey. On the other hand, approximately 90% of the students enrolled in the Traditional Section did not prefer the Flipped format in the first survey. This is expected due to the fear that most students do show when exposed to new pedagogies. However, this number change to approximately 50%, and this is due to the fact that students learned from their colleagues about the activities going on in the other section. Also from the comments the authors learned that some students in the Traditional Section got copies of the lecture videos from their colleagues. This proved to be a convenience for several students, especially those who can’t concentrate well in class.

A similar trend could be observed when the students were asked if they like to see the Flipped format implemented in other courses. The flipped section responded with approximately 88% positive response in both surveys, while the traditional section started with 28% in the first survey increasing to 67% positive response in the second survey. Overall, one can conclude that students’ perception of the effectiveness and appreciation of the Flipped classroom was positive especially among those who have experienced flipped learning and it improved for the students in the traditional section as the semester went along and students became aware about the Flipped format.

Another aspect monitored in the survey is the amount of time students are spending on class preparations and on Homework assignments. The data demonstrate that the Flipped section students are spending more time on the class preparation and less time on the Homework assignment. This is as expected in the Flipped format.

4 Conclusion
A senior level Engineering course was simultaneously offered in a Traditional and a Flipped format at the Lebanese American University. The effectiveness of the two delivery methods is compared in terms of content coverage, student performance on exams and student satisfaction and perception. The face-to-face time in the flipped classroom was reduced thus enabling the faculty to cover topics with more depth. The students taking the Flipped section performed approximately 6% better on average on Exam 1 and Exam 2. Furthermore, a survey on student perception was administered twice, the first time at the beginning of the course before Exam 1 and the second time during the last week of the course. The survey demonstrated that approximately 90% of the students experiencing the Flipped format preferred it over the Traditional format and they also would like to see it implemented in other courses. This result was consistent in both survey results. However, the students registered in the Traditional section did not appreciate the Flipped format in the beginning while this improved as they learned more about it from their colleagues. For instance, at the time of the first survey only 10% of these students preferred the Flipped classroom, while this number improved to 50% at the end of the course.

In summary, the flipped classroom format proved to be an effective method that has the potential to enhance student learning outcomes while providing a more efficient and likeable overall learning environment.
5 References


EXPERIENCES AND LESSONS LEARNT FROM EMBEDDING SUSTAINABILITY IN ENGINEERING

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ABSTRACT

Problem based learning (PBL) offers educational institutions involved with delivering quality education an avenue for creating a transformational culture with global outlook while enabling students to acquire needed skills for effective engagement in society. Students were able to assume roles as business consultants, through team projects initiatives which required implementation of sustainability ideas. Identification of stakeholders and mapping out how well their respective interests could be satisfied is highly impactful and focuses the students in putting into use skills developed through role-play. Making contacts with professionals within the university and ‘clients’ from outside organisations made project briefs and outcomes realistic, thereby creating value added experience for the students. Analyses of survey data suggest that students perceived that the PBL course unit had effected changes in their attitudes as well as in their knowledge and skills. Typical transformational feedback from students who were involved with courses based on the PBL approach at Manchester, ranged from strong interests in pursuing careers in sustainability and international developments, social innovation, humanitarian aid, and green businesses. Delivered lectures alone, have been well established to be inadequate in developing critical thinking and required problem-solving skills, for example, professional engineers.

Key words: Sustainable development, diversity, skills acquisition, global social responsibility, engineering education

1.0 Introduction

Research on education suggests that the use of traditional methods alone does not assist in providing our graduates with the skillset required in the workplace. Wals in of his work [1] on sustainability in higher education suggests that the nature of education for sustainable development demands new perspectives on matters like curriculum, teaching and learning. Other authors [2-3] studied different approaches to education for sustainable development for engineers and emphasized the need for a holistic approach, deduced in their studies that a traditional approach to education with theoretical classes is insufficient. Steinemann supports this view adding that “[t]raditional methods of academic instruction, such as lectures, may inadequately prepare students to make the transition from the
Sustainability embedded in education leads to a more transformational effect on students beyond the classroom. Stephen Sterling [13] suggests that transformative learning enables the student to move out of his or her paradigm and is essential for education in sustainable development. “It is not then just a matter of intellectual or conceptual learning, but engages our emotional and intuitive selves as well”. Jack Mezirow [14] described transformative learning as ‘learning that transforms problematic frames of reference to make them more inclusive, discriminating, open, reflective and emotionally able to change.’ The UNESCO DESD review [1] strongly suggests that the traditional method of learning is rather regurgitative and that the application of sustainability in education demands “new kinds of learning … of a transformative nature (i.e. learning as change)”. This new ‘kind of learning’ or approach to learning can be facilitated through application of a problem-based approach.

Problem-based learning has been an effective teaching approach, which utilises a multifaceted real-world problem set to challenge students’ learning. The PBL approach with the courses considered at the University of Manchester is kick-started with a ‘trigger’ to get students’ minds focussed on problem-solving attitude, in a radical move away from being spoon-fed with knowledge such as in traditional lectures. Courses conclude with a reflective report and are further described in the nine steps design as described by [15]. This effectively focused the learning responsibility and knowledge ownership to the students, away from a didactic instructor.

2.0 Research Design and Strategy

In this section, the main focus is the research methods used to gather and analyse the empirical data. The choice of these methods is derived from the underlying research methodology, which has a quantitative focus and relates to the aim and objectives of the study. In the context of the aim of this paper, which is, to gain an understanding of the lessons learnt, both rewards and challenges, from embedding sustainability in the engineering curricula, the objective is to arrive at the aim primarily from the perspective of engineering students who have taken courses driven by a sustainability agenda.

This paper thus discusses the experiences and lessons learnt from embedding sustainability in the engineering curricula at the University of Manchester. In so doing, it considers the responses from students taking courses both in the School of engineering and interdisciplinary courses in the Business School. The paper, therefore, makes a case for problem-based learning for ensuring sustainable engineering education, and compliments similar initiatives championed by The Royal Academy of Engineering [15].
Figure 1: Illustration of major responses and key indicators for the embedded sustainability modules considered in this paper.

Drawing on ideas reviewed in the introduction, a framework was devised to examine the research aim. The idea was to develop from the current discourse on Sustainability in the Engineering Curricula an agenda that could be operationalised for examining the research aim of this paper. This framework comprised three main sections: the learning process, learning outcomes and employability skills. The Learning Process looks primarily at study skills, new ideas and new information that the student has developed as a result of engaging in the sustainability aspect of the course through a problem-based approach. Learning Outcomes focuses on how the student’s behaviour toward applying sustainability ideas in everyday life has changed as a result of engaging in the sustainability aspect of the course. It also reflects the influence this aspect of the course has had on the student’s attitude and aptitude in other areas such as communicating ideas, understanding and appreciation for sustainability issues and engineering studies, and the practice of reflection to reinforce learning and overall adeptness to studying. The third element of the framework, Employability Skills, focuses on the level of confidence the student has gained toward becoming employable at the end of his degree program as a result of participating in an engineering course in which sustainability was embedded through a problem-based approach. This element of the framework considers teamwork skills the student has gained, online technology engagement and overall feelings about employability confidence.

A questionnaire reflecting the framework was designed and given to 74 students from the School of Mechanical, Aerospace and Civil Engineering. Of the 74 questionnaires distributed 64 were returned fully or partially completed. Similarly, survey data from another undergraduate module MCEL30022 ‘Interdisciplinary Sustainable Development’, which was delivered by Manchester Business School (Manchester Enterprise Centre) in the second semester of 2013/2014 academic session with majority of the 49 registrants as engineering students, are also analysed comparatively.

Sustainability, in the modules considered, denotes ideas and undertakings which promote consideration for social, economic and environmental aspects as they relate to case studies.

2.1 The Role of a facilitator
A trained facilitator (oftentimes a post-graduate research student or doctoral researcher) is assigned to a team. Each facilitator is committed to be present at all scheduled team meetings; treat students courteously with professional courtesy; keep the team focused on deliverables; stimulate curiosity and intervene to promote informed team decisions and dynamics, without being didactic; provide learning support through shared personal/professional experiences and offer sincere and productive feedback; encourage individual team member to keep/update
a reflective diary after team meetings; focus and support the team to develop self-facilitation with minimal exterior involvement, thereby gaining confidences within the team-members. In summary, a good facilitator considers himself/herself as a co-learner with the assigned teams, this transfers ownership of knowledge acquired to the team members. Built capacities for the educational system in achieving sustainable learning outcomes with facilitators as change agents cannot be over-emphasised and have, in fact, been regarded as transformational. Facilitators foster a sustainable approach to learning that provokes student engagement not as ‘regurgitators’ of the text but as ‘discoverers’ of new ways of applying already devolved skills and learning.

In the case of the University of Manchester, facilitators are graduate teaching assistants who are well-trained and equipped with lifelong skills required for effective tutorship roles. Under the full supervision of an academic staff as course leader, facilitators offer the opportunity for an active engagement with assigned student groups and teams, who are encouraged to take responsibility for their learning processes towards fulfilling a desired outcome. Contact time with students was fixed at two hour per week during the term. Students were encouraged to have extra group meetings and undertake assigned tasks, according to self-study hours assigned to the module.

The definition of a team in this research conforms with that of Katzenbach and Smith: 'A team is a group of people with complementary skills who are committed to a common purpose and hold themselves mutually accountable for its achievement' [16]. Teams were scheduled to have about two – hour compulsory meetings each week during 75% of the course duration, with attendance strictly monitored by the facilitator and course leader. These were intended to stimulate constructive discourse and engagement (norming process) about diversity, prejudice, stereotyping, discrimination, and violence. The workshops equip students with the skills and confidence to become activists against bigotry and agents for change and to lead workshops for their peers. By facilitating discussions with their peers in their schools and the larger community, peer trainers disseminate knowledge and incorporate practices that increase awareness about diversity and foster respect.

The model deployed for engagement with the students’ groups in these PBL courses were as proposed by Tuckman and Jensen [17] and illustrated in Figure 2.

![Critical Stages of Team Development](image)

**Figure 2**: Illustration of model for team engagement with the PBL course module.
The schedule for the PBL base modules made it possible to achieve the several stages of team engagement processes as shown in Figure 1. The first two weeks were devoted to introductory lectures, with case studies, overviews and an evaluation of students' expectations from the module, and highlights on learning (Forming stage). Students were also given a reflective writing exercise, in week 2. During the third and fourth weeks, the students were assigned to teams (maximum of 9 per group) with a facilitator. Facilitated exercises on teamwork and management are introduced, while the first assignment is collected. At this stage (storming), students were expected to have familiarise themselves within their teams and settled in for module proper. Teams are further encouraged to establish a working relationship by setting 'ground rules' in week 5, followed by team review on how best to focus on assigned projects. A formative peer assignment (not counted for final grading of course) was carried out by the individual students on every other team mate in the sixth week. In addition, students get feedback on the first team assignment. By the seventh week, students would have achieved a level ethical conduct and effective communication with team mates, tools for mutual problem solving, and fashioned out mechanism for decision making, while acknowledging some strength in cultural (and/or disciplinary) diversity. Norming occurs during weeks 5 - 7, priming the students for the performing stage of engagement in week 8 - 12. Another team process review was scheduled for week 9, more facilitated discussions of team assignments, while students' individual reflective report (which is weighted and factored in the final score of each student) submitted in week 12. In week 11, teams were involved in presentations on specific projects assigned. Also, a summative peer assessment under examination condition is done on-line, after which student feedback was administered, all within the last day of the module.

3.0 Presentation of Data and Analyses

Data collected from students through designed questionnaires are presented with respective analyses (Tables 1 – 3) are based on students' experience and learning from the module "Managing Emergency Projects" (run in the school of Mechanical, Aerospace and Civil Engineering, University of Manchester). Weights are measured according to the following: Not at all- 1; A little- 2; Moderately- 3; Quite a lot- 4; A great deal- 5

<table>
<thead>
<tr>
<th>Table 1: LEARNING PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To what extent do you attribute the following to the Sustainability aspect of this Module</strong></td>
</tr>
<tr>
<td>I developed new ideas and learned new information through communication with my fellow students</td>
</tr>
<tr>
<td>I developed new ideas and learned new information through discussion with my facilitators.</td>
</tr>
<tr>
<td>I developed new ideas and learned new information through reading provided materials.</td>
</tr>
<tr>
<td>I developed new ideas and learned new information through researching for project assignments in this module</td>
</tr>
<tr>
<td>My facilitator helped me to find my own answers about the content of the course when I needed it</td>
</tr>
<tr>
<td>What key study skills have you developed as part of the learning process:</td>
</tr>
<tr>
<td>a</td>
</tr>
<tr>
<td>b</td>
</tr>
<tr>
<td>c</td>
</tr>
<tr>
<td>d</td>
</tr>
<tr>
<td>e</td>
</tr>
<tr>
<td>f</td>
</tr>
<tr>
<td>g</td>
</tr>
<tr>
<td>h</td>
</tr>
</tbody>
</table>
### Table 2: LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>To what extent do you attribute the following to the Sustainability aspect of this Module</th>
<th>Return Rate %</th>
<th>Total Frequency</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am better adept to problem solving when presented with a task</td>
<td>80</td>
<td>58</td>
<td>4</td>
</tr>
<tr>
<td>I increased my ability to be able to apply ideas of sustainability to other modules in my studies in Engineering</td>
<td>83</td>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>I increased my ability to plan my time and study independently</td>
<td>50</td>
<td>36</td>
<td>4</td>
</tr>
<tr>
<td>I developed my capacity to evaluate whether information is biased or credible</td>
<td>83</td>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>I developed my ability to communicate with people from other countries</td>
<td>86</td>
<td>62</td>
<td>4</td>
</tr>
<tr>
<td>I developed my ability to study and communicate with people from other disciplinary backgrounds</td>
<td>86</td>
<td>62</td>
<td>4</td>
</tr>
<tr>
<td>I developed my ability to provide constructive criticism on fellow students’ work</td>
<td>86</td>
<td>62</td>
<td>4</td>
</tr>
<tr>
<td>I developed my ability to reflect on the quality of my own work</td>
<td>86</td>
<td>62</td>
<td>4</td>
</tr>
<tr>
<td>I am better adept to communicating my point of view to a wider audience, e.g. oral presentations</td>
<td>86</td>
<td>62</td>
<td>4</td>
</tr>
<tr>
<td>I have a greater appreciation for sustainability/environmental issues because of this module</td>
<td>83</td>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>I have a greater appreciation for my studies in engineering because of this module</td>
<td>86</td>
<td>62</td>
<td>4</td>
</tr>
</tbody>
</table>

This module has made me change my own sustainability behaviour in the following ways:

<table>
<thead>
<tr>
<th></th>
<th>Return Rate %</th>
<th>Total Frequency</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Recycle waste</td>
<td>80</td>
<td>58</td>
</tr>
<tr>
<td>b</td>
<td>Try to save energy in the home</td>
<td>77</td>
<td>55</td>
</tr>
<tr>
<td>c</td>
<td>Try to save energy when on campus, e.g. turning off lights, computers, etc.</td>
<td>80</td>
<td>58</td>
</tr>
<tr>
<td>d</td>
<td>Employ green practices when shopping, e.g. buying organic, Fairtrade, locally sourced food/products</td>
<td>83</td>
<td>60</td>
</tr>
<tr>
<td>e</td>
<td>Take your own bags to the supermarket</td>
<td>77</td>
<td>55</td>
</tr>
</tbody>
</table>

### Table 3: EMPLOYABILITY SKILLS

<table>
<thead>
<tr>
<th>To what extent do you attribute the following to the Sustainability aspect of this Module</th>
<th>Return Rate %</th>
<th>Total Frequency</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you gained any skills as a result of this module that will improve your chances of getting a job now or in the future?</td>
<td>83</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>What teamwork skills have you developed that will enhance your employability:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you enjoy working in a group?</td>
<td>83</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>Did your group work well together?</td>
<td>83</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>How effective did you find working in groups on group projects?</td>
<td>83</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>How effective did you find using online media for sharing/investigating your group project tasks and carrying out group work?</td>
<td>83</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>What were the main methods of online communication used by your group during this module?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>Skype</td>
<td>65</td>
<td>22</td>
</tr>
<tr>
<td>ii</td>
<td>Facebook</td>
<td>68</td>
<td>23</td>
</tr>
<tr>
<td>iii</td>
<td>WeChat</td>
<td>80</td>
<td>27</td>
</tr>
<tr>
<td>iv</td>
<td>Email</td>
<td>83</td>
<td>28</td>
</tr>
<tr>
<td>v</td>
<td>Group meeting in the Library</td>
<td>83</td>
<td>28</td>
</tr>
<tr>
<td>vi</td>
<td>Blackboard IM</td>
<td>74</td>
<td>25</td>
</tr>
<tr>
<td>vii</td>
<td>Face to face talk</td>
<td>80</td>
<td>27</td>
</tr>
</tbody>
</table>

Has this module helped you improve your team work skills in any of the following ways:

<table>
<thead>
<tr>
<th></th>
<th>Return Rate %</th>
<th>Total Frequency</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Listening to others opinions and respecting people’s differences during group work</td>
<td>83</td>
<td>28</td>
</tr>
<tr>
<td>b</td>
<td>When I’ve been communicating ideas, I’ve thought over how well I’ve got my points across (so that others understood)</td>
<td>83</td>
<td>28</td>
</tr>
<tr>
<td>c</td>
<td>Effective discussion and negotiation within a team</td>
<td>83</td>
<td>28</td>
</tr>
</tbody>
</table>

Tables 4 – 6 are data from questionnaire administered on engineering students' experience and learning from the undergraduate module MCEL30022 Interdisciplinary Sustainable Development, 2013-2014. Response options and assigned weights were: Agree (5); Mostly Agree (4); Neither Agree Nor Disagree (3); Mostly Disagree (2); and Disagree (1).
Table 4: LEARNING PROCESS

<table>
<thead>
<tr>
<th>The feedback that I received on my work was helpful</th>
<th>Percentage (%)</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>54.17</td>
<td>5</td>
</tr>
<tr>
<td>Mostly Agree</td>
<td>37.50</td>
<td></td>
</tr>
<tr>
<td>Neither Agree Nor Disagree</td>
<td>4.17</td>
<td></td>
</tr>
<tr>
<td>Mostly Disagree</td>
<td>4.17</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Staff were enthusiastic about what they were teaching</th>
<th>Percentage (%)</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>58.33</td>
<td>5</td>
</tr>
<tr>
<td>Mostly Agree</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td>Neither Agree Nor Disagree</td>
<td>16.67</td>
<td></td>
</tr>
<tr>
<td>Mostly Disagree</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>There were opportunities to obtain formal and informal feedback</th>
<th>Percentage (%)</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>50.00</td>
<td>4.5</td>
</tr>
<tr>
<td>Mostly Agree</td>
<td>45.83</td>
<td></td>
</tr>
<tr>
<td>Neither Agree Nor Disagree</td>
<td>4.17</td>
<td></td>
</tr>
<tr>
<td>Mostly Disagree</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Seminars/Workshops provided opportunities to obtain formal and informal feedback</th>
<th>Percentage (%)</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>50.00</td>
<td>4.5</td>
</tr>
<tr>
<td>Mostly Agree</td>
<td>33.33</td>
<td></td>
</tr>
<tr>
<td>Neither Agree Nor Disagree</td>
<td>16.67</td>
<td></td>
</tr>
<tr>
<td>Mostly Disagree</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

Comments from students ("What aspect of 'the lecturer's approach to teaching best helped your learning?'"): Clear and concise lecturing; Always available for questions; Made efforts to see each group every week; Clear presentations, good knowledge of the subject, enthusiastic; Extensive feedback, had good overall knowledge of the topic. Not that much to say, as there are not a lot of lectures in this module; I enjoyed conversing and analysing the concepts taught with my peers; Not really a lecture-based module; Providing us with the opportunity to analyse open ended questions in group discussions, utilising methods that were well taught in class; She focuses on practical aspects of sustainability which is I think important for this to be this well-organised; The feedback provided was very well defined and helped to improve a great deal; I valued the fact that 'the lecturer' came to see each group every week and this allowed problems or questions to be answered which was very helpful and showed she dedication to ISD; The PBL approach worked well; Useful feedback; Very approachable and friendly.

Table 5: LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>The course unit provided opportunities for participation and discussion</th>
<th>Percentage (%)</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>79.17</td>
<td>5</td>
</tr>
<tr>
<td>Mostly Agree</td>
<td>16.67</td>
<td></td>
</tr>
<tr>
<td>Neither Agree Nor Disagree</td>
<td>4.17</td>
<td></td>
</tr>
<tr>
<td>Mostly Disagree</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>
Comments from students ("Please provide details of what you valued about this unit"): Peer reviews - this is an excellent way of ensuring fair marking in a group situation; Emulates real life, real projects, team-based learning, active learning style, 100% coursework element, very interesting and engaging; Enhance my group working experience and understanding sustainability; Good practice of working in teams. Improved my knowledge of global sustainability issues; I have valued the diversity in the teams which were produced and I got to interact with students who I wouldn't have interacted with in a normal lecture; I thoroughly enjoyed the sustainability aspects of the course; Improved learning in a group format, and also was interesting in terms of climate change which is a topic I have a lot of interest in; Interesting and opportunity to learn team work; it was 100% coursework. it provided a new learning experience; Passive study of group dynamics and figuring out how to get the best out of individual members of the team whilst maintaining a good work environment; Team work opportunity; Team working skills; The projects were really interesting. I have enjoyed thinking of ways to solve problems differently.

### Table 6: EMPLOYABILITY SKILLS

<table>
<thead>
<tr>
<th>The course provided opportunities to enhance skills that will be useful to me in the future</th>
<th>Percentage (%)</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>66.67</td>
<td>5</td>
</tr>
<tr>
<td>Mostly Agree</td>
<td>29.17</td>
<td></td>
</tr>
<tr>
<td>Neither Agree Nor Disagree</td>
<td>4.17</td>
<td></td>
</tr>
<tr>
<td>Mostly Disagree</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>This course enabled me to connect academic concepts with real world examples</th>
<th>Percentage (%)</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>70.83</td>
<td>5</td>
</tr>
<tr>
<td>Mostly Agree</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td>Neither Agree Nor Disagree</td>
<td>4.17</td>
<td></td>
</tr>
<tr>
<td>Mostly Disagree</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Disagree</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

### 4.0 Discussion and Conclusions

Tables 1 -3 demonstrate that the median choice of response in almost all questions was to agree *Quite a lot* and this is underlined by the data in Tables 4 – 6 which suggest that these students more often opted to *Agree* with the statements, with at least 83% *Agreeing or Mostly Agreeing* and in some cases as many as 96%. These figures, together with the recorded comments, suggest that the intentions behind the course units were very largely met.

Lessons learnt from the experiences as captured in the survey and feedback support the aim and objective of this research, in broadening the learning outcome of engineering students; the team building skills; experiential learning; negotiating skills; practical project management skills; improved employability; sustained interests in the engineering profession; enterprise orientation; sustainability awareness; and best practices.

Knowledge acquired in this research could be beneficial to Engineering Regulatory institutions (e.g. Council for the Regulation of Engineering in Nigeria – COREN) and professional engineering entities like the Nigerian Society of Engineers. As stakeholders, these engineering establishments could adopt the PBL model in facilitating sustainable learning and skills acquisition for final year (or pre-final year) engineering students, during
their industrial attachment programmes. This approach could also be implemented during the National Youth Service Corps year. A sustainable system for realisation of this proposal could be the enlistment of certified engineers in research institutions and industry. These certified engineers would participate as mentors and act as supervisory agents having been given requisite training. Research projects (within the time frame of engagement) are pre-defined, with impact on the private or public sector, and assigned to a group of trainee engineers (not more than 8), with the mentor as ‘principal investigator’. These groups would be required to collaborate and work as a team to deliver of set goals. The project evaluation would be done through a combined report for each team (weighted with a peer assessment), in addition to an individual reflective report.

Challenges to overcome with embedding sustainability in engineering curricula, using the PBL approach include: cost intensive nature of deployment of well-trained facilitators; space to accommodate cohorts of maximum of nine students/trainees, where the course module has high rate of registrants; stricter enforcement on lack of participation from registered team members; teams need to be more mixed between different subjects to ensure more diversity in disciplines/subject areas, to stimulate alternative viewpoints; the PBL based module requires a large amount of time commitment and work, by students, compared to other modules.

Despite the constraints this approach has proved to be very successful, not just with the students but also in the learning journeys undertaken by the facilitators and the academic staff. Other research undertaken with graduate of these courses [18] suggests that the skills developed are very relevant to employment.

Acknowledgement

One of the authors acknowledges the doctoral research scholarship provided by the Federal Government of Nigeria (TETFUND) in conjunction with the Federal University of Petroleum Resources Effurun (FUPRE).

References


A Multi-disciplinary Approach to Developing an Introductory Course in Engineering and Architecture

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3 Department of Electrical and Computer Engineering, Department of Mechanical Engineering, Faculty of Engineering and Architecture, American University of Beirut
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5 Department of Mechanical Engineering, Faculty of Engineering and Architecture, American University of Beirut

Abstract – Engineering and architecture is aimed at improving the life of humans by designing and building products and services to the needs of civilizations. In real life settings, designing and building a product/service is a multidisciplinary event that involves the collaboration of a variety of specialists from different backgrounds. Accordingly, students need to acquire multidisciplinary skills and a holistic view of the world to be more successful in their future jobs. A committee of faculty from various disciplines in engineering and architecture at the American University of Beirut (AUB) was entrusted to design and introduce a new course that inspires creativity in engineering and design, engages first-year students from architecture and various engineering disciplines, and above all provides a multi-disciplinary experience to engineering education. This paper presents the theory, pedagogy, and background of introducing such a course to engineering and architecture students at AUB.

Keywords – Multi-disciplinary education, introduction to engineering and architecture, innovation in education, pedagogy.

1. Introduction

While education continues to advance towards more focus on specialized disciplines, the job market seems to be advancing at a faster pace towards multi-disciplinarily skills, with a much higher demand for well-rounded engineers and architects. Generally speaking, students often graduate in Engineering or Architecture without holistically understanding the different engineering perspectives and disciplines that enter into the whole engineering and design process. Students from the different departments of Engineering (e.g. Civil, Mechanical, Electrical, Computer, Industrial, Chemical, etc.) are often educated in silos with little exposure to the other disciplines. Architecture students, although commonly educated about the role of engineering disciplines within the building industry, are often not exposed to working jointly with engineers, and tend to design and develop their ideas in a detached manner. This lack of exposure, in turn, leads to lack of influence, and hence reduces the possibility for crossings of minds and disciplines, necessary often for innovation. This also leads to misconstruing possible
constraints during the early stages of the design process. Furthermore, students sometimes face difficulties after graduation, when they find themselves in work environments that require them to work in teams from multiple disciplines.

On another note, students often enter university, without being fully aware of their program’s constituents, and without having sufficient information to make an educated choice. This is particularly true for students entering the Faculty of Engineering and Architecture (FEA) at the American University of Beirut (AUB) where students are not always clear about the distinction or overlaps between the different disciplines.

For these different reasons, an idea for cross-education in early years across FEA is proposed to expose students to the different disciplines and encourage collaboration, innovation, teamwork, and well-rounded knowledge. The goal is to have a common course that can introduce and educate new students to the different disciplines in engineering and architecture, in their first year. An additional motivation for the introductory nature of this education is that it could help students make a more educated choice of the program or field that they want to continue in. This objective presents several challenges. First, the instructor of such a course needs to be skilled in the different disciplines to provide the necessary multi-disciplinary information with sufficient depth. Second, the course content needs to have the right balance of being challenging, educational, and fun. The students need to be educated, yet at the same time enjoy the course and its varied content. Another challenge, of course, would be to bring together a large number of students from the different programs, in one course that needs to address and tailor for their different fields.

In this paper, we present this new introductory course targeted at first year students entering the programs of Engineering and Architecture. The course is taught by a committee of professors from the different programs, providing in-depth information about every discipline and exposing the students to multi-disciplinary interactions. The course is divided into program modules to enable flexibility in teaching of each field. However, multi-disciplinary aspects are emphasized within each discipline’s module, and a common theme is used to illustrate the potential overlaps. Example themes include discussions about different aspects of a product, like a car or laptop, from design and architecture to consideration for different elements and components in industrial, chemical, electrical, mechanical, and civil engineering.

The rest of the paper is organized as follows. Section 2 presents related work in providing introductory engineering education to first year students. Section 3 provides a detailed description of the targeted course. Section 4 provides a conclusion and future directions.

2. Research Background

Several engineering schools have introduced a common undergraduate course for first year engineering students. The American University of Sharjah, UAE introduced a 2-credit hour required course for all students enrolled in the College of Engineering for six departments (Computer Science, Civil, Chemical, Computer, Electrical, and Mechanical Engineering). The goal of this course is to develop an understanding of the major responsibilities of engineers, foster collaboration among engineering disciplines, form a basic background in problem solving, as well as develop ethical responsibilities in
students. The course includes recitation lectures, six laboratory experiments each pertaining to one engineering discipline and a common design project such as paper bridges, Q-tip bridges, and paper airplanes. The results show, using both direct and indirect evaluations, that this course benefited students, met its objectives and also met ABET criteria. Furthermore, it was established that it is possible to provide a meaningful and well-rounded design experience to undergraduate engineering students with minimal conceptual foundation in their own engineering disciplines [2].

In response to the demand for enhanced design, problem-solving, and team skills in engineering graduates, Pennsylvania State University has instituted a course for first year engineering students to meet these fundamental aspects of the professions. Researchers found that this is important because recent studies show that engineering students are entering the workforce ill-prepared to solve real problems in a cooperative way, lacking the skills and motivation to continue learning. The course introduces students to design process skills in addition to traditional engineering content. It also emphasizes the importance of graphical, oral, and written communication and incorporates skill-oriented tasks, such as analysis, and interpretation of experimental data into team-oriented design projects. During the course, students spend less time in lectures and more time working on various hands-on design projects in teams. This allows them to discover that they cannot engage in open-ended, team-based, design projects without seeing that multiple solutions are possible, and that part of their task is to evaluate the many potential solutions on criteria that they must define. The analysis also suggests that having a multidisciplinary course may provide the type of intellectual environment that stimulates students’ natural progression toward more complex thinking [3].

The Ohio State University provides its engineering students with a two course sequence during their first year of engineering that involve skill development applicable to all engineering disciplines. In these courses, students are required to design and build a scaled version of a roller coaster. This project engages them in a working knowledge of physics and engineering and exposes them to the various disciplines of engineering. The analysis of this course has shown that it provides students since their first year with crucial experience in time management, task scheduling, development of design techniques and problem solving skills. Finally, it also exposes them to the constraints of “real world” work and forces them to communicate and work in a collaborative environment [4].

Virginia Tech University offers a course required for engineering and design students with the target of showing students a glimpse of the real world and giving them a taste of collaboration between engineers and designers on interdisciplinary design projects. Throughout the years, the course contained different projects such as the design of push-pull toys, LEGO programmable RCX bricks, and a walking device using a rechargeable electric screwdriver as the power source. The responses towards this course indicated an increased understanding and students’ appreciation for their own discipline as well as the other disciplines. Working in interdisciplinary groups fostered communication and allowed students to realize that “there is more to engineering than taking in information and spitting out solutions” [5].

Worcester Polytechnic Institute offers an introductory course for all engineering students, which focuses on the development of skills such as using software to solve equations, plot data, create drawings, and write reports. The course project was to design
and build a prototype of a sensory stimulation table for an adult man with profound mental retardation, which had to be submitted along with written and oral reports. The remainder of the course consisted of lectures and laboratory sessions, which introduced students to reverse engineering activities. The authors note that one key challenge in designing a first-year problem-based common course is that students in the first year of engineering have typically not been exposed to a course in engineering design. This is why reverse engineering has been used to help students become familiar with the design process. Course evaluations indicated that the class project, hands-on activities, and the emphasis on case studies were well received by the students. However, considerable care must be taken in utilizing and selecting design projects for first year courses. The authors warn that such courses must include mechanisms for rapidly building student experience in design while keeping in mind that they come with no background in engineering. The project has to be simple enough yet motivating and effective [6].

Professors at Michigan State University have integrated their engineering academic program and made it common to all first year engineering students. Among the program requirements are courses based on themes essential to students across engineering: design, engineering modeling, oral and written technical communication, teamwork, creativity, ethics, and professionalism. Another goal for these courses is to demonstrate to students the importance of engineering and the positive impact that engineers make on society and the world around them. In a survey of all engineering students who had taken the course, over 85% agreed that they felt that the course had improved their team skills, and about 70% indicated strong agreement or agreement with improvement in understanding the scope of engineering (applications, careers), development of problem-solving skills, and positive gains in verbal and written communication skills [7].

Miami University also offers first year interdisciplinary curriculum for engineering students. The program includes a one-credit hour course required for all nine engineering majors available. The course is entitled “Computing, Engineering and Society.” The goal of this course is to allow students to “gain an understanding of the work of a professional engineer, appreciate the various engineering majors, experience the engineering design process, develop skills in problem solving, develop teamwork and communication skills, and build community among students.” The course is divided into lecture and laboratory sessions. The main focus is placed on the course project in which students have to design and build a scaled train model layout prototypical to an era and geographic region through which a given train line would operate. The evaluation of the course showed that having an interdisciplinary course where students from various engineering disciplines participate in a fairly realistic engineering experience, which takes them through design in a team environment, is an effective approach in introducing first year students to the fields of engineering [8].

Despite the presence of a wide range of courses that address a common first year engineering class and several that address specific fields in engineering [9], the committee in charge of developing such a course at the American University of Beirut (AUB) is aiming to introduce a new course that inspires creativity in engineering and design, engages first-year students from architecture and various engineering disciplines, and above all provides a multi-disciplinary experience to engineering education.
3. Proposed Multi-Disciplinary Course

3.1. Course Description
The course is designed to familiarize first year students at the Faculty of Engineering and Architecture with the different programs being taught, including: Architecture, Civil, Mechanical, Electrical, Chemical, and Industrial Engineering. It takes a unique multidisciplinary approach to the field, and introduces the related disciplines and the technologies used in the world of engineering and architecture. One key objective is to promote multidisciplinary interaction and innovative thinking. The course is organized into modules covering the different disciplines within the Faculty of Engineering and Architecture. The last module of the class showcases multidisciplinary projects demonstrating interactions among the different fields. The lectures explain, as applicable to each discipline and through examples, notions of problem solving, design thinking, process of invention and innovation, environmental and civic responsibility, and measures of success in aesthetics and performance. The course project is a key component of the course, with a multidisciplinary nature, bringing ideas and solutions from all disciplines in engineering and architecture.

The purpose of the course is to: introduce students to the different engineering professions, provide students with an overview of engineering ethics, present to the students the various areas within each of the engineering professions, promote multidisciplinary interaction and innovative thinking, and foster effective communication and teamwork skills among students.

3.2. Student (Learning) Outcomes:
Students who successfully complete this course will: 1) have a realistic understanding of the different engineering professions and the working environment of engineers; 2) develop understanding of engineering ethics and professional responsibilities, and get familiarized with codes of ethics of different engineering disciplines; 3) understand the synergy between different engineering disciplines, and the importance of multidisciplinary collaborations as integral to creativity and innovation; 4) be able to work and function in a multidisciplinary environment; 5) develop understanding of engineering problem-solving concepts and principles; 6) demonstrate an understanding of the engineering design process including problem formulation, constraints, alternatives, prototyping and testing; 7) be able to apply critical thinking and basic research skills to formulate and exchange innovative ideas; 8) be able to integrate knowledge, methods, and relevant information from related disciplines into the design processes; 9) develop an awareness of challenges occurring in teamwork (e.g., task division, communication skills, etc.); and 10) develop presentation skills.

3.3. Course Organization into Multi-disciplinary Modules
The course will be taught in modules. Each department in FEA will offer three 50-minute lectures to cover the following aspects of “Who we are” in the specific discipline, “How we integrate with other disciplines,” and seminars for invited speakers. The instructors are expected to rotate yearly to maintain a level of freshness to the course.

To describe “Who we are,” each department’s lectures will first introduce the program and the disciplines within the department. Students are informed about different
programs and related professions. Each instructor will then cover description of the discipline curriculum. Finally, professors will share their experience and introduce their work. Light and informal lectures are provided, where students can be inspired by guest professionals who share their personal experience and showcase their work.

To describe “How we integrate/interact with the others,” each department’s lecture will present cases that involved engineers or architects from other fields, explaining how they impacted the process and the quality of the product. Students have the opportunity to hear versions about the profession from different perspectives. Each lecture aims to bring out interdisciplinary aspects with other fields and technology.

The course will also include a module providing an introduction to Codes of Ethics and Professional Standards. This module prepares engineers and architects for understanding the ethical expectations of the profession.

One module will also be dedicated to expose the students to hands-on technology experience. The labs are meant to be fun and challenging, yet without requirements for any particular background. As an example, the students may be asked to develop specific designs with Lego Robotics integrating elements of design, architecture, programming, mechanical, and civil engineering. The hands-on experience with engineering tools is meant to support the use of technology and design, covering general engineering and architecture concepts that are not necessarily specific to a particular area.

3.4. Course Project:
The course entails two projects that together provide the students with the necessary skill-set and learning outcomes of the course. One project teaches students about the basics of robotics, sensors, actuators, communication, computer software and hardware, and embedded control by building a robot that contends with other robots in a competition format. The second project teaches students about design innovation, originality, complexity versus simplicity, functionality, aesthetics, and economy of means by building a bridge. Performance assessment measures performance on the aforementioned criteria. Both projects foster collaboration, teamwork, multidisciplinary approach, time management, and effective communication skills.

Course projects are an essential component of the course. The goal of the projects is to encourage students to be creative and innovative, understand the multidisciplinary nature of engineering and architecture, relate aspects of the project to the different disciplines in FEA, discover their own skills and strengths, apply concepts and approaches learned, and work with teams of different FEA disciplines.

Students are assigned to groups. Where possible, each group of students must be constituted of at least one student from each department. Each group will be assigned to a faculty jury committee. The types of projects are intended to cover technology while being fun (e.g. based on Lego Robotics), or open fostering creative thinking (e.g. building bridge, robot competition, dropping eggs, etc.). Projects may not necessarily require their physical presence in a lab. Students work on project 1 in the first half of the semester and on project 2 in the second half.

Projects will go through trial and error before maturity, and they are intended to be self-driven by the students. Lab instructors will be assigned to specific groups, and will post their availability to the students. Professors (class instructors) are available during office hours for additional consultation if needed.
3.5. Course Assessment

Student performance shall be evaluated as Pass/Fail based on the following strict criteria: project contributions, class attendance, and lab evaluation. For project assessment, each the team is required to reflect innovative input, teamwork, and understanding of the project and hence each team is assesses based on these criteria. Each faculty committee member will give a Pass/Fail evaluation at the end of semester for the groups they oversee. They would also nominate exceptional projects for further competition and awards. A competition will be held with the nominated groups, and finalists are awarded. Up to four awards may be awarded per semester. Competition jury is the same as the coordination committee or designates, if they choose.

For class assessment, attendance is mandatory and required in every class, where students would be penalized for absences exceeding four sessions. The student may seek to be exempt from counting a particular absence by presenting a petition along with a documented valid excuse explaining the absences, to the course committee. Attendance will also be subject to university regulations. For example, at the American University of Beirut, students who miss more than one-fifth of the sessions of any course in the first ten weeks of the semester will be required to withdraw from the course with a grade of “W.”

For Lab assessment, each team will be assessed for Pass/Fail based on their contribution and learning in Lab work and assignments.

4. Conclusion

This paper discusses the theory, pedagogy, and multidisciplinary approach of designing an introductory course in engineering and architecture at AUB. The new course is designed to meet the needs of future engineers and architects, and their employers, to help them develop multidisciplinary skills, teamwork spirit, professional ethics, and effective communication skills. It is designed to enhance the students understanding of the various programs offered at the FEA, how they complement each other, and which discipline is the right fit for them.

The course is aligned with the new trend in education where students from different backgrounds are constantly engaged on multidisciplinary teams and challenged to operate in environments that require collaboration, innovation, and problem solving. While many leading academic institutions have adopted this trend, AUB is championing the movement in Lebanon and the region. Although many similar courses exist in engineering schools around the world, this can be considered one of the world’s first courses addressing both engineering and architecture disciplines in one introductory course that takes a multidisciplinary approach while encouraging creativity and innovation in education.

The course meets the basic requirements of the involved departments as well as some requirements of the ABET accreditation system. Measures are taken and metrics are defined to assess students learning outcomes. Future research will present actual results describing the performance of the new course as well as lessons learned from teaching the course to engineering and architecture students at AUB.
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5. References
CLIMATE RESPONSIVE AND ENVIRONMENTALLY SENSITIVE BUILDING DESIGN AT THE FACULTY OF ENGINEERING AND ARCHITECTURE (FEA), AUB

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Abstract
Professions dealing with the building industry are expected to integrate passive and hybrid environmental strategies and techniques in building design in order to mitigate the negative impacts on the ecosystem. As an integral part of that industry, Architecture and Engineering students must learn how to design buildings that are sensitive to and harmonious with the environment. To achieve this, a new interdisciplinary educational approach is required to bridge the gap between the disparate domains of the technical lecture and the imaginative studio to ensure that thorough environmental knowledge is integrated with the students’ creative skills. In an attempt to sensitize students to the relationship between buildings and the environment, the Faculty of Engineering and Architecture (FEA) at the American University of Beirut (AUB) has been tailoring its curriculum since the late nineties to reflect the growing awareness of the importance of this issue by offering numerous courses that address the subject of “environmentally sensitive” design. Interaction between Engineering and Architecture disciplines is paramount in teaching at FEA. This approach is intended to create in the FEA graduates an awareness and ability to act within a strategic perspective that relies on the understanding and assessment of environmental and cultural contexts.

Keywords
Climate responsive design, education, architecture, engineering

1. Introduction
Evidence shows that humans are changing the climate [1] and that buildings are generating a considerable percentage of the greenhouse gas emissions that are responsible for this change [2, 3]. This is the most important environmental threat affecting the earth today [4]. Professions involved in the building industry are expected to integrate passive and hybrid environmental strategies into the design and construction phases in order to alleviate the negative impacts on the natural environment [5]. In order to reduce the detrimental effect of buildings on the environment (figure 1), architecture and engineering students must learn how to design buildings that are sensitive to and harmonious with the environment. Therefore, a new interdisciplinary educational approach is required to bridge the gap between the disparate domains of the technical lecture and the imaginative studio to ensure that thorough environmental knowledge is integrated with the students’ creative skills.

Figure 1: The environment threatened by buildings
Worldwide, many universities are exploring and developing strategies and methodologies to strengthen the climate responsive design and environmentally sensitive architecture components of their curricula. These efforts vary from integrating climate responsive strategies in coursework, to implementing service learning and real world problem solving, to creating learning laboratories and connecting future graduates with potential employers [3, 6]. For example, Brown University offers a course on Sustainable Design in the built Environment which gives students a thorough understanding of sustainability as relating to planning, engineering and architecture [3]. Cornell University offers a course that includes lectures and an interactive web based curriculum that facilitates interdisciplinary exchange. A third example is the Intelligent Workplace at Carnegie Mellon University which is used for research, teaching, demonstrations and design charrettes on sustainability focused on building components and building systems.

2. Pedagogic approach at the Faculty of Engineering and Architecture (FEA) at the American University of Beirut (AUB)

The FEA has been aware of the importance of the need to sensitize students to the relationship between buildings and the environment since the early 2000s. As a result, numerous curriculum changes have been introduced and a variety of courses in the different departments of the faculty have addressed the subject of environmentally sensitive design by offering lectures, labs and having students engage in projects that were, at least, partially executed. The following brief overview presents key achievements towards addressing sustainability within the Faculty.

2.1 Early 2000s

The Department of Civil and Environmental Engineering started offering courses and researching the subject of natural fiber reinforcement in concrete since the early 2000s. Different aspects such as the potential benefits of integrating hemp in concrete masonry units, the use of the fibers in geotechnical and soil stabilizing measures as well as its integration in pavements were addressed.

In 2002, the Department of Mechanical Engineering started the Thermal Comfort Research Group [7] (figure 2). The four main research areas that this group is working on are (1) clothing model of a walking human, (2) development of a new transient bioheat model of the human body and its integration with clothing models, (3) human thermal comfort and radiation model and (4) combined radiant cooling with desiccant dehumidification, a numerical and experimental study.

2.2 Academic year 2007-2008

2.2.1 Applied Energy Master’s program

In response to the marked need to enhance environmental sustainability in Lebanon by strengthening the educational capacity in the areas of energy efficiency in buildings and renewable energy technologies, the Applied Energy Master’s program was established by the Department of Mechanical Engineering in 2007 [8]. This program enables student to address different aspects of energy in buildings including the:
1. Design and management of efficient energy systems for buildings of high-quality indoor environment
2. Integration of renewable energy technologies with conventional energy systems to improve sustainable aspect of energy supply systems

2.2.2 Center for Civic Engagement and Community Service
This Center was established in 2007 to encourage the involvement of university students with the Lebanese community. It allows the students with an opportunity to address and resolve real life problems such as rehabilitating the water supply in remote villages, designing and building prototype temporary housing units, etc.

2.2.3 Energy Research Center project
The Mechanical Engineering and Electrical and Computer Engineering Departments, were involved in a study conducted by the Energy Research Center on energy efficiency planning of university campus buildings [9]. The project was initiated to propose a reduction in the energy cost at AUB. The project’s objectives were to:

(i) Target the inefficient operations in AUB buildings and propose improvement measures that are technically sound and economic,

(ii) Develop effective tools for audit and evaluation of all campus buildings energy consumptions using patterns and energy indices to compare different buildings energy requirements, and

(iii) Create an energy conservation plan for the campus.

2.2.4 Climate responsive design strategies in Architecture
In the spring term, the Department of Architecture offered, for the first time, an entire course that addressed the integration of passive strategies into the design process. ARCH 065, “Climate responsive design strategies in Architecture” was offered as an elective course to third and fourth year architecture students. It was designed as a lecture based course combined with short design applications addressing the main topics that enhance the understanding of buildings, energy and comfort. Topics presented in this course include a general lecture about the state of energy on Earth, population increase and urbanization, a series of lectures address the subjects of solar radiation, wind flow and daylight – both in and around buildings and other lectures on the environmental aspects of the building envelope and an introduction to active systems.

After the lectures, the students apply the knowledge obtained in concise design exercises as described below.

A research assignment helped the students analyze vernacular building typologies and understand the basic concepts of how buildings can provide comfort without the support of mechanical and electrical systems.

As shown in figure 3 [10], the solar lecture/exercise introduced the basics of solar radiation (location of the sun throughout the year/days, solar intensity and the cosine law, etc.) and its relationship to buildings (massing,
orientation, thermal zoning and occupancy patterns, etc.). The design exercise required the student to design a small project (5 – 6 spaces) while focusing mainly on the relationship with solar incidence. Some students addressed “protection” from solar incidence (typically a hot area), while others designed the project as “exposed” to solar radiation thus benefitting from it (typically a cold area).

The wind flow lecture/exercise presented the basics of wind movement and its relationship to the built form (figure 4) [11]. Starting with reasons for what generates wind flow and what governs its direction, the students are introduced to the strategies that allow wind to flow in and around buildings. The design exercise for this subject engaged the students in thinking about the adaptability of the strategies and their applicability in their designs. It is to be noted that the students were required to maintain the same spatial configuration as in the solar exercise. A visit to the wind lab whereby students positioned their 3D models in a smoke machine strengthened their sense of understanding as they were able to visualize wind flow and its relationship to the built form.

The daylight lecture/exercise, shown in figure 5 [12], described the importance of daylight in buildings by presenting daylight strategies that are applicable in different spatial and envelope configurations. Topics discussed included spatial configurations, orientations, direct and diffused daylight, reflectivity of materials, daylight factors, etc. The design exercise required that the students apply the strategies of daylighting so that each space benefits from it. Again, similar to the 2 previous exercises, the students were required to maintain the same spatial configuration as in the solar exercise.

A final “combined” design approach required that the students integrate the requirements for the adequate performance of solar, wind and daylight strategies into a building. The challenge here was to deal with contradictory requirements such as the fact that openings oriented north provide quality daylight but at the same time result in heat loss during the winter season. Assessing the performance of the strategies remained mainly qualitative.
In addition, students were required to address one of two subjects: the environmental assessment and availability of a specific building material or the research and analysis of an existing local or international climate responsive building. Local climate responsive buildings that were built in the 50s and 60s provided the students with insight on the climate responsive design possibilities in Lebanon. The study and analysis of international buildings allowed the understanding of how buildings behave in different climates and is usually associated with more elaborate mechanical systems.

All the presentations as well as additional reading material were posted on Moodle so that the students were supported while working on their exercises and/or writing up the reports. At that time, the knowledge obtained from the course did not smoothly propagate into other courses – particularly the design studio. This course was well received by the students who found the content to be very interesting and informative. However, they faced difficulties in applying the acquired knowledge in their design course projects because of lack of awareness of other design instructors pertaining to this subject.

2.3 Academic year 2012-2013
The ARCH 065 course was offered for one term only to both Architecture and Engineering students to allow groups of students from different majors to work together on integrating passive design measures in their projects (figure 6). The presence of fourth year students from the Civil, Electrical and Mechanical Departments allowed a more elaborate approach when assessing the strategies. The students, divided into groups that included Architects and Engineers, were required to complete the exercises but with a more quantitative approach relating to the performance of the climate responsive strategies. The integration of active systems into buildings was also more thoroughly addressed. The Sketch up software was used by the students to visualize and assess incident solar radiation during particular times of the year and of the days. Although the students benefitted from this interdisciplinary approach, they still faced difficulties in the practical design applications of the knowledge.

2.4 Academic year 2013-2014
The “Climate responsive design strategies in Architecture” had its code changed from ARCH 065 to ARCH 360 and became a mandatory course for all third year architecture students. The course maintained its basic form and content with the addition of 2 lectures: one addressing the environmental performance of the building envelop and another introducing the environmental

Figure 6: Student's work

Figure 7: Climate responsive investigations
aspects of Water. An example of a student’s investigation is shown in figure 7 [13]. Given that the course was now integrated in the core curriculum, it aroused interest not only from the students but also from faculty members who became relatively more engaged in the process.

2.5 Academic year 2014-2015

2.5.1 Green building basics course
The Mechanical Engineering Department offered the course “Green Building Basics” which is part of the curriculum for Engineering students enrolled within the Masters in Mechanical Engineering – Applied Energy program. This course addressed more advanced content starting with the basics of climate responsive buildings and included a more elaborate investigation of the design of the building envelope using appropriate software as shown in figure 8 [14]. The importance of this course lies in the understanding of architectural climate responsive design concepts by engineers of various backgrounds. This is consistent with the interdisciplinary approach that is being promoted in the faculty.

2.5.2. Progreen Diploma
In March, AUB started managing the Progreen Diploma that aims to provide a unique and focused program that caters for the engineering and architecture professionals aspiring to enhance or complement their technical and decision-making skills in green technologies or progress in green businesses [15].

2.5.3. Third Year Design Studio and ARCH 360
ARCH 360 and the design studio were offered for the first time in the same term. ARCH 360 was given with the particular intent of supporting the third year design studio. All coursework was scheduled in parallel. The third year design studio was based on the theme of sustainability. The student design projects in the studio varied in quality ranging from average to very interesting designs that successfully addressed climate responsive parameters. The latter showed a certain maturity in the design thinking process whereby the climate responsive strategies were integrated into the concept and were not merely “added on” just to satisfy the requirements.

2.6 Academic year 2015-2016
The third year design studio focuses on architecture in the environment and is again offered simultaneously with ARCH 360. The content and coordinated progress of both courses will help strengthen students’ understanding and environmentally sensitive design capabilities. This term is the first time that the course is purely lecture based and the assignments are research oriented and not design exercises contrary to previous years. The aim is that the students are required to apply the knowledge gained from the ARCH 360 course directly into their architectural projects in the design studio. In order to increase the possibility of success, the content of the two courses has been closely coordinated so that the lectures provide the necessary support to the design studio in a consistent manner. A matrix has been developed to ensure that the ARCH 360 supports the students’ design work throughout the different design phases.
2.7 Undergraduate final year projects in the Faculty

In addition to the courses offered, students are encouraged to incorporate sustainable issues into their final year projects. These take on a broad range of topics as shown in the selective list of final year student projects presented below.

In 2013-2014 [16]:
- Geothermal pavements
- Use of fibrous walls to passively dehumidify indoor living rooms using solar energy,
- Performance evaluation and economic feasibility of integrated earth-air-tunnel heat exchanger evaporative cooling system for a residential house in Bekaa

In 2012-2013 [17]:
- Converting AUB into a Green Campus
- Recycled concrete aggregate as a substitute for natural aggregate
- On-shore wind farm construction
- Evaluation of hempcrete
- Renewable Energy System for Municipality Schools in remote areas
- Calculate the embodied energy of cement

In 2011-2012 [18]
- Papercrete
- Reconversion of Gemmayze Area into a sustainable protected pedestrian area
- Architectural space design with localized air-distribution for occupant-controlled macro-environment
- Energy consumption at household level in Lebanon: modeling and opportunities for conservation

In 2010-2011 [19]:
- Thermal comfort of active people in transitional spaces
- Outdoor thermal comfort

3. Upcoming initiatives

Consistent with the strategy and efforts towards interdisciplinary and practical applications, the FEA is continuing to develop its programs and curricula in order to educate future architects and engineers about climate responsive and environmentally sensitive design.

Upcoming initiatives include developing the “Climate Design Unit” and offering the advanced “Green Building Basics” course to Engineering and Architecture students at both graduate and undergraduate levels.

The Climate Design Unit will be a space that provides support to Architecture and Engineering students at all levels by:
- Allowing students to use the instruments and tools (heliodon (figure 9), wind tunnel, lux meters, simulation softwares (figure 10), etc.) to visualize, assess and better inform the climate responsiveness of their design approach.
- Having up to date references that help keep the students informed of the different aspects of environmentally friendly building design;
- Serving as a hub whereby students and instructors of different backgrounds can discuss issues pertaining to climate responsive and environmentally friendly design.
• Acting as an interface that links students with other labs, experts and resource centers at AUB and beyond.
• Having a library focusing on the environmental aspect of building materials. The qualitative and quantitative understanding of the energy use in all the phases of building materials (extraction, manufacture, execution, disposal and transport) is very important for students to help them understand strategies in the aim of safeguarding natural resources.

As for the advanced course, its content would complement the ARCH 360 course to include a more developed approach to building envelop design, solar radiation, windflow and daylight simulations as well as waste reducing construction methods.

5. Conclusion
In summary, the strategic vision of the pedagogy of climate responsive and environmentally sensitive building design has developed along the three stages explained below:
Stage 1 (figure 11): “climate responsive design strategies in architecture” was a stand-alone course whereby its contents were not consistently transferred to other courses. Integration of the material learnt into other courses or design projects remained a function of the student’s interest to apply these notions and the instructor’s willingness to engage in these subjects.

![Figure 11: Climate responsive design: stage 1](image)

Stage 2 (figure 12): the “climate responsive design strategies in architecture” course is strongly integrated in a number of other courses such as the design studio, building construction, the fourth year comprehensive studio and the fifth year final projects.
Stage 3 (figure 13): the reason for the “climate responsive design strategies in architecture” course would not exist anymore because the different aspects of this subject would be addressed within all courses thus providing students with the required knowledge within the different subjects.

Today, seven years after introducing the subject of climate responsive design as a main component in the curriculum we have reached stage 2. After several curriculum modifications and updates, there is now a strong perception of the need for efficient coordination with a number of other courses in the Faculty.

Finally, interaction between Engineering and Architecture disciplines is paramount in teaching at FEA. This approach enhances awareness in the FEA graduates and empowers them to act within a strategic perspective that relies on the understanding and assessment of environmental and cultural contexts [20]. Graduates will be equipped with a high level of environmental competence, where technical knowledge is synthesized within creative exploration of design solutions [21]. This is very important in Lebanon and in the region since climate responsive design is still kicking off. Given that there is no lack of opportunities to integrate and apply these notions and concepts, it is necessary to have knowledgeable graduates to implement them in the building industry.
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INTEGRATING GIS IN THE LEBANESE CURRICULA

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Abstract

GIS is an important information system of high computer-based performance that enables us to understand, interpret, capture, update, map and display graphical and non-graphical information of natural and human-originated events on earth. This system applies spatial observations to bring out these phenomena in a form of synthesis as it is accumulated, saved, processed and presented to the users in coherence. Through years, GIS proved to be an effective application to be used in many studying disciplines at different countries. Our approach is to show the importance of Geographic Information System integration in the Lebanese curriculum as a new way of learning. The study was conducted to cover five schools from different Lebanese governorates. It covered three selected lessons from the history, geography and mathematics books of Grade 11 (second secondary level) as a sample to be explained, with evaluation papers for students and teachers that highlighted mainly on their impressions on the application and whether or not the GIS have played role in better understanding to the topic explained and if or not they encourage the idea of implementing GIS in their curricula. The statistical results favored utilizing GIS in teaching as it has enhanced the general understanding of the material and made it better to memorize. Accordingly the statistic results ranked mathematics as number one followed by geography and then history.

1. Introduction

Today's society differs from the one existed so many years ago, where the utility of technologies in education has become a very fruitful source of easy learning. Geographic Information System, as one of these technologies, is important in which graphical and non-graphical information are accumulated, saved, processed and presented to the users. GIS is a high performance computer-aided chain of software which enables us to understand, interpret, capture, update, map, and display natural and human-originated events on Earth.

Accordingly, GIS introduces students to a new way of viewing, thinking and interacting with the world around them and provides a framework for learning other academic disciplines. In addition to interacting with data in a new way, students learn teamwork since GIS projects typically require a high level of cooperation and explore course content in a way that enhances logical, mathematical, linguistic, spatial and interpersonal intelligences. Also, it is a modern tool that can be used across the curriculum wherever there is a spatial question to be answered including Geography, History, Mathematics, Biology, Chemistry, Earth Science, Environmental Science and other subjects.

Likewise, GIS enables engineering students to visualize factors (economic, social, environmental, and political factors) easily making it a critical tool for the engineering design professional.
In particular, GIS provides a unique combination of complex relational databases, comprehensive spatial analysis tools, and powerful 2D and 3D graphical displays that allow engineering students to better manage information for learning design and modeling. Hence, it became an engineering standard for developing, analyzing, managing, and displaying geographic information and vital in engineering education in many areas including surveying, site development, hydraulics, hydrology, transportation, planning, and public works.

Students, using GIS tools, will be proficient in the field of engineering by learning chief points, for instance:

- Querying and analyzing simple data
- Editing basic data
- Making measurements using multiple methods in GIS software
- Creating maps (under the context of safety analysis/planning)
- Calculating materials costs, for example, based on vendor locations for a concrete mix design
- Creating a spatially-referenced database
- Mapping ‘restricted areas’ and creating buffers around it for a hypothetical water treatment plant (under the context of disaster planning)

Generally, Lebanon fully understands the role of technology in addressing the implementation of educational reform to qualify education for all learners. Lots of organizations and communities planned variable strategies for enabling Lebanese children get benefit from technology and be updated to all new teaching and learning techniques such as Lebanon’s National Educational Technology Strategic Plan to guide the integration of information and communications technology into the general education system.

Nowadays GIS has been introduced in almost all Lebanese universities and ministries. Universities such as Lebanese International University (LIU), Notre Dame University (NDU), American University of Beirut (AUB), Lebanese American University (LAU), University of Balamand (UoB), and many others are promoting both GIS Education and GIS in Education. Each university is taking a different approach and developing its own GIS position to supply for the pressing needs in this domain. As an example about promoting GIS education, at Notre Dame University (NDU), under the faculty of Natural and Applied Sciences, department of Computer Science, a Geographic Information Science major is applied, by which a sequence of GIS courses are taught such as GIS331 (Desktop GIS), GIS 441 (Cartography, Geodesy and GPS), GIS 490 (Senior Project), and many others. Another example on promoting GIS in education, the Lebanese International University (LIU) is applying the GIS courses in several majors such as the Surveying Engineering major, where a course, SURV 455 (GIS-I), is taught in addition to SURV 560 (GIS-II). These courses are applied to facilitate several work domains in this major as well as to advance the used techniques in it.

This study aim to highlight on the effective impacts of engaging GIS techniques as a developing tool and technique in teaching. This study state the facilities that GIS can easily provide in education and illustrate how it can help students to analyze, interpret and evaluate information.
2. Method

This project passes through two main phases: elaboration phase and implementation phase in order to cover the whole process of integrating GIS in education. The first phase includes the manner of choosing schools, class, subjects and lessons as well as preparing the specified lessons. Diversity of Lebanese schools requires to elect a school from each governorate in order to cover a large area of application. So, one school was randomly picked from each of the five governorates Beirut, Beqaa, Mount Lebanon, Nabatieh and South Lebanon. Tripoli was excluded due to security reasons.

Geography is selected to be explained using GIS since it is based on displaying maps and statistics about several issues. Considering it as the basic element in GIS, it was decided to have two alternative ways for explaining this lesson; ArcGIS and Story Map Series - Side Accordion Layout Template. Mathematics was the second material since it is considered as a base for engineering study which plays; as well, a vital role in several teaching domains. The basic point behind selecting the third choice “history” was to illustrate the countless fields that GIS can occupy for facilitating education. Accordingly, three lessons for the selected courses were taken from Lebanese official books commonly used in schools (official and private). Moreover, from the governorates Beirut, Beqaa, Mount Lebanon, Nabatieh and South Lebanon, the selected schools are; Palace of Modern Culture School, Omar El Moukhtar Education Center, Beirut Modern School, Generation High School, and Sarafand Official High School respectively.

During the first visit with a permission letter, a meeting with the administrator of each of the five schools occurred by introducing the general idea of this project with a brief definition about GIS. It included also, statement about the aims behind implementing GIS in teaching and how it could serve them in educational growth. Correspondingly, it ended with an agreement on a specific date for each school to present the advanced way; April 15th, 21st: Generation High School, April 27th, May 2nd: Sarafand Official High School, April 28th, 29th: Beirut Modern School, April 30th: Omar El Moukhtar Education Center, May 15th: Palace of Modern Culture School.

Starting with the preparation of Geography lesson, several facts about the overall idea of natural gas are summed up in few basic topics mentioned in the book as shown below:

- Distribution of natural gas production around the world
- Global consumption of natural gas (properties of natural gas, factors affecting natural gas consumption)
- The basic centers for the consumption of natural gas
- The importance of natural gas (economically, strategically)
- International trade of natural gas (exporting countries, importing countries, means of transporting natural gas)
- Average annual consumption per capita

Locations of each country were derived from the base map of the GIS online. Combined with all the texts, tables, graphs and maps, all data were inserted in separate excel sheets. Through the add data command all excel sheets were imported to GIS, converted to shape files by the export data command then designed using various quantities and charts from the symbology.
For more clarification, extra examples from daily life are given with different images through hyperlink command. All materials were then organized in separate layers and saved in a single project file to be presented later as a first method. However, in the story map application, all layers were saved as various active project files and were published online and overlaid on a specific base map in the template.

Figure 1: An example of a section in Geography lesson

Regarding mathematics, understanding the concept of Orthogonality in space depends on the following main points:

- Angle between 2 straight lines in space
- Straight line perpendicular to a plane
- Properties
  - Property 1 & 2: Straight line perpendicular to intersecting lines in a plane
  - Property 3 & 4: Two straight parallel lines perpendicular to a plane
  - Property 5 & 6: Two parallel planes perpendicular to a straight line
  - Property 7 & 8: Straight line perpendicular to a plane through one point
  - Property 9, 10 & 11: Straight line perpendicular to a plane and perpendicular to another straight line contained or parallel to the plane
- Theorem of the perpendicular and oblique lines
- A mediator plane of a segment
- Angle between a straight line and a plane
- Dihedral angle (line of intersection of two semi planes, measurements, etc…)
- Perpendicular planes
- Common perpendicular
- Bisector of a dihedral
For each face, features were drawn as 2D points, polylines and polygons and organized using an equivalent symbology. Also, all shape files were grouped by a separate layer. Using the duplicate, move, rotate, copy… tools from the 3D Editor Toolbar, features were modified and transformed into a 3D scene. Afterward, new fields, “Name” and “Property”, are added to provide enhanced explanation. These properties can be easily seen through the identify command, and connected by the HTML popup command to the internet for more search details.

![3D scene with features modified](image)

**Figure 2: An example of a property in Mathematics lesson**

In history, The German invasion of the Soviet Union is assembled of a sequence of major incidents as listed below:

- Reasons behind the German invasion of the Soviet Union
- Battles path
- North Axis: Siege of Leningrad
- Middle Axis: middle front
- South Axis: Gains in the south
- The second phase of the attack
- Sebastopol Occupation
- Battle of Stalingrad
- The role of allies in the Russian war

Countries’ coordinates are obtained from the base map on GIS online, recorded in excel sheets, inserted by the add data command then converted to shape files with the export data command in GIS. Subsequently, every point of interest was designed and edited by means of data management tools and editor toolbar, and represented by diverse colors and symbols. Then, all layers were saved in discrete project files that were later published online and added as a web map in the template. Additionally, supportive images and videos are appended on this set of journal entries showing a better overview.
Last and not least, an evaluation paper was distributed for both students and teachers in order to evaluate the whole process of teaching with GIS from the objectives, content, presenters, and most important the comparison between the conventional methods in teaching and the new implemented method.

The second phase was the implementation phase, in this phase the procedure for giving the lessons was defined. Accordingly, the lessons start with an introduction on GIS, followed by subjects’ explanation and then the evaluation.

In both methods in geography, the natural gas lesson is explained in many sections for instance, by displaying a map about the distribution of natural gas production around the world with some facts listed beside it. Students are asked to obtain countries with the highest and lowest values from each area zoomed to in the map. A graph also about the global consumption of natural gas in the world as a function of time is analyzed by students to describe its direction and state its peak stages. After this analysis, they became able to derive the properties of natural gas and the factors affecting its consumption. Another section includes an exercise about the average annual consumption of natural gas per capita given on a map with specific legend.

In mathematics, the explanation method focused on certain steps mainly on rotation, zooming in and out, turning layers on or off, and many others. For an example, the corresponding property for a mediator plane of a segment is displayed as a polygon representing a plane (P) and a polyline representing a segment (AB) crossing this plane with its midpoint (I) lying on it as a point. Another existing point (M) on the same plane joined with the midpoint (I) is identified as the median of the isosceles triangle (MAB) and the perpendicular bisector of (AB) as well. In addition, students saw how lines are drawn from another points on (P) and joined with the edges of (AB). By their interaction with this dynamic sketch, they became able to define by themselves the general property: for any point belonging to (P), (MA) = (MB).
The incidents of the German invasion of the Soviet Union are chronologically organized and each step is highlighted separately with related maps, images and videos in many sections. Through zooming in to each axis, all the related cities are viewed with the localization of both armies in addition to a short video describing a part of the invasion. For example, a section about the occupation of Sebastopol included the geographic location of the city on the map. Concerning the battle of Stalingrad, a map about the city traced with Volga River is presented with some symbols of the equipment used such as warplanes and tanks for more clarification.

3. Results and Discussion

The results of students’ questionnaire state how much they understood the displayed content, and their interest in the new teaching method. The answers to the first question are classified based on specific standards. Therefore, the highest results of mathematics (58%) and geography (56%) are in the excellent grade where mathematics recorded the highest percent. The highest one in history, on the other hand, is in the good grade (35%). Likewise, Most of students’ point of view is directed to be strongly agree (seven out of nine questions) in learning faster with GIS, increasing their interest in field of study and preferring the new way using GIS.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math</td>
<td>65</td>
<td>31</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>%</td>
<td>58</td>
<td>28</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Geography</td>
<td>49</td>
<td>25</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>%</td>
<td>56</td>
<td>28</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>History</td>
<td>36</td>
<td>37</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>%</td>
<td>34</td>
<td>35</td>
<td>29</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 1: Students’ evaluation results-part 1

<table>
<thead>
<tr>
<th>I have learned a lot in this class.</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>56</td>
<td>69</td>
<td>42</td>
<td>36</td>
<td>22</td>
</tr>
<tr>
<td>%</td>
<td>34</td>
<td>45</td>
<td>41</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>GIS has increased my interest in this field of study.</td>
<td>63</td>
<td>39</td>
<td>54</td>
<td>33</td>
<td>41</td>
</tr>
</tbody>
</table>

Table 2: Students’ evaluation results-part 2
By examining these results, it is apparent that students are able to grasp the three lessons clearly, remember many points from the lecture, favor the new way of education using GIS and are more attracted to studying than they were in traditional methods.

Moreover, teachers’ feedback about the objectives, content, teaching methods and presenters, is considered positive as their ratings are between high and very high. Also, questions about details in the lesson and students’ reaction averaged as well. Besides, two out of fourteen teachers had a previous knowledge about GIS, six found the program substantially effective to improve their expertise and six found it somehow effective. Moreover, eleven teachers declared that they would recommend this program to others.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the main points of the course stated clearly?</td>
<td>High</td>
</tr>
<tr>
<td>Was the way of explaining on Arc Map effective?</td>
<td>High - Very High</td>
</tr>
<tr>
<td>Knowledgeable in content areas</td>
<td>High - Very High</td>
</tr>
<tr>
<td>Clarified content in response to questions</td>
<td>Very High</td>
</tr>
<tr>
<td>Appropriate for intended audience</td>
<td>High</td>
</tr>
<tr>
<td>Consistent with stated objectives</td>
<td>Very High</td>
</tr>
<tr>
<td>Visual aids, handouts, and oral presentations clarified content</td>
<td>Very High</td>
</tr>
<tr>
<td>Teaching methods were appropriate for subject matter</td>
<td>Very High</td>
</tr>
</tbody>
</table>

Table 3: Teachers’ evaluation results-part 1

<table>
<thead>
<tr>
<th>Questions</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presented useful examples</td>
<td>Good</td>
</tr>
<tr>
<td>Attention to detail of content</td>
<td>Good</td>
</tr>
<tr>
<td>Indicates important points to remember</td>
<td>Excellent - Good</td>
</tr>
<tr>
<td>Shows students’ interest during the lecture</td>
<td>Good</td>
</tr>
<tr>
<td>Effectively encourages students to ask questions and give answers and arouses discussion</td>
<td>Fair</td>
</tr>
<tr>
<td>Stimulates interest in material</td>
<td>Good</td>
</tr>
</tbody>
</table>

Table 4: Teachers’ evaluation results-part 2

The general evaluation of the efficiency of GIS and how it excel the traditional method can be defined by observing teachers’ opinion where most of the results encourage and support this integration.
4. Conclusion and Recommendations

This project targeted to develop a new technique in learning by measuring the interaction of students in class with the implication of feedbacks from teachers. Thus, GIS can be used to enhance students’ capabilities as well as teachers’ expertise as an effective method in improving education in Lebanon.

Students, nowadays, are exposed to a different direction of studying in universities that requires more developed techniques to be used and support them. Hence, using GIS can help them discover course details in a way that boosts their logical, spatial, lingual and interpersonal qualifications. This study informs about the facilities in education provided by GIS and explained how it can aid students analyze, interpret and evaluate information instead of just getting answers. Observing the results of evaluations recorded, students understood mathematic and geography in an excellent way and history in a good way. Instructors highly supported and consider GIS as a recommended methodology that should be integrated in the curriculum.

It is affirmative now to present this project as a demo to the Educational Center for Research and Development (CERD) in Lebanon to be approved and adopted by the Ministry of Education. Moreover, expanding this project across Lebanon should be done to include Tripoli and other governorates and increase the spread of GIS awareness in schools in the entire country before presenting it to the CERD. This step certainly requires preparation and insertion of more lessons and courses on GIS and arrangement of a training course about the basics of working with GIS to teachers and instructors.
5. References


التعليم العالي الهندسي والبحث العلمي في مواجهة تحديات البطالة والاستثمار والتنمية: العلاقات المفقودة

مقدمة

يدرس هذا البحث واقع أسواق العمل وحركة الاستثمار وعلاقاتهما بالتعليم العالي والبحث العلمي. ويحاول الإضاءة على التحديات التي تواجه كل منهم، وإيجابية على التساؤلات الكثيرة عن أسباب عدم قدرة منظومة التعليم العالي والبحث العلمي في العالم العربي ومن ضمته لبنان، على المساهمة في تعزيز التنمية وزيادة فرص الاستثمار وتوسيع أسواق العمل، وعن أسباب إنشار أنواع من البطالة المقنعة والسفيرة.

وفي الوقت الذي ساهم التعليم العالي الهندسي في إنتاج آلاف الوظائف وزيادة فرص الاستثمار ومعدات النمو في الدول البوفور، وفي الدول السريعة النمو، لا يزال هذا التعليم عاجزاً حتى عن توفير القدر الكافي من المهارات ذات القيمة المضافة لخريجيه أو زيادة تنافسيةهم في أسواق العمل، كيفك به والمساهمة في خلق الوظائف وتعزيز الاستثمار.

لقد أدت الزيادة الكبيرة في عدد طالبي الالاتساب إلى التعليم العالي في العالم من 100 مليون مطلع القرن الحالي إلى 220 مليوناً، إلى حدوث طفرة في عدد مؤسسات التعليم العالي ودخول الأقسام الخاص إلى هذا القطاع. وعربيةً، يوجد لدينا اليوم حوالي 500 جامعة عربية، و300 معهد جامعي ولو اعتبرنا أن سكان العالم العربي يوازي 330 مليوناً، فإن عدد جامعاتنا لا يوازي سوى 15% من عدد جامعات الولايات المتحدة، ما يعني نظرياً أننا بحاجة إلى سبعة أضعاف هذا العدد... وتكرار نماذج موحدة منها حتى داخل البلد الواحد، دون أن يترافق ذلك مع تحسن في النوعية والجودة وهذا ما زاد من خطر الوقوع في البطالة، وإن كان قد ترافق ذلك مع تحقيق انتقال من حقبة "الخبيرة" في التعليم إلى فتحة أمام مختلف شرائح المجتمع، من هنا بدأ يطرح السؤال حول العاطلين عن العمل من حملة الشهادات الجامعية، وهم باتوا يشكلون أكثر من ثلث أعداد الخريجين العرب خصوصاً بين الشباب منهم. حتى في الدول العربية الجاذبة لحملة الشهادات والتي تتمتع بأسواق عمل واسعة فإن عدد العاطلين عن العمل من الشباب الخريجين لا تزال مرتفعة جداً، والسبب يوجد إلى ضعف مهارات الخريجين وعدم قدرتهم على تبادل وظائف ذات قيمة مضافة.
من هنا، كان لا بد من العمل على التوفيق بين قدرة الجامعات على نقل المعرفة وتوطينها وإعادة إنتاج معرفة جديدة، ومسؤوليتها تجاه المجتمع من خلال تزويد خريجيها بالمعرفة والمهارات التي تسمح له بالانتقال السريع نحو سوق العمل. وفي هذا المجال لا بد من طرح الإشكالية التالية حول قدرة الجامعة من خلال البحث والإبتكار على المساعدة في تعزيز حركة الاستثمار وتوسيع أسواق العمل وبالتالي الإجابة على السؤال التالي، لماذا اعتمدت جامعات العالم المتقدم والسريع النمو المساهمة في خلق فرص عمل ولا تستطيع جامعاتها القيام بذلك؟ ولماذا تستطيع جامعات عديدة أن تبني أرباحًا من خلال تعاونها مع عالم الأعمال؟ بينما يتخذ عالم العمل والأعمال موقفًا حيادياً وح Dietary لسلاسل من جامعاتها وأساتذتها وخبرجيها؟ وكيف يمكن لقطاع الأعمال والإنترنت أن يبني أرباحًا ويوسع نشاطاته في دول العالم المتقدم والثابت بينما يترد عالم العمل العربي في التعاون مع الجامعات العربية؟ قد يكون ضرورياً تحديد هوية للجامعات العربية، فهناك جامعات بحثية وأخرى للتعليم، وبعضها مختلف وأخرى ذات طابع عام... وأين يقع موقع الجامعات الحكومية الخاصة... وما هي آليات تطورها وخلق بيئة بحثية ملائمة ودور الأساتذة والطلبة في ذلك.

وفي هذا الإطار لا بد من البحث عن دور الدولة في رسم السياسات التنموية وإعطاء منظومة التعليم والبحث دوراً واسعًا ومهمًا في تنفيذها ومراقبة آليات التنفيذ والنتائج. كما أن موضوع تمويل الجامعات والباحثات العلمية يطرح إشكالية إضافية ينتج عنها عدم قدرة الجامعات على إجرام معايير الجودة. بينما تغيب إشكالية التمويل عن جامعات العالم المتقدم بسبب قدرة هذه الجامعات على التطور والإبتكار وتسويق منتجاتها البحثية، وبالتالي مساهمتها في زيادة فرص الاستثمار وتعزيز قدرة الاقتصاد على النمو. وهذا ما يجلب إليها ما يكفي من الأموال لسد نفقاتها.

كم لا بد من التذكير بدور الطالب نفسه في تطوير ذاته ليصبح أكثر تنافسية في العمل أو أثناء البحث عن وظيفة، وعن دور مراكز التوجيه المهني والتوظيف وتعزيزها.

لقد قادت دول شرق آسيا ودول البريكس قطع النمو العالمي... وتحولت الصين والهند وغيرهما خلال أقل من عشر سنوات إلى غمالة في الصناعة والإنترنت من خلال تعزيز ثقافة الإبتكار والإبداع بالإرث الذي من منظومة التعليم والبحث... بما يجاوز تلك العلاقات المحكمة بين منظومة التعليم والبحث في الوطن العربي وحركة الاستثمار وأسواق العمل داخله في كل دولة... وبالتالي كيف يمكن جعل تعليمنا العالمي استثمارًا إيجابيًا يُؤدي دوره في التنمية الاقتصادية والبشرية ويساهم في تقليص البطالة وزيادة مُعدلات الدخل الفردي والوطني.
1 - البطالة وأسواق العمل: من الجامعة إلى سوق العمل

يبلغ متوسط مدة البحث عن عمل حوالي 19.2 شهراً بالنسبة للأعمار من 35-44 عامًا، وتتعرض النسبة من 13.2 شهراً للباحثين عن عمل من حملة الشهادات الإبتدائية إلى 10.1 شهراً كمعدل وسطي للباحثين عن عمل من حملة الشهادات الجامعة. وتتفوق معدلات البطالة مع ارتفاع مستوى التعليم، وتتخفض معدلات البطالة مع ارتفاع معدلات الأعمار وأعلى نسبة بطالة هي للشباب من 15-24 سنة، والمعدل العام لبطالة الشباب في الوطن العربي يقارب 23.2% والمعدل العالمي يقارب 13.9%.

1 - معدل البطالة للخريجين الجدد وعدد الأشهر للبحث عن وظيفة

<table>
<thead>
<tr>
<th>الجنس</th>
<th>معدل البطالة %</th>
<th>عدد الأشهر</th>
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<tr>
<td>الذكور</td>
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<td></td>
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<td>6</td>
</tr>
<tr>
<td>64 – 45</td>
<td>20</td>
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1 - أوراق العمل على الصعيد العالمي: أفق مسند أمام الشباب في سوق العمل مكتب منظمة العمل الدولية 2012.
2 - تقرير البنك الدولي حول الأعمال – بيروت 2014.
## 2 - البطالة وسوق العمل في الدول العربية وبعض الدول النامية

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<thead>
<tr>
<th>البلد</th>
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<th>المجموع (%) من اليد العاملة 1996-2005</th>
<th>متوسط (%) من اليد العاملة 1996</th>
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<th>النساء (%) من الرجال</th>
<th>النساء (%) من الرجال</th>
<th>النساء (%) من الرجال</th>
<th>النساء (%) من الرجال</th>
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<td>4.3</td>
<td>إيران</td>
<td>11.5</td>
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</table>

1- المستوى العام للبطالة والفقر: مؤتمر العمل العربي، شرم الشيخ، جمهورية مصر العربية، شباط 2008، وتقرير التنمية البشرية للعام 2009، الأمم المتحدة.

2- الأرقام الواردة في الجدول وفي النص هي تقريبية وتختلف بنسبة المصدر والسنة.

3- لا يوجد إحصاء دقيق للبطالة في لبنان بسبب معدل الهجرة المرتفع لدى الشباب.
3 - البطالة والرضا بالوظيفة في الوطن العربي

| الدولة | الثقة بالحكومة | الرضا بالوظيفة | الرضا بحرية الخيارات | الرضا العام بالحياة | تشغيل الأطفال | بطاقة الشباب من 10-5 | بطاقة الشباب من 14-5 | نسبة العاملين إلى مجموع السكان بنسبة المونية من فئة 25 سنة وما فوق | نسبة العاملين إلى مجموع السكان بنسبة المونية من 24-15 سنة وما فوق | نسبة العاملين إلى مجموع السكان بنسبة المونية من 14-15 سنة وما فوق | نسبة العاملين إلى مجموع السكان بنسبة المونية من 10-15 سنة وما فوق | نسبة العاملين إلى مجموع السكان بنسبة المونية من 5-15 سنة وما فوق | نسبة العاملين إلى مجموع السكان بنسبة المونية من 0-15 سنة وما فوق |
|--------|----------------|----------------|----------------------|-------------------|------------------|----------------------|---------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| قطر   | 89.0           | 86.0           | 90.0                 | 6.6               | -                | 8.9                  | 89.9                |                        |                        |                        |                        |                        |                        |                        |
| الإمارات العربية المتحدة | 80           | 88.7           | 87                    | 7.2               | -                | 21.8                | 83.4                |                        |                        |                        |                        |                        |                        |                        |
| البحرين | 60           | 79.3           | 73.0                 | 4.5               | 5.0              | -                    | 72.2                |                        |                        |                        |                        |                        |                        |                        |
| الكويت | -             | -              | -                    | -                 | -                | 11.8                | 75.5                |                        |                        |                        |                        |                        |                        |                        |
| المملكة العربية السعودية | 46.0         | 88.5           | 80.0                 | 7.3               | -                | 45.8                | 59.7                |                        |                        |                        |                        |                        |                        |                        |
| ليبيا | -             | 64.3           | 41.0                 | 4.9               | -                | -                    | 53.6                |                        |                        |                        |                        |                        |                        |                        |
| لبنان | 37.0           | 70.8           | 65.0                 | 5.2               | 7.0              | 22.3                | 47.6                |                        |                        |                        |                        |                        |                        |                        |
| عمان | -             | 85.3           | 91.0                 | 6.9               | -                | -                    | 65.7                |                        |                        |                        |                        |                        |                        |                        |
| الجزائر | 53.0         | 58.7           | 53.0                 | 5.2               | 5.0              | 37.5                | 43.9                |                        |                        |                        |                        |                        |                        |                        |
| الأردن | 77.0           | 74.9           | 72.0                 | 5.7               | -                | 46.8                | 44.9                |                        |                        |                        |                        |                        |                        |                        |
| دولة فلسطين | 49.0         | 70.8           | 51.01                | 4.8               | -                | 49.6                | 41.2                |                        |                        |                        |                        |                        |                        |                        |
| مصر | 24.0           | 64.7           | 57.0                 | 4.1               | 7.0              | 54.1                | 51.3                |                        |                        |                        |                        |                        |                        |                        |
| سوريا | -             | 55.5           | 47                    | 4.1               | 4.0              | 40.2                | 45.8                |                        |                        |                        |                        |                        |                        |                        |
| المغرب | 60           | 65.4           | 54.0                 | 5.1               | 8.0              | 18.1                | 50.9                |                        |                        |                        |                        |                        |                        |                        |
| العراق | 37.0           | 64.2           | 30.0                 | 5.0               | 11.0             | -                    | 41.9                |                        |                        |                        |                        |                        |                        |                        |
| اليمن | 39.0           | 54.3           | 59.0                 | 3.7               | 23.0             | -                    | 50.9                |                        |                        |                        |                        |                        |                        |                        |
| جزر القمر | 44.0         | 49.8           | 50                    | 3.9               | 27.0             | -                    | 62.7                |                        |                        |                        |                        |                        |                        |                        |
| السودان | 54.0         | 48.8           | 56.0                 | 4.4               | -                | -                    | 89                  |                        |                        |                        |                        |                        |                        |                        |
| الصومال | -             | -              | -                    | -                 | -                | 49.0                | -                    |                        |                        |                        |                        |                        |                        |                        |
| مجموع الدول العربية | 52.0         | 73.1           | 73.9                 | 5.3               | -                | -                    | 65.8                |                        |                        |                        |                        |                        |                        |                        |

يُقدر عدد سكان الخليج العربي بحوالي 16 مليون يتحدون بأكثر من 50 لغة وتتنتمي إلى أكثر من 70 جنسية، وتتلقى تعليما في أكثر من 600 مدرسة خاصه لها.

تنشير الإحصائيات المتعادلة حول معدلات البطالة إلى وجود تفاوت كبير بين تقديرات الهيئات الدولية والتقديرات الصادرة عن الهيئات الوطنية، كما نلاحظ من الجدول التالي:

<table>
<thead>
<tr>
<th>الدولة</th>
<th>الترتيب/118</th>
<th>تقريرات موسسة الخليج للاستثمار 2012 (%)</th>
<th>تقريرات مؤسسة ديلويت للشرق الأوسط 2012 (%)</th>
<th>معدل البطالة (%)</th>
<th>تقريرات صندوق النقد الدولي 2012 (%)</th>
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</thead>
<tbody>
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<td>-</td>
<td>113</td>
<td>2.1</td>
<td>2012</td>
<td></td>
</tr>
</tbody>
</table>

باستناد إلى هذه الأرقام، وإلى أكثرية الدراسات المتواجدة، يُضح أن معدلات البطالة مرتفعة في دول الخليج بالرغم من حجم الاستثمارات الهائل الذي تمتلكه، وتوسع أسواق العمل بشكل كبير، وأن المتوسط معدلات البطالة لا يقل عن 14% للعام 2011-2012 بالرغم من تحوّل دول الخليج إلى أكثر الدول الجاذبة للاستثمار... والبطالة لدى الإناث تصل إلى 70% أحياناً.

1- البطالة في دول الخليج العربي: حامد بن عوض الغنزي – الصحفية الاقتصادية الإلكترونية 2014.
5 - توزيع المُفَوَّة حسب التعليم والقطاع (لبنان)

<table>
<thead>
<tr>
<th>القطاع</th>
<th>المادة (%)</th>
<th>الجامعي (%)</th>
<th>الثانوي (%)</th>
<th>الإبتدائي (%)</th>
<th>غير مصنف (%)</th>
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1. تقرير البنك الدولي – 2010

World Bank, Employee – Employer Survey.
### توزيع العمالة الحرّة حسب القطاع ومستوى التعليم

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<tr>
<th>القطاع</th>
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<th>الجامعي (%)</th>
<th>الثانوي (%)</th>
<th>الإبتدائي (%)</th>
<th>غير مصنف (%)</th>
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المصادر: البنك الدولي، الاستمارة في استمارة الموظف، 2010.

7 – الإنفاق على التعليم

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<th>التعلم التكميلي (%)</th>
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8 – تحديات التعليم وأسواق العمل والبطالة

إنطلاقاً من تجارب الدول النامية والتحولات الجارية في أسواق العمل والتحول نحو الاقتصاد القائم على المعرفة، يمكن توزيع العلاقات المقيدة والتحديات التي تواجه التعليم العالي الهندسي وعلاقته بقضايا الاستثمار والبطالة وأسواق العمل إلى ثلاث مُستويات 1:

1- المستوى الاقتصادي والابتكاري، ودور الاستثمار في توزيع أسواق العمل وخلق فرص عمل جديدة بالاستناد إلى التعليم العالي والبحث العلمي.

2- مستوى التعليم العالي والبحث العلمي ودورهما في التنمية وتعزيز حركة الاستثمار ومن خلالهما إنتاج فرص عمل جديدة.

3- مستوى الفرد نفسه ودوره في إيجاد فرصة عمل لائقة من خلال زيادة معدل تناقصه من جراء خسارة اختياره للجامعة ولاقتصاصات والتزود بالمعارف والمهارات واحترام قواعد السلوك والانضباط... وغير ذلك.

ويُرجع الخبراء ضمور أسواق العمل العربية وتراجع حركة الاستثمار في القطاعات ذات الإنتاجية العالمية (الهندسة والتكنولوجيا...) والتي تحتاج إلى أيدي عاملة ماهرة وذكية، والمُنَجِّرة للوظائف، إلى:

1- الاقتصاد الريعي الذي يعتمد بشكل كبير على المواد الطبيعية (عائدات نفطية) وعلى قطاع الخدمات الذي توسع بشكل كبير في الوطن العربي على حساب قطاعات الصناعة والبناء... خصوصاً في ظل الخصخصة أو ما يُسمى بالإصلاحات الهيكليّة للأقتصاد وفقاً لنصوص الجهات الدولية.

2- صغر حجم القطاع الخاص بالمقارنة مع القطاع العام، وتواضع حركة الاستثمار في قطاعات الصناعة والبناء والإنشاءات التي تحتاج إلى أيدي عاملة ماهرة وشهادات هندسية مخصصة بمعارف ومهارات ذات قيمة مُضافة.

3- تؤكد استطاعات البنك الدولي وأراء أرباب العمل على ظاهرة عدم التناسب بين المهارات المطلوبة للوظائف، خصوصاً الوظائف الفنية والهندسية والشهادات التي يحملها طالباً الوظائف.

1- تقديرات منظمة العمل الدولية 2013. وتقديرات مؤسسة الفكر العربي، مؤتمر فكر 2014.
4 - جنوح حركة الاستثمار نحو قطاعات تُؤمّن أرباحاً سريعة كأسواق الخدمات والعقارات والسياحة والترفيه، والأخيرة لا تُمؤمّن وظائف مُستدامة.

5 - نوعية وأشكال التعليم الشائع الذي يُركز عموماً على التلقين دون أن يبلغ مرحلة إنتاج المعرفة أو تزويد الخريجين بمهارات ومعارف ذات قيمة مُضافة.

6 - ضعف الأداء الباحثي وعدم مساهمته في عمليات الإبتكار والإبداع وبالتالي إنتاج فرص استثمار جديدة قائمة على المعرفة، تسمح بإنتاج سلع وأدوات وخدمات قابلة للإنتاج والتسويق.

7 - ترهل النظم التشريعية المحاذية لحركة الاستثمار والإنتاج وتخلف التشريعات المتعلقة بحرية الفساد والمساحة والمحاسبة، أو التشريعات التي تسمح بتغريز الاستثمار وتيسير الإجراءات الإدارية والوجستية للانطلاق بالمشاريع.

8 - تردد أصحاب العمل في تنفيذ إستراتيجيات طويلة الأجل... ولجوئهم إلى المشاريع السهلة ذات القيمة المُضافة المُستدامة.

9 - ضعف نَقَطة المستثمرين بنجاح بحوث الأكاديميين في كليات العلوم والهندسة والإنشاءات، وتواضع مساهمتهم في تحسين عمليات الإبتكار والإبداع، أو في الاستفادة من نتائجها في توثيق مجالات الاستثمار وتعزيز الإنتاج بما يُساهم في زيادة الناتج القومي والفردي وتسيع أسواق العمل ومجالاته.

10 - التردد في متابعة الخطط التنفيذية للخطط الوطنية لتعزيز التعليم العالي بشكل عام والهندسي بشكل خاص، والمحور العلمي الذي تقتضي إلى الإبتكار والإبداع إنتاج سلع وخدمات جديدة.

11 - تحويل أرباح الاستثمارات وعائدات الاقتصاد العربي إلى أرصدة نقدية مما ساهم في تقلص المشاريع الصناعية المُنَتِّجة للوظائف المُستدامة، كما ساهم في تقلص تموزل الشركات الصغيرة والمتوسطة... مما أعاد عملية التوظيف وتموزل الشركات الصغيرة والمتوسطة... التي أثبتت جدارتها في لحم مُعادل البطاله المرتفعة خصوصاً في ضوء تقديرات لحاجة المنطقة العربية إلى 75 مليون وظيفة جديدة حتى العام 2020.1

---

1 - تقرير منظمة العمل الدولية حول اتجاهات العمل في العالم حتى العام 2020.
1 - الاستثمار الخارجي المباشر ونقل التكنولوجيا الحديثة

استقصاء معلومات: إلى أي حدٍ يتأثر الاستثمار الخارجي بالتكنولوجيا الحديثة التي تحتاج إلى مهارات هندسية إلى بلدك:

1 - لا يأتي:
2 - المصدر الأساسي للتكنولوجيا الحديثة:
3 - المعدل العالمي: 6.4

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2 - الاستثمار ومُستوى التجمُّعات الصناعية والخدماتية

جدول حول آراء أرباب العمل حول مُستوى التجمُّعات الصناعية والخدماتية والتي تُشكّل الهندسة والإبتكار أساس العمل فيها.

سؤال: ما مدى نمو التجمُّعات الصناعية والخدماتية؟

1 - تجمُّعات غير موجودة: 1
2 - تجمُّعات صناعية وخدماتية في عدة مجالات: 7
3 - المُعدل العالمي: 3.7

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المصدر: تقرير المجلس الاقتصادي العالمي حول التنافسية الدولية للعام 2012-2013. مؤسسة الفكر العربي، بيروت، تقرير التنمية الثقافية للعام 2014.
3 – الاستثمار ومَوْسَطّى إِسْتِخْدَامِ التَّقْنِيَاتِ وَأَدَواتِ الإِنْتَاجِ الْحَدِيْثَةِ

مَوْسَطُ تَطْوُرِ عمَلَياتِ الإِنْتَاجِ وَإِسْتِخْدَامِ التَّكَنُّوْلُوجِياَ الْحَدِيْثَةِ وَعَلْمَيْ الْهَنْدَسَةِ وَالْإِنْشَاءَاتِ.

الإِجَابَةُ عَلَى السَّوْلِ: مَا مَوْسَطُ التَّطْوُرِ الَّذِي يُمِيِّزُ عمَلَياتِ الإِنْتَاجِ؟

1 - غَيْرُ مَتَطْوُرُةَ: 0
2 - تَسْتَنَدُّ إِلَى أَجِيَالٍ سَابِقَةَ: 1
3 - مَتَطْوُرَةُ لَغاَيَةً: 7

البلد | القيمة الدولي | الاترتيب الدولي |
--- | --- | --- |
قطر | 5.6 | 12 |
السعودية | 5.1 | 26 |
الإمارات | 5.0 | 27 |
عمان | 4.4 | 37 |
البحرين | 4.3 | 42 |
الأردن | 4.0 | 52 |
تونس | 3.8 | 59 |
سوريا | 3.5 | 79 |
مصر | 3.4 | 86 |
لبنان | 3.4 | 94 |
المغرب | 3.3 | 97 |
الكويت | 3.3 | 100 |
ليبيا | 3.1 | 116 |
مرتفعات | 2.7 | 126 |
اليمن | 2.4 | 137 |
الجزائر | 2.3 | 141 |
إسرائيل | 5.7 | 10 |
تركيا | 4.4 | 38 |
قبرص | 3.8 | 63 |
إيران | 2.1 | 71 |

1 - نَتَائِجُ وَسَطِيَّةُ 2010-2011. المَرْجُوعُ: تَقْرِيرُ المَجْلِسِ الْاِقْتَصَادِيِّ الْعَالِمِيَّ عَنْ التَّنَافْسِيَةِ الْوَلَيْلِيَّةِ لِلْعَامِ 2012-2013.

التَقْرِيرُ السَّادِسُ لِلْتَنَمِيَةِ اِثْقَانِيَةِ - مَؤْسِسَةُ الفَكْرِ الْعَرَبِيَّ، بِرَوْتُ 2014.
- مؤشر الاقتصاد المعرفي القائم على التعليم الهندسي

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<td>الصين</td>
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</tr>
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</table>
5 - ترتيب الدول العربية في مؤشر الاقتصاد المعرفي القائم على البحوث والإبتكار (بحوث وطنية وأجنبية)

<table>
<thead>
<tr>
<th>الدولة</th>
<th>الترتيب 2012</th>
<th>الترتيب 2010</th>
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<tbody>
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<td>الإمارات العربية المتحدة</td>
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<td>عمان</td>
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<tr>
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<td>50</td>
<td>67</td>
</tr>
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<td>قطر</td>
<td>54</td>
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</tr>
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<td>الكويت</td>
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<td>46</td>
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<td>تونس</td>
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<td>لبنان</td>
<td>81</td>
<td>68</td>
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</table>

6 - مؤشر الإبتكار العالمي

<table>
<thead>
<tr>
<th>Innovation Outputs</th>
<th>Innovation Inputs</th>
<th>Innovation Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>نتائج الأعمال الإبتكارية، المعرفة، الأعمال الخلاقة</td>
<td>العناصر المشجعة للابتكار تطور قطاع الأعمال والمؤسسات والبنية التحتية</td>
<td>العناصر الداعمة للابتكار في الاقتصاد الرأسمال البشري ومتوسط البحوث والبنية التحتية</td>
</tr>
<tr>
<td>ولبنان</td>
<td>25</td>
<td>42.2</td>
</tr>
<tr>
<td>المعدل العالمي</td>
<td>30.99</td>
<td>42.82</td>
</tr>
<tr>
<td>معدل الدول العربية</td>
<td>24.86</td>
<td>36.69</td>
</tr>
<tr>
<td>معدل دول مجلس التعاون الخليجي</td>
<td>-</td>
<td>48.2</td>
</tr>
</tbody>
</table>
7 - نتائج البحوث والإبتكار: براءات الاختراع

بلغ مجموع براءات الاختراع الصادرة عن الوطن العربي ١٧٥ براءة للعام ٢٠١٢.

السعودية ٧٨، ألمانيا ٦٨٦٧، تركيا ٣٦٧، فرنسا ٤٦، إسرائيل ١٨٨٢، مصر ٢٩، الصين ٦٠٨٩، الإمارات ٢٩، بريطانيا ٥٥١٧، الهند ٧٦٦، المغرب ١٥، هولندا ٤٣٤٩، السعودية ٤١١٤، البرازيل ٤٥١، السويد ٣٨٣٢، ألمانيا ١٩، سوريا ١٣، إسرائيل ١٩، تونس ٧، جيبوتي ١٧٧، إيطاليا ٢٩٢٩، قطر ٤، إيران ١٧٧، فنلندا ٢١١٩، كوريا الجنوبية ٧٩٠٨.

٨ - متوسط الأوراق العلمية

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<thead>
<tr>
<th>الدول العربية</th>
<th>الاتحاد الأوروبي</th>
<th>الولايات المتحدة</th>
<th>الهند</th>
<th>إسرائيل</th>
<th>دول شرق آسيا والمحيط الهادئ</th>
</tr>
</thead>
<tbody>
<tr>
<td>أقل من ١%</td>
<td>٣٧%</td>
<td>٣١%</td>
<td>٢.٢%</td>
<td>١.٣%</td>
<td>٢١%</td>
</tr>
</tbody>
</table>

من الملاحظ تبوأ الدول الخليج صدارة مؤشر الاقتصاد المعرفي في الوطن العربي، وأن دولاً أكثر تقدماً على صعيد التربية والتعليم كلينان والأردن ومصر وتونس جاءت في مراتب متاخرة، وهذا يعود إلى الطفرة الاقتصادية والمالية والإنفاق المتنامي على المشروعات القائمة على المعرفة والتي سمحت بتمويل مشروعات عملاقة على صعيد العقارات والإنشاءات والخدمات واستخدام تقنيات عالية لإدارتها وصيانتها.

ولكن بالاستعانة بحملة شهادات هندسية أجنبية وعربية مزودة بمهارات عالية.

١ - المنظمة العالمية للملكية الفكرية ٢٠١٢.
9 - ترتيب الدول العربية بالنسبة لسهولة ممارسة الأعمال في قطاع الهندسة والانشاءات ومشاريع الإنتاج والخدمات

<table>
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<th>الترتيب العالمي</th>
<th>الدولة</th>
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</thead>
<tbody>
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<td>الإمارات</td>
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<tr>
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<tr>
<td>50</td>
<td>قطر</td>
</tr>
<tr>
<td>53</td>
<td>البحرين</td>
</tr>
<tr>
<td>60</td>
<td>تونس</td>
</tr>
<tr>
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<tr>
<td>160</td>
<td>السودان</td>
</tr>
<tr>
<td>175</td>
<td>سوريا</td>
</tr>
</tbody>
</table>

يحتاج رجل الأعمال إلى 74 يوماً لبدء عمل في العراق و75 يوماً لتسليم عقار في المغرب و159 يوماً للحصول على كرهاة في الجزائر و218 يوماً للحصول على تصريح بناء في مصر...

بالمقابل تحتاج هذه الإجراءات في كوريا الجنوبية على التوالي: 7 و11 و28 و29 يوماً.

المعوقات الأساسية: الفساد والبيروقراطية والمرتكبة الإدارية... تعقيد التشريعات القانونية... وسوء البنية التحتية.

1 - تقرير البنك الدولي حول التنافسية العالمية للعام 2013.
1 التحديات التي تواجه التعليم العالي الهندسي في مواكيته لأسواق العمل والاستثمار والتنمية

- تكدس التخصصات في مجالات معيّنة على حساب تخصصات أخرى.
- إنخفاض معدل الوظائف في القطاع العام وارتفاعها في مجال الخدمات.
- ارتفاع معدلات البطالة لدى الشباب مع ارتفاع درجاتهم العلمية.
- زيادة معدلات الوظائف في قطاع الخدمات التي لا تحتاج إلى مهارات ومعارف عالية، أو إلى شهادات هندسية ذات قيمة مُضافة.
- إنخفاض معدلات النمو، وعدم ثبات عالم العمل والمشاكل التي يواجهها على صعيد الأوضاع السياسية والأمنية.
- تشغيل ظاهرة الهجرة غير الشرعية، ومنافسة حملة الشهادات من الخارج للحملة الشهادات من الجامعات الوطنية.
- إنعدام التوازن والامان في الوظائف الشامانية وارتفاع معدلات الوظائف بدوام جزئي أو على المشروع.
- ضعف الثقافة العلمية لدى المواطنين العرب.
- ضعف ثقافته الإبتکار والإبداع.
- ضعف المهارات والمعارف ذات القيمة المُضافة في شهادات الخريجين من الجامعات الوطنية، مما يستوجب الاستعانة بأيدي عاملة أجنبية مزودة بشهادات عالية ذات قيمة مُضافة...
- ضعف نمط أرباب العمل بالأكاديميين وضعف مشاركتهم في تمويل مشاريع البحوث داخل الجامعات لتطوير سلع ومبتكرات، وعدم الاستفادة من نتائجها.
- المنافسة الشديدة بين حملة الشهادات من الجامعات الحكومية والخاصة وبين حملة الشهادات من الخارج وحاملها من داخل البلدان العربية.
- ضعف مراكز التوجيه الأكاديمي ونشاط هيئة التوجيه المهني.
- عدم وجود مصادر لأعمال العمل داخل الجامعات، وعدم وجود هيئة استشراف لمستقبل المهن والوظائف أو لمجالات الاستثمار وضعف إهتمام قطاعات الصناعة، خصوصا الصناعة القائمة على المعرفة في اقتصاد معرفي ذكي.

2- عدم التناسب بين المهارات المطلوبة للوظائف وكفاءة ومهارات الموظفين وحملة الشهادات الجامعية، وخصوصاً في مجال الهندسة.

فيما يلي معدل التناسب بين المهارات المطلوبة من الوظائف ومستوى الكفاءات أو مهارات الموظفين أو أصحاب المهن الحر:

أ- موظفو

<table>
<thead>
<tr>
<th>مهارات متدنية</th>
<th>مهارات عالية</th>
<th>العامل</th>
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<tbody>
<tr>
<td>%28.6</td>
<td>%14.3</td>
<td>غير مناسبه تماماً</td>
</tr>
<tr>
<td>%20.1</td>
<td>%20.5</td>
<td>مناسبة لبعض الأشغال</td>
</tr>
<tr>
<td>%29.4</td>
<td>%61.1</td>
<td>مناسبة تماماً</td>
</tr>
<tr>
<td>%21.9</td>
<td>%4.2</td>
<td>لا يوجد مجال عمل محدد والمهارات للوظيفة</td>
</tr>
</tbody>
</table>

ب- مهن حرّة

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<tr>
<th>مهارات متدنية</th>
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<th>مهن حرّة</th>
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<td>%22.7</td>
<td>غير مناسبة تماماً</td>
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<tr>
<td>%16.1</td>
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<td>تناسب متوسط</td>
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<td>مناسب تماماً</td>
</tr>
<tr>
<td>%25.6</td>
<td>%20.7</td>
<td>لا يوجد مجال عمل محدد أو مهارات مطلوبة للعمل</td>
</tr>
</tbody>
</table>

\(^1\) World Bank – Employee – employer survey - 20
ج - مستوى تدريب العاملين وتأهيل حملة الشهادات وأصحاب الوظائف

جدول مستوى تدريب العاملين في بعض الدول العربية والشرق أوسطية

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<th>قيمة المؤشر</th>
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</tr>
<tr>
<td>3.0</td>
<td>134</td>
<td>إيران</td>
</tr>
</tbody>
</table>
1 - جودة التعليم العالي

اعتماد التعليم العالي الهندسي، وتطوير البرامج التعليمية.

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<tr>
<th>الدولة</th>
<th>عدد البرامج المعتمدة</th>
<th>عدد الجامعات</th>
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<td>مصر</td>
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<td>9</td>
</tr>
<tr>
<td>السعودية</td>
<td>35</td>
<td>7</td>
</tr>
</tbody>
</table>

مع الإشارة إلى أن معظم الجامعات التاريخية في الوطن العربي، وبعض جامعات دول الخليج قد بدأت تولي إهتماماً ملحوظاً للجودة، وبرامجها هي في التقييم لدى هيئات الاعتماد الدولية الموثوقة: الجامعات اللبنانية الأميركية، الجامعة الأمريكية في بيروت، جامعة بيروت العربية، وغيرها.

ABET: American Board for Engineering Technology - 1

22
<table>
<thead>
<tr>
<th>الرتبة</th>
<th>اسم المؤسسة</th>
<th>الدولة</th>
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<tr>
<td>1</td>
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<td>2</td>
<td>الجامعة الأمريكية في بيروت</td>
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<td>جامعة العلوم والتكنولوجيا الأردنية</td>
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<td>الجامعة الأمريكية في دبي</td>
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1- قضايا النوعية في التعليم العالي في البلدان العربية: رئيس التحرير د. عدنان الأمين، الكتاب السنوي الثامن للهيئة الإقليمية للعلوم التربوية 2013.
البحث العلمي ومساهمتها في تعزيز الاستثمار ومواجهة البطالة وتوسيع أسواق العمل

1- هوية الجامعات العربية: جامعات مختصة، جامعة بحثية، جامعات للدراسات الجامعية بدرجة ماستر ودكتوراه، جامعات تكنولوجية مرتبطة بمن قناعية...
2- رسالة التعليم العالي ومواعقتها مع الخطط الوطنية للتنمية والتطوير.
3- استقلالية الجامعات العربية، والحرية الفكرية، وحرية المجالس الأكاديمية.
4- الأحزام الجامعية والتنظيم الأكاديمي.
5- الجامعات الحكومية والخاصة: جامعات خاصة حديثة لا تراعي معايير الجودة والتنوع.
6- الأساتذة: روابط الأساتذة، دور الأساتذة في الإبتكار والإبداع، الانتقال من سياسة النشر والترقيم الأكاديمي إلى سياسة الإبتكار، تدريب الأساتذة، معدل الأساتذة إلى عدد الطلبة... وغير ذلك.
7- الإنتساب والطلبة: إنتساب جز، إنتساب من خلال امتحانات تجريم أو قبول، توجيه بعض الجامعات إلى جذب العدد الأكبر من الطالبات، أليات التقييم والنجاح ومنح الشهادات، الخبرات والمهارات لإستطابطلة الأجانب المتفوقين (شرق آسيا).
8- تمويل الجامعات: حكومية على نفقة الدولة، من الأساتذة الجامعية فقط.
9- المشاركة مع أرباب العمل من خلال بيع نواتج البحث والابتكار. مثلاً، تتفق هارفرد ملياري دولار على البحث والابتكارات، المرتبطون بحالة 18 مليار دولار، تتفق لتحسين أوضاع الطلبة والأساتذة والتجهيزات السنوياً.
10- التعاون مع الجامعات العالمية، والشراكة مع الجامعات المحلية والعالمية في البحث واستقبال الطلبة والأساتذة.
11- معايير النشر والبحث: ضعيفة وتهدف للترقي المهني... ولا تهدف إلى تطوير العلم وتعزيز التنمية.
12- مساهمة الجامعات في التنمية البشرية والاقتصادية، دراسات، إبتكارات، براءات اختراع، تطوير العلم.
12 - مُعدل قبول خريجي الجامعات في سوق العمل، ومُعدل المدة المطلوبة لخريجيها للحصول على وظيفة، ودور جمعيات الخريجين في البحث عن وظائف.

13 - مساهمة الجامعات في تأسيس الشركات:
تمتلك الجامعات البريطانية حاضنات تكنولوجية خاصة بها ولديها استثمارات في شركات ومصانع.

14 - ضعف التكامل بين الأكاديميين ورجال الأعمال:
- سيادة قطاع الخدمات
- ضعف البنية التحتية
- ثقافة البيع السريع
- ضعف الثقافة العلمية في المجتمع الغربي
- تردي ثقة رجال الأعمال بالإنجاح البحثي والابتكارات الوطنية ما يدفعهم إلى البحث عن شهادات استثنائية ومبتكرات جاهزة.

من المقابل تولي الدول المتقدمة أهمية كبيرة للتعاون بين أرباب العمل والجامعات.
- أقرت الحكومة البريطانية عام 1986 قانوناً ينص على نقل الملكية الفكرية من الحكومة لصالح الجامعات، مما سمح لها باستثمار عائدات الاعترافات والابتكارات المطوره داخلها. كما شجعت الحكومة الجامعات على تأسيس صندوق أموال للمساهمة في الاستثمارات الصناعية والتجارية، كما طرحت الجامعات علامات تجارية خاصة بها على المستثمرين.

كما تدفع الحاضنات التكنولوجية بقوة نحو تأسيس شركات قائمة على توظيف مورخات ومنتجات البحث العلمي وتحويلها إلى منتج قابل للإنتاج والمنافسة.
- حاضنة أوكسفورد قامت بتأسيس أكثر من 40 شركة في السنوات العشر الماضية.

15 - تواصل الباحثين مع مؤسسات العمل والإنجاح من خلال إنشاء هيئات وجمعيات وحاضنات تكنولوجية تسمح بإقامة إتصال دائم بينهم:
مثال: - واحة البحث العلمية في مدينة غرينبي - فرنسا، وتشتمل 19 ألف باحث وحوالي 200 مختبر و60 ألف طالب وجمع 10 مدشة كبرى في الهندسة وكلية كبرى في الإدارة مع شبكة هامة من الشركات التجارية، نذكر منها: Caterpillar, Hewlett Packed, Siemens, France Telecom, Schneider Electric, Aston Power,...
مشروع Giant

- مشروع مراكز Mitt للتنمية/Grenoble, Alep, Iseres, Nanotechnologies

بهدف إنشاء مركز للتقنية على غرار مركز MIT

وهو ساهم في تسهيل عملية نقل المعرفة بين مختبرات البحث العلمي وقطاع الصناعة، وتتأسس شركات صناعية صغيرة على أيدي مستثمرين وأفراد بقيمة 2 مليار أورو.

16- تحويل الجامعات وكليات الهندسة إلى ركيزة أساسية للشركات:

- إنشاء أقطاب جامعية متعددة التخصصات في مجالات العلوم، الهندسة، القانون، الإدارة... تكون ذات سعة قد تصل إلى 25 ألف طالب.

- استقطاب الطلبة المتفوقين، خصوصاً من دول شرق آسيا.

- التعاون مع باحثين ومكانتهم على بحوثهم وإشارتهم في القرار الأكاديمي والاقتصادي.

- تشجيع تأسيس المشاريع الوعود ومساعدتها للحصول على رأسال خاص مع إعفاءات ضريبية ومشاركة من مستثمرين وساهمين من الطلبة والأساتذة ورجال الأعمال.

17- الإنتقل من سياسة النشر إلى سياسة الابتكار والترويج للإنتاج البحثي وإختراعات الأساتذة والطلبة:

يغلب على عمليات البحث والتطوير داخل الجامعات العربية هدف الترقّي والتطوير الوظيفي... لذا، يركز الأساتذة أبحاثهم في مجالات تخدم هذا الهدف، بنشرها في مجلات أو في كتب... دون الاهتمام بتوظيف نتائجهما في مجالات التنمية والإنتاج، والاتصال بعالم العمل والعمال لتقنيتهم بالفؤاد الاقتصادية الناتجة عن مخرجاتهم بحوثهم والمساهمة في تطويرها لإخراجها في سلعة قابلة للتسويق والإنتاج.

وتتفق الجامعات العربية على وجود دوائر جامعية خاصة مهمتها الترويج للإنتاج البحثي للأستاذة... أو إلى مراكز نقل المعارف التكنولوجية وتطويرها وإعادة استثمارها أو توظيفها في مجالات صناعية أو زراعية أو خدمية مختلفة... أو إلى آليات لتعزيز الابتكار وتقدم المشورة القانونية وتوفير المساعدات المالية الكافية والمساعدة في إجراء دراسات جدوى بالإضافة إلى صعوبة الحصول على الدعم المادي اللازم لتأسيس مشاريع إنتاجية ذات طابع إستثماري.

وكمثال على أهمية دور مركز نقل التكنولوجيا في الجامعات البريطانية تشير إلى تجارب:
- جامعة سري (Surrey) في إنشاء مؤسسة EADS عام 2008. وهي مؤسسة رائدة في إنتاج الأقمار الصغيرة وتسمك 85% من أسهمها شركات تابعة، وهي من أنجح المشاريع التي خرجت من مختبرات البحث Satellite Technologies SST العلمي الخاصة.

- شركة Technology Cambridge Authority التابعة لجامعة كايمبردج... وهي مخصصة في صناعة الأدوية الجينية والمضادات... وأسهمها مدرجة في بورصة ناسداك.

كما لا بد من الإشارة إلى التحري الإسرائيلي في إقامة مراكز متخصصة لنقل التكنولوجيا وتوظيفها... وإلى مراكز وحاضنات تكنولوجية لتقدم كافة التسهيلات والمشورة القانونية والعلمية والإدارية والمالية لتحويل الأفكار إلى مبتكرات...

- تنظيم عمليات البحث والتطوير وإدارتها داخل الجامعات:

تحتاج جامعات الدول العربية إلى إغناء تجاربها في إنشاء وتنظيم إدارة المراكز البحثية... فمعظم المراكز المنشأة لا تزال طريقة العود وتتحتاج إلى تجميع وكنز الخبرات لتصبح مؤهلة لإنتاج البحوث وتوظيفها وتمثيلها وتوسيع مجالها.

وبالرغم من القدرات المالية للجامعات في دول الخليج العربي... لا تزال المراكز البحثية فيها بحاجة إلى خبرات تنظيمية وإدارية لرفع منسوب إنتاج البحوث وتوظيف نتائجها و بعضها يستعين مختبرات عالمية...

وفي مقابل ذلك، إكتسبت جامعات الدول اليوروب خبرات واسعة في مجال إدارة البحوث وتنظيم فرق العمل فيها... نذكر من هنا سبيل المثال تجارب جامعة هارفرد وماساشوستس وغيرها من الجامعات الأمريكية... وفي إسرائيل حيث ركزت الحكومات على أهمية البحث والتطوير... فأنشأت العديد من المراكز البحثية المتخصصة في شؤون الزراعة والصناعة والتكنولوجيا اليوم وصناعة السلاح... وغير ذلك.

وفي فرنسا يوجد حوالي 9 مؤسسات حكومية ذات طبيعة علمية وتقنية... و15 مؤسسة حكومية ذات طبيعة تجارية لتسويق البحوث من بينها الوكالة الوطنية لدعم الشركات الصغيرة والمتوسطة الحجم... ANVAR
وفي بريطانيا، هناك 7 مجالات بحثية مهمة تمويل جزء من الأبحاث الجامعية... تعمل بالتعاون مع 169 جامعة وكلية تقنية مُتدفقة الاختصاصات (الأقطاب البحثية الكبرى وهي الجامعات البريطانية العريقة مثل كايمبردج، أكسفورد، أمبريل كوليج، كلية لندن للأعمال ...) تعتمد منهجية الإنتاج والتواصل مما يسمح بتبادل الخبرات والمعارف بين الباحثين من مختلف الاختصاصات والاهتمامات.

كما تشجع الجامعات البريطانية عمليات التفاعل والتواصل بين الباحثين والشركات التجارية على نتائجبحوثهم، بحيث تتكفل الجامعة بعمليات الابتكار لصالح شركة ما تقوم بتوظيفها وتثبيتها واستثمارها. كما يتمتع الباحثون في بريطانيا بأهمية مزاعمة مهام إستراتيجية وجي المكافات لقاء ذلك.

وبينما تعتمد إدارة البحوث في بريطانيا على مبدأ الليبونة والمرونة وفق نظام التعاقد على المشروع وفترات زمنية محددة بعدة سنوات (3 إلى 5 سنوات)، تقوم إدارة البحوث الفرنسية على استقاص الباحثين بحجز بوظيفة حكومية أو خاصة غير مشروطة بالإنتاج... مع تقييم النتائج وإصدار مالي للبحوث المُنجزة والمُسؤقة.
- العلاقات المفقودة: البحث العلمي في مواجهة تحديات البطالة وتعزيز الاستثمار والمساهمة في التنمية

١ - بينة البحث العلمي:

1 - الثقافة التعليمية وأخلاقات العمل والانضباط والتفكير النقدي.
2 - رعاية المواهب وصقلها وتمييزها.
3 - الموارد البشرية للبحث العلمي:
   - هل من الممكن اعتبار كل أستاذ جامعي باحث؟
   - هجرة الأدمغة والباحثين وكيفية إعادتها... تجربة الصين وإسرائيل.
4 - صياغة رؤية وطنية للبحث العلمي والآليات التنفيذية لمساهمته في التنمية.
5 - تمويل البحوث العلمية - حكومي، مساعدات خارجية، مساهمة قطاع الأعمال، جمعيات غير ربحية.

يعتبر قطاع الأعمال المساهم الأكبر في تمويل البحوث في الدول الوريثة، ونسب تتراوح 82% في اليابان، و56% في دول الاتحاد الأوروبي و72% في الولايات المتحدة، و70% في الصين... ولا يتجاوز سوى 8.2% في معظم الدول العربية.

فاليبحث العلمي هو أحد مصادر التنمية ومحرّك للاستثمار وموسع لأسواق العمل... في الدول الوريثة...

ونظرًا لأهمية تمويل البحوث ١ حذر علماء من جامعة MIT من خطر على الأمة نتيجة العجز في مجال الابتكار بسبب تقليص مُعدلات الإنفاق في مجالات البحوث الأساسية في ميادين تتعلق بإبقاء حياة البشر، بدءًا من الإنساناوي مرورًا بطاقة الإنتاج النووي وانتهاء بالأمراض المُستعصية... وفي تقرير بعنوان "إرقاء المستقبل" يشير إلى أن تمويل العلوم بلغ أدنى مستوى له منذ الحرب العالمية الثانية ضمن الميزانية الاتحادية وهذا يُهدد مستقبل أمريكا.

١ - عالم الفيزياء في جامعة MIT مارك كاستن، رئيس لجنة أرقاء المستقبل، 2015.
2 - البنية التحتية للبحث العلمي:

1 - البيئة القانونية المُساعدة للبحوث العلمية والاستثمار في نواتجها.
2 - الهيئات الناظمة للبحوث العلمية، مجالس البحوث، الهيكلية الأكاديمية والتنظيمية والإدارية.
3 - آليات المتابعة والتنفيذ.
4 - التمويل الحكومي.
5 - مراكز نقل التكنولوجيا وتوطين العلوم.

3 - مراكز توطين المشاريع التكنولوجية وتوفير دعم قانوني ومادي للاستثمار في نواتجها.

4 - مراكز تسويق الاختراعات والابتكارات:
- الجدوى الاقتصادية.
- توفير المشورة العلمية واللوجستية القانونية للإنتاج والتسويق.
- توفير الدعم المالي لإنشاء الشركات الصغيرة والمتوسطة لإنتاج سلع مطورة داخلياً.
- وغير ذلك.

5 - تأسيس مراكز بحوث وتطوير صناعية داخل قطاع الصناعة والإنضواء والشركات الكبرى.

مثال: المؤسسة الحكومية لتأسيس الشركات في فرنسا OSEO، وهي مؤسسة حكومية تخضع لإدارة وزارة الاقتصاد والبحث العلمي، وتقوم بدور الرابط بين الوكالة الوطنية للبحث العلمي والوكالة الوطنية لدعم الإبتكار والصناعة... مهمتها تمويل شركات ناشئة وتوفير ضمانات مصرفية لها ومشروعة قانونية واقتصادية.

شركة سامسونغ لديها مراكز بحثية تضم حوالي 70 ألف باحث وتفتق عليها ما يقارب 13.6 مليار دولار على البحوث لتطوير منتجاتها وزيادة تنافسيتها داخل الأسواق العالمية.
6 - دعم إنتاج وتسويق الإبتكارات والابتكارات الوطنية... وحصول المؤسسات على شهادات جودة.

7 - إنشاء حاضنات تكنولوجية ومناطق صناعية وحدائق تكنولوجية.

مثالًا: قامت الصين بتأسيس منطقة إبتكار باسم حديثي بينهاي الصناعية الجديدة على مساحة 424كم² وتضم 21 معجمًا صناعياً... شبيه بوادي السيلكون الأمريكي.

أ - مدينة الملك عبد الله للعلوم والتكنولوجيا في السعودية.

ب - مدينة مصدر للعلوم في الإمارات العربية المتحدة (أبو ظبي).

8 - العلاقة بين أرباب العمل ومراكز البحوث داخل الجامعات وخارجها.

1 - تردد أصحاب العمل في التعاون مع الأكاديميين ومراكز البحوث الوطنية.

2 - طغيان قطاع الخدمات والاقتصاد الريفي على اقتصادات الدول العربية.

3 - الارتفاع المتزايد في المشاريع العقارية والترفيه والخدمات.

4 - ضعف مشاركة قطاعات الصناعة والزراعة في إقتصادات الدول العربية.

5 - ضعف مشاركة القطاع الخاص في تمويل البحوث العلمية: معدّل 9% فقط في مقابل 52% - 82% في الدول الأوروبية.

6 - الاعتماد على التمويل الحكومي بشكل كلي لتمويل البحوث.

7 - النظر إلى البحوث والتطوير كትفر ثقافي وعلمي أو للترقيات الأكاديمية وليس كقوة إنتاجية تساهم في عملية التنمية وتوسيع آفاق الاستثمار وتوسيع أسواق العمل.

8 - تفضيل أرباب العمل على إنتاج سلع جاهزة بشهادات امتياز بدلاً من إنتاج سلع وأجهزة مبتكرة أو مطورة داخليا.
INNOVATIVE AND SUSTAINABLE ENTREPRENEURSHIP: THE ROLE OF ACADEMIC INSTITUTIONS IN LEBANON

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Abstract

Entrepreneurship is gaining momentum in the world, especially in developing countries, since it is believed to be a main contributor to economic growth and an effective solution for the increasing problem of unemployment. Hence, it is often aligned with the principles of sustainability. Although research in engineering education acknowledges the importance of entrepreneurship at the university level, there is a lack of studies that tackle the issue of student entrepreneurship in developing countries such as Lebanon. Having determined a positive attitude towards entrepreneurship when surveying engineering students from universities about their career aspirations and perceptions, the authors of this paper have also found that many students with entrepreneurial intentions do not have the courage to start their own businesses immediately after graduation. This paper reports on the results of a study which aims at identifying the reasons behind this fear and proposing effective solutions to support sustainable and innovative student entrepreneurship. Feedback was solicited from 30 individuals ranging including university students, professors, entrepreneurs, and entrepreneurial supporters. The paper offers a set of recommendations for the use of academic and professional institutions as well as entrepreneurs to improve the chances of entrepreneurial engineers in transforming their ideas into real successful businesses.

Keywords: Entrepreneurship, Innovation, Sustainability, Engineering Education, Lebanon

1. Introduction

The increasingly difficult economic conditions in many developing countries have raised a need to create sustainable knowledge economies by investing and supporting innovation and entrepreneurship. In order to form a better understanding of young and innovative entrepreneurship for engineering graduates in the
areas of technology and sustainability, a research project was conducted at the American University of Beirut’s Faculty of Engineering and Architecture. The project, which was funded by the Center for Teaching and Learning (CTL), aims at investigating the phenomenon of student and young entrepreneurship, and identifying and documenting the needs of young graduates from their academic institutions in order to further foster this trend. Universities have a responsibility to graduate innovative people with a capability of making a positive social and environmental impact in the world. Hence, the project targets the academic ecosystem in Lebanon with the goal of forming a proper understanding of innovative and sustainable entrepreneurship and translating this understanding into recommendations for improvements to engineering education.

2. Background

Entrepreneurship is neither a new term nor a new area of research. Simply meaning the startup of new businesses, entrepreneurship has globally attracted in the past few decades a growing interest from various financial, academic, and research institutions to name a few (Eid, 2007). The importance of establishing small and middle enterprises (SME’s) lies in the great role that SME’s play in the economy of countries especially developing ones, such as Arab countries in the Middle East. SME’s contribute to the economy in terms of GDP, job creation, sales and export, innovation, and competitiveness (Davey et al, 2011; El-Saouda, 2006). With the increase of population and unemployment rates, economists agree that the private sector has a primary role to play in the Middle East and North Africa (MENA) and that the best way to create new jobs for the young generations is through the establishment of new companies. Many of these companies can be established by job seekers themselves who are often fresh graduates with amplitude of enthusiasm, risk propensity, and innovation. In order to maximize the chances of these entrepreneurs, they need to be first equipped with the necessary skills needed by their markets and second provided with capital to implement their promising ideas (Eid, 2007). It is the role of the society to maximize the chances of success of young entrepreneurs by providing guidance and support on the levels of the government, private sector, financial institutions, and academic institutions. Currently there is a trend in the Middle East and North Africa for supporting entrepreneurship financing by the monetary and financial sector. Moreover, capital financing from the private equity sector is gaining popularity and encouraging yet more financing for entrepreneurs (Eid, 2007).

When 15 private equity firms from MENA region were asked to rank a series of obstacles facing entrepreneurship in this part of the world, the majority mentioned that the number one obstacle is the “lack of business and entrepreneurial skills/ideas” followed by “lack of business/management skills in
general” (Eid, 2007). This shows that in spite of the willingness of private equity firms to finance entrepreneurship ideas, they are often faced with a lack of innovation, creativity, good management, and planning from the entrepreneurs’ side. This clearly implies that the problem of realizing entrepreneurial intentions does not start at the financing stage but way before that which means that there is a need to work on this problem at the early levels of idea initiation and planning. Luryi et al. (2007) support this by stating that engineers often learn entrepreneurship on their own, usually many years after graduation and this requires rapid change from universities in terms of their curricula and attitudes towards entrepreneurship.

Since academics are key role players beside practitioners and policy makers in promoting the entrepreneurial mindset of people in society, they have done numerous efforts in this area by exposing students to entrepreneurship through offering undergraduate courses, creating graduate programs, establishing entrepreneurship centers, and conducting entrepreneurial competitions. Two of the most exemplary programs on entrepreneurship are MIT and Stanford’s programs that provide opportunities for engineering students to realize their innovative ideas (Luryi et al., 2007). MIT has also launched an entrepreneurship competition where the best business plan earns $50K as a prize and has expanded this competition beyond the borders of the USA to support entrepreneurship in the young minds (Luryi et al, 2007).

In Lebanon, entrepreneurship provides a real opportunity for economic growth. A recent study (Itani and Srour 2015) revealed that engineering students in Lebanon do have a positive attitude towards entrepreneurship but that more than half of those with intentions to pursue entrepreneurship are not willing to do so directly after graduation. Since no research studies have been conducted on students with entrepreneurial intentions to study the factors that will ultimately encourage/discourage the future entrepreneurs to realize their ventures, it is important to study this issue and form a proper understanding of the problem and how it can be solved. This paper reports on the results of a study examining the students’ entrepreneurial intentions and factors that might hinder their realization of innovative ideas. A comprehensive framework based on Beattie’s basic framework in Figure 1 is being devised to highlight the areas of weakness and assist academic and training institutions in delivering entrepreneurship training and supporting student entrepreneurship.
Sustainability has been receiving a lot of attention by entrepreneurs. Sustainability aims at minimizing the negative impacts of development while maintaining a good quality of life for current and future generations. This requires balancing the three dimensions of society: economics, environment, and society (Srour et al. 2012). Several entrepreneurs research, develop, and market technologies that are in-line with the principles of sustainability. Examples include technologies used to generate cost efficient renewable energy (e.g., Photovoltaic cells, wind, hydroelectric, geothermal, biofuels, wave, waste-to-energy). Examples also include technologies used to reduce energy demands such as motion and heat sensors as well as energy efficient home and office appliances. Entrepreneurs are also continuously investigating and marketing technologies used to reduce, recycle, and reuse natural resources such as water and building materials.

3. Study Objectives and Methodology

Several research studies in Europe and North America (e.g., Davey et al., 2011; Deng and Liu, 2012; Zappe et al., 2013) have looked into the entrepreneurial intentions of students. However, there is a need for more international research in this area targeting students in developing countries and comparing them with developed ones (Davey et al, 2011). The area of student entrepreneurship has not been explored in the Middle East and specifically in Lebanon. Since the economy of developing countries depend a lot on small-to-medium sized enterprises, it is important to encourage this type of businesses. This paper offers an assessment of the circumstances surrounding student entrepreneurs and providing the suitable training that will encourage them to start their own businesses while having a solid understanding of what makes a startup successful and sustainable.

The main objective of the study is to determine how entrepreneurship education should be offered or reformed at the university level, based on the most important needs of university students in order to
enable an easier start for their entrepreneurial journey in innovative and sustainable technology. The adopted methodology included surveying and interviewing more than 30 individuals ranging from senior university students, professors, entrepreneurs, and entrepreneurial supporters. The utilized mixed-methods approach consisted of filling a short questionnaire and answering a set of open-ended questions. This approach allowed for collecting important information from the experiences of the interviewees, many of which were entrepreneurs, such as their needs, faced difficulties, and lessons learned. The mix of quantitative and qualitative methods enhanced the ability to make more meaningful conclusions.

4. Results

Findings recommended the transformation of entrepreneurship education in engineering schools to a much more hands-on experience with emphasis on incorporating projects, engaging real entrepreneurs in such programs, and exposing students to successful entrepreneurs and entrepreneurship projects as role models and motivators for pursuing such a risky journey. Students emphasized on the need to offer contemporary technical courses that expose them to topics, technologies, and applications that have the potential in being developed and transformed to new ventures such as advanced and sustainable development courses. The interviewees highlighted the crucial role of academic institutions in providing networking opportunities with investors and funders, in addition to business workshops based on new trends and best practices that help students in business planning, iterating, and pitching.

5. Conclusion

This paper lays down the main components of a framework to implement student entrepreneurship through practical courses or programs on entrepreneurship to be offered to students at the university level. By doing so, the universities which adopt this framework will be playing a fundamental role in encouraging students with innovative and realizable ideas to start their own businesses and increasing their chances in being successful and contributing to the economy. There are many possibilities of how universities and engineering programs can benefit from the proposed framework. A few examples include training engineering students to transform their capstone or final year projects into real businesses and allyng with the industry to sell innovative ideas while employing the fresh minds.

References


Acknowledgements
The authors would like to thank the American University of Beirut’s Center for Teaching and Learning (CTL) for funding this study through Project # 21649 (Award #: 102718). Also, the authors would like to thank the interviewees for sharing their experience.
Abstract— The United Arab Emirates (UAE) has experienced an accelerated drive to harvest the abundantly available solar energy and to increase the share of alternative energy sources in its fossil-fuel reliant energy generation. University research productivity on renewable energy (RE) has been on the rise in the UAE. However, universities have not been able to integrate RE into their core curricula but rather at the senior level in the form of technical electives or senior design projects. This paper surveys the status of RE education in the UAE. It also addresses the actions needed to prepare future graduates for the new challenging RE job market.

Keywords—Education, Public Awareness, Renewable Energy, UAE Universities

1. Introduction

The share of the world's energy mix attributed to fossil fuels has not changed in the last 25 years (i.e. 82% from coal, oil, and gas) despite the unprecedented efforts to increase the share of renewable energy sources (solar, wind, geothermal, and hydropower) [1]. This means continued global warming, health problems, and degradation of Mother Nature. Moreover, the fact that the total world energy consumption is expected to increase from 8,918 Million Ton of Oil Equivalent (Mtoe) in 2011 to 11,750 Mtoe in 2035 [2], surely necessitates the installation of additional capacity to meet the huge load demand with the minimum possible effect on the ecosystem.

Energy produced from renewable resources, integrated with the power grid, stands as the solution to the aforementioned problems, since most of the resources emit few or none greenhouse gases, and they can produce a notable amount of energy, adding variety to the total energy mix. Moreover, Pembina Institute, in a study performed in 1997 for Environment Canada, found that investment in renewable energy yields more job opportunities than investments in traditional energy sources. For every one million dollar investment, 12.2 jobs are granted in the renewable energy sector as compared to 7.3 jobs in the conventional energy district [3].

While renewable energy technologies such as wind, geothermal, hydropower and solar have huge potential to reduce both greenhouse gas emissions and other negative environmental impacts from electricity generation, integrating these technologies into the electric power grid poses ongoing technological and institutional challenges. Deployment of renewable energy and integration to smart grids requires a great deal of planning, design, and in-depth knowledge with renewable energy technologies. It should also be coupled with public awareness regarding the true value of renewable energy and what it can offer to the energy sector. In parallel to these efforts, the science of the various renewable energy technologies should be introduced in the secondary schools and college curricula. As the source of our energy shifts towards renewable and more emphasis is put on consumption, conservation, efficiency, and sustainability, understanding and learning energy use and generation will be imperative to everyday life in the decades ahead [4].

According to a report by IEA [5], the global energy supply is not getting cleaner, despite efforts to advance clean energy. Coal technologies continue to dominate growth in power
generation, especially in emerging economies. The report also recommends cross-sector awareness and capacity building on renewable energy and energy efficiency.

Technologies for harvesting renewable energy from the sun and wind are constantly improving with the continuous advances in research and development. This is due to the heightened public concern about the climatic effects of greenhouse gases produced from conventional energy sources. Moreover, the recent tragic accident at the Fukushima Daiichi nuclear power plant, in Japan, has prompted the search and development of other alternative energy sources. For example, Space Based Solar Collectors in geosynchronous orbit could generate power nearly 24 hours a day yielding a 1 gigawatt commercial system – about the same output of a typical nuclear reactor [6].

Both the United Nations Project “Sustainable Energy for All” [7], and the IRENA Renewable Energy Road Map 2030 [8], project the increase of the share of renewables in the world’s energy mix to double (30%) by 2030. According to participants at the World Future Energy Summit in Abu Dhabi held during 15-17 January 2013 “While most countries are expected to fall short of that goal, there will still be considerable growth in solar and wind energy, geothermal energy, hydropower and energy-storage technology”.

It is evident nowadays that several Arab countries are implementing strategic visions for RE share of energy consumption. Table 1 summarizes the projected targets for some Arab countries with regard to renewable energy capacity.

<table>
<thead>
<tr>
<th>Country</th>
<th>RE Target and Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>6% of electricity generation by 2015; 15% by 2020; 40% by 2030, of which 37% is solar (PV)</td>
</tr>
<tr>
<td>Bahrain</td>
<td>5% by 2020</td>
</tr>
<tr>
<td>Egypt</td>
<td>20% of electricity generation by 2020, of which 12% is wind 2% of electricity generation by 2016</td>
</tr>
<tr>
<td>Kuwait</td>
<td>5% of electricity generation by 2020; 10% by 2030</td>
</tr>
<tr>
<td>Jordan</td>
<td>7% of primary energy by 2015; 10% by 2020</td>
</tr>
<tr>
<td>Lebanon</td>
<td>12% of electrical and thermal energy by 2020</td>
</tr>
<tr>
<td>Libya</td>
<td>3% of electricity generation by 2015; 7% by 2020; 10% by 2025</td>
</tr>
<tr>
<td>Morocco</td>
<td>42% of installed power capacity by 2020</td>
</tr>
<tr>
<td>Oman</td>
<td>10% by 2020</td>
</tr>
<tr>
<td>Palestinian Territories</td>
<td>25% of energy from renewables by 2020; 10% (or at least 240 GWh) of electricity generation by 2020</td>
</tr>
</tbody>
</table>
2. Renewable Energy Education

Professor Kornelis Blok, a lecturer at the University of Utrecht and director of science of the Dutch-based Ecofys Group, an international consultancy in renewable energy and climate policy said “We not only need to educate students who can work in future renewable energy areas, but we need to train already established professionals in how to use the new technologies”[7].

Demeo [4] conducted a series of workshops targeted to students’ bodies from various age groups. In the first workshop, she introduced the course “Math and Physics of Sustainable Energy” in the spring of 2010 at the College of the Atlantic (COA) in Bar Harbor, Maine. The objective of this course was for students to gain a reasonable grasp of the issues regarding sustainable energy, with the goal that they would be able to quickly and roughly to estimate numbers - like the number of wind turbines needed to power a town, or the feasibility of a solar array sized to power the country - and determine the accuracy (or inaccuracy) of the information from other sources. Demeo concluded that Renewable energy is a topic that students are really motivated to learn [4].

Demeo then reported another experiment at Pemetic Elementary School in Southwest Harbor. At this school, students start learning and experimenting about renewable energy and sustainability from the sixth grade. By the time students graduate from the eighth grade, they would have completed a student-led project geared at helping the school and community. Projects are as various and large and include:

- A No-Idling Project focused on improving health by reducing vehicle idling at Pemetic and in the community. All district schools now have “No Idling” signs.
- Designing reusable grocery bags.
- Installing twelve solar panels (1.8 kW system) on the roof of the school.
- Replacing all the incandescent exit sign bulbs with energy efficient light-emitting diode (LED) exit signs.
- Eventually, installing a 2.4 kW wind turbine at the edge of the soccer field.

This experiment clearly proves the efficiency of implementing renewable energy in the minds of our kids. Renewable energy education can yield generations geared towards sustainability and efficiency [4].

Universities around the globe are adding the “Renewable Energy” element into their curricula, and starting partnerships with industrial sectors to foster R&D on green energy. Students are taught how renewable energy can decrease emissions of greenhouse gases and fight global warming and then, they are taught the details of each field.

<table>
<thead>
<tr>
<th>Country</th>
<th>Target Meanings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qatar</td>
<td>At least 2% of electricity generation from solar by 2020</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>16-22% by 2032</td>
</tr>
<tr>
<td>Tunisia</td>
<td>11% of electricity generation by 2016; 25% by 2030; 16% of installed power capacity by 2016; 40% by 2030</td>
</tr>
<tr>
<td>UAE</td>
<td>Dubai: 5% of electricity by 2030; Abu Dhabi: 7% of electricity generation capacity by 2020</td>
</tr>
<tr>
<td>Yemen</td>
<td>15% of electricity by 2025</td>
</tr>
</tbody>
</table>
Yumurtaci and Kecebas [10] stated that in Turkey there are a small number of universities having courses about renewable energy. There should be further development in that important field at the university level. Although biomass energy is one of the main energy sources in Turkey, a questionnaire done by Yumurtaci and Kecebas on three groups of students from three Turkish universities showed that the students had shallow knowledge about this topic. The authors conclude the following: "We must not ignore the social and economic implications of renewable energy education in our world, where the rate of energy usage is an indicator of the level of development of a society." That is why renewable energy education should be highlighted in universities.

Another research about renewable energy education in Turkey by Karabulut et al. [11] show that there are no degree programs offered on renewable energy systems in particular. Some courses may be offered at the graduate level such as solar, wind, and geothermal energy, however the undergraduate programs barely mention the renewable energy sources within some engineering courses. The authors applied a questionnaire to 14 Turkish universities focusing on how many courses are offered about renewable energy, number of faculty members who teach renewable energy courses, and number of students studying this topic. They concluded that the high cost of materials required for teaching such courses and the lack of qualified users of such equipments are the main problems facing the growth of RE education.

The Renewable Energy Materials Research Science and Engineering Center at the Colorado School of Mines, USA [12] recommends the following four steps to complete the implementation of renewable energy in educational programs:
1. Develop an energy minor curriculum with a track dedicated to renewable energy.
2. Develop an upper division undergraduate engineering course on renewable energy.
3. Form a student Energy Club, or Renewable Energy Club.
4. Deliver a ten-week summer research program that engages undergraduate students in renewable energy.

A survey conducted by a group of scientists on renewable energy courses for Architecture students [13] concludes that renewable energy courses are not hands-on oriented and the degrees offered are less flexible. Moreover, all renewable energy courses are offered as electives, and student feel that they should be introduced earlier in the core of the curriculum [13].

In its mission to foster research, awareness, and training regarding green energy, Morocco announced in 2008 plans for a new campus providing knowledge-based services to strengthen research and training in clean technology. The 'knowledge campus' is part of a US$3.2 billion five-year renewable energy investment plan, prepared by the Moroccan National Electricity Office and scheduled to run between 2009 and 2014. The campus is be part of a clean energy industrial park in the eastern city of Oujda to support private sector investment as well as renewable energy companies [14]. Driss Zejli, head of the Renewable Energy Economy and Technologies Unit at Morocco's National Centre for Scientific and Technological Research said:"The Park will build the capacity needed for long-term research programs, and the knowledge campus will help develop the scientific workforce through training programs, conferences and seminars, new Master's courses in renewable energies and through research projects". Moreover, Zejli pointed out that the geographic position of the knowledge campus — on the border with Algeria — creates more opportunities for knowledge sharing, technology transfer and science cooperation between Morocco and Europe and between Morocco and other Arab and African countries [14].

There are numerous activities that can be implemented with the aim of introducing RE culture into the university environment. These include:
1. Online solar training courses;
2. Integrated course modules on renewables
3. Agricultural programs with an emphasis in biofuels;
4. Establish programs at technical colleges in clean energy, green energy, renewable energy, turbine technology, and wind energy;
5. Minor programs at four-year colleges in green building design, green engineering, renewable energy, and sustainable energy systems engineering;
6. MS/PhD programs in energy engineering and fuel cells.
7. Workshops by manufacturers and distributors of renewable energy systems
8. Senior design projects oriented towards renewable energy systems
9. Involving student teams in community service projects using renewable and alternate energy sources
10. Field trip visits to manufacturing facilities and companies dealing with renewable energy photovoltaic design and research, solar panel installation, wind power systems, fuel cell membrane development, hybrid automobiles, geothermal drilling, “green” building design, urban wind farms, recycling programs, and outdoor lighting practices.
11. Host technical conferences on renewable energy in order to increase students and faculty awareness about renewable energy. Students should play an active role in the event organization.
12. Establish a Renewable Energy club. The main activities include participation in RE workshops, project competitions, community awareness, etc.
13. Offer an Undergraduate Research summer experience that aims at bringing a diverse group of students, visiting scholars, and scientific staff together into the RE research environment.

The fastest way to attract students’ interest remains through involving them in undergraduate research work and project competitions on renewable energy applications.

3. Renewable Energy Education in the UAE

This study surveyed the engineering programs in public and private universities in the UAE to identify the curricular components and programs related to renewable energy. Table 2 shows a list of seventeen universities with engineering programs that offer courses related to renewable energy. Two universities should be noted; University of Sharjah (18 courses) and Amity University Dubai (11 courses) where they offer a complete bachelor degree program on renewable energy. Masdar Institute (7 courses) is also characterized by a relatively large number of graduate level courses. Table 3 lists twelve universities with engineering programs that do not offer renewable energy courses.

<table>
<thead>
<tr>
<th>No.</th>
<th>University</th>
<th>Emirate</th>
<th>No. of R.E. Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MASDAR INSTITUTE OF SCIENCE AND TECHNOLOGY</td>
<td>ABU DHABI</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>AL-HOSN UNIVERSITY</td>
<td>ABU DHABI</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>KHALIFA UNIVERSITY OF SCIENCE, TECHNOLOGY &amp; RESEARCH</td>
<td>ABU DHABI</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>THE PETROLEUM INSTITUTE</td>
<td>ABU DHABI</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>HIGHER COLLEGES OF TECHNOLOGY</td>
<td>ABU DHABI</td>
<td>1</td>
</tr>
<tr>
<td>No.</td>
<td>University</td>
<td>Emirate</td>
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<td></td>
</tr>
<tr>
<td>6</td>
<td>UNITED ARAB EMIRATES UNIVERSITY</td>
<td>ABU DHABI</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>HIGHER COLLEGES OF TECHNOLOGY</td>
<td>DUBAI</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>AL GHURAIR UNIVERSITY</td>
<td>DUBAI</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>AMERICAN UNIVERSITY IN DUBAI</td>
<td>DUBAI</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>AMITY UNIVERSITY DUBAI</td>
<td>DUBAI</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>MANIPAL UNIVERSITY - DUBAI CAMPUS</td>
<td>DUBAI</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>HIGHER COLLEGES OF TECHNOLOGY</td>
<td>FUJAIRAH</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>AMERICAN UNIVERSITY OF RAS AL KHAIMAH</td>
<td>RAS AL KHAIMAH</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>KHALIFA UNIVERSITY OF SCIENCE TECHNOLOGY &amp; RESEARCH</td>
<td>SHARJAH</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>AMERICAN UNIVERSITY OF SHARJAH</td>
<td>SHARJAH</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>UNIVERSITY OF SHARJAH</td>
<td>SHARJAH</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>HIGHER COLLEGES OF TECHNOLOGY</td>
<td>SHARJAH</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. UAE Universities with Engineering Programs that do not offer RE courses
Figure 1 shows the distribution by topic of RE course offerings among UAE universities. Most courses are of general nature, introducing students to the different sources of renewable energy and applications. The next most popular courses are related to solar energy which is abundant in the Arabian Peninsula. Figure 2 displays the distribution of RE courses by Emirate with institutions in Sharjah, Dubai and Abu Dhabi offering most of these courses.

The authors have previously addressed the activities taking place at UAE University to promote renewable energy applications through the two-semester capstone design experience course (named, graduation project) and through student involvement in design competitions [15]. Similar activities are taking place in engineering colleges at numerous UAE universities as evidenced by the large number of participating teams in renewable energy competitions. However, the integration of RE fundamentals and applications into the engineering curricula is still modest and requires strategic decisions by university officials to push forward with this change.

There is more to be done in the UAE to fulfil the 2020 and 2030 visions of Abu Dhabi and Dubai that call for a targeted RE energy share of 7% and 5%, respectively. Higher and secondary education institutions and schools in the UAE have to revolutionize their educational strategies in line with the national strategic vision. This requires the collaboration...
of government, private sector and educational institutions to update their curricula in line with the future skill requirements of the job market. Such initiatives may reflect positively on the UAE economy through the creation of new non-traditional jobs and on the reduced dependency on fossil fuels for energy consumption. Abundant resources exist in solar, biomass, and wind energy among others that can be better exploited with proper government policies and incentives, increased public awareness, and training students and professionals for the requirements of the RE market.

4. Conclusion
This paper presents the current status of RE education in the UAE. The authors feel that UAE universities have much more to achieve in preparing their students for the future job market. UAE’s strategic vision calls for a targeted share of RE in energy consumption. The integration of renewable energy poses real opportunities and challenges for the government and public sectors as well as for the educational sector. The ongoing research effort at the graduate level should be complemented by introducing RE fundamentals and applications in secondary schools and baccalaureate programs core curricula.

5. References

WEB-BASED SYLLABUS GENERATOR

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Abstract – To improve the university student learning experience, and towards ABET accreditation, it is crucial to have a clear and consistent syllabus encompassing the course learning outcomes and their relationship to the overall program outcomes for every course offered. This paper aims to present the automation of the course syllabus in the multi-campus Lebanese International University (LIU) by introducing a web-based software application for course syllabus generation. The application has been developed using the best practices in educational theories and is fully aligned with ABET guidelines for program accreditation. It streamlines the process of writing syllabi and ensures compliance and conformity for all courses offered within a program. Such automation also contributes to reducing errors, improving the student learning experience, reducing costs and environment harm due to paper printing.

Keywords: ABET, engineering education, student learning, syllabi generation, quality improvement.

1. Introduction

Managing courses in a large scale, campus distributed, university with central management is a challenging task. Typically, in this model, several campuses belonging to the same university are located in relatively far locations from the central management (Deans/Chairpersons). The School of Engineering (SoE) at the Lebanese International University (LIU) offers different majors at the undergraduate and graduate level in 9 different campuses located all around Lebanon [1]. To ensure consistency in material taught in classes and that each student, overall campuses, graduates with the same academic level, a common syllabi approach is deemed necessary. On another hand, syllabi design should adhere to ABET norms. ABET is recognized as the worldwide leader in assuring quality and stimulating innovation in applied science, computing, engineering, and engineering technology education. It accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology at the associate, bachelor, and master degree levels [2]. Over the past year, the SoE revised the syllabi of all courses offered at the school to ensure that the learning outcomes are clearly stated according to best educational practices in this regard. 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 with ABET guidelines in an attempt to seek accreditation in the future.

Clearly, an online solution is best fit for this model since it removes the hassles of managing syllabi through email or via hard copies which is tedious, costly and environmentally harmful. However, designing a web-based syllabi generator that empowers course coordinators with the tools necessary to build a well-structured ABET compliant syllabus is challenging. The design
should be user friendly for non-technical users and should provide adaptability for different types of courses. Furthermore, this application should provide a mapping between the Program Student Outcome (PSOs) and the Course Outcomes (COs). Probably one of the most challenging parts in achieving an ABET compliant engineering program is ensuring that the program has a pyramid-like structure when it comes to program outcomes. Manually computing the structure would be an exhaustive task that requires time and effort. With the web-based generator the Chairperson has an efficient way of creating the structure of the target program in an automated way. Moreover, the application will aid in identifying irregularities in the program structure.

The underlying strategy is to follow a process where the outcomes are simple and clear, achievable, and assessable. In order to achieve that, the well-known Bloom’s Taxonomy of educational objectives was adopted. The list of direct unambiguous active verbs presented in Bloom’s Taxonomy was strictly adhered to. In addition, the engineering programs were re-designed to comply with Bloom’s six domains of knowledge arranged successively in a hierarchy as depicted in Figure 1:

Bloom’s Taxonomy is not simply a classification; it is an effort to arrange the various thinking processes in a hierarchy. In this hierarchy, each level depends on the student’s ability to perform at the level or levels that are below it [4]. The focus here is on the cognitive domain which is quite suitable for disciplines like engineering. Furthermore, Bloom’s research was centered on attitudes, feelings and values. This aligns well with ABET’s guidelines and thus paves the way to successful accreditation once fully implemented. It must be noted that Bloom’s Taxonomy also considers the affective domain. This domain is concerned with issues relating to the emotional component of learning and ranges from basic willingness to receive information to the integration of beliefs, ideas and attitudes [5]. This dimension has not been considered in building the tool as it is more suitable for other non-engineering domains.

This paper highlights the successful implementation a web-based online syllabi generator. The syllabi generator is currently deployed and in use at the SoE at LIU and has proven its ability to scale across many programs over multiple campuses.

2. Issues at stake

Many universities are still developing their syllabi in a traditional fashion where course coordinators use a template to put together each individual syllabus for each respective course. The coordinator would then distribute the syllabus to all instructors teaching the course and in
their turn they distribute the syllabus to the students taking the course. This may be done through email or paper hard copies. There are major issues with this approach.

First, the development with the syllabus remains highly arbitrary due to the fact that each coordinator may approach various syllabus items differently. For example, when developing the course outcomes, the coordinator may adopt some vocabulary that is not fully aligned with best educational practices such as Blooms Taxonomy. This would lead to huge discrepancies between different courses syllabi within the same engineering program. Eventually, the program students outcomes (PSOs) would not fully map to individual course outcomes (COs) thus leading to non-conformance with ABET requirements. The COs are learning outcomes composed of statements of what a learner is expected to know, understand and/or be able to demonstrate after completion of a process of learning [6].

Second, since the syllabus template is usually in MS Word™ format, it poses an issue whenever a new version is created due to a bug fix or enhancement where it must be re-distributed to all course coordinators. “Version wars” become inevitable causing dysfunctional conflict between faculty members which may lead to unsatisfactory experience for instructors. In addition, data inconsistency may be another issue as manual entry and updates of data is an error prone process leading to potential exposure to additional risks.

Third, distributing the syllabus as a hard copy, 5 pages on average, to thousands of students is not environmental friendly and costly. While sending it by email becomes a tedious process with students registering or dropping courses within the first week of the course in addition to the fact that some students do not check their emails as needed or they may miss it if the email is marked as spam or send to the junk folder.

3. Proposed solution

At the top level, the system is based on multitier web-application architecture. The main components of that architectures being the web-clients (with special mobile features), the workflow orchestrator, and the data vault (database and file system). The architecture is depicted in Figure 2 below.

Fig. 2: Architectural view.
The application allows multiple client types and platforms through browser-based and platform-based (Apple IOS™, Android™, Windows™ Mobile) applications. The browser-based access is being made default for effective deployment. The application follows a layered architecture. The rationale behind selecting this type of architecture hinges mainly on a maintenance quality attribute. This quality attribute gives flexibility of in replacement of platform/technology at any level in the hierarchy, and thus freeing the dependencies on a specific platform/technology.

At the base of the architecture lies the network layer. This module abstracts the detailed implementation of the web servicing and security authentication from the layer above. All components required for the proper integration of web server and security authority are lumped into the network infrastructure module. This layer provides services to the Syllabi Generation Manger (SGM) layer without exposing the intricacies of the implementation. Such services includes: authentication results, structured query results, etc…

The SGM layer is the main part of the system. Due to its pivotal role, this layer is represents the core of the design. The major components of this layer are: the course metadata database, the syllabus generation engine, and the course outcome editing tools. This layer is designed with flexibility and scalability being the major requirements. SGM employs data-driven mechanism to eliminate or otherwise minimize any hardcoding of syllabi generation mechanism. This ensures more flexibility and scalability in the design. The course outcome editing tools allow the creation, editing, and deletion of course metadata. The metadata is saved in the Course Metadata Database in XML (eXtensible Markup Language) format.

The SGM layer hides all its detailed implementation from the presentation layer. The services provided to the presentation logic layer includes all processes needed to render process steps and/or data exports to clients. The last part of the architecture is the data vault. This is simply a conundrum of data services (database, local file system, network file system, etc…). These services are responsible for serializing any information to/from any process.

The architecture described above showed an important attribute, namely, layer-to-layer portability. By this attribute, the architecture is not implementation dependent on any technology/product. This value-added dimension allows institutions employing the ABET syllabus generator application tool to revert to any economical implementation that suits the reliability requirements. In general, portability is central to secure flexible solutions [7]. The basic servers required to implement the syllabus generator application will include:

- Linux: Acting as main OS and file server.
- Apache HTTPD: Web servicing component.
- Apache Tomcat: Application server.
- MySQL (or MariaDB): Database server.

3.1. Tool Description

The web-based ABET syllabus application allows course coordinators to build their respective course syllabi online and the student to access a website to view syllabus and PSO/CO mapping as needed by ABET. The main purpose of the web application is to allow coordinators to build their syllabi online. This application allows building a web-based system with the following features:

- Build the syllabi online by the administrator and the coordinator.
• Possibility to browse courses and view desired syllabus by any visitor online.
• Login as administrator or faculty member. A faculty member can view and print all engineering syllabi or filter syllabi by department.

3.2. The PSO’s View

The program students’ outcome (PSO’s) view shows the contribution of each course to the ABET a to k PSO’s. Figure 3 illustrates the view of the various courses that are offered in one of the engineering programs; the Computer and Communications Engineering program in this case. Furthermore, each course has specific learning outcomes that are aligned with education best practices and they map to the overall program outcomes as required by ABET. These are the famous a-k program student outcomes (PSO’s). Such a view will indicate if there are any gaps within the offered program so that appropriate action is taken accordingly to address the issues.

3.3. The Pyramid View

At the end of the list, the application puts the measurable learning outcomes into perspective and shows the outcome pyramid model. Figure 4 is an example taken from the Industrial Engineering program at the Lebanese International University. It demonstrates the use of Bloom’s verbs representing the various knowledge domains areas and the number of the verbs occurrences which are then represented as a building block of the different pyramid’s layers.
3.4. Other Features

The second view lists the ABET a to k skills and offers the possibility to view the program related courses from outcome as depicted in figure 5.

![Fig. 5. View of program courses from outcomes.](image)

Moreover, the application allows each coordinator to edit and publish the syllabi of courses being coordinated. This contributes to the strategy of using the outcomes based approach to align with ABET criteria which provides an opportunity to enhance understanding of teaching and learning. Developed by technical professionals from ABET’s member societies, this criteria focus on what students experience and learn. [2]. Figure 6 shows the list of courses coordinator by a faculty member and the available options. The coordinator of a course has the possibility to create a new syllabus or to modify and publish existing one. It must be noted that when creating the syllabus, the tool will force the coordinator to use the active verbs only available in Bloom’s Taxonomy thus avoiding any undesired deviation both on the CO’s and PSO’s levels.

![Fig. 6. Creating and editing syllabi by the course coordinator.](image)

In addition to writing the syllabus, the coordinator has the possibility to add a general note to the students as an announcement. Figure 7 captures an example of such announcement.

![Fig. 7. Snapshot of an announcement.](image)
When logged in as an administrator, the user has the possibility to perform one of the following functions:

1. Assign coordination.
2. Import courses (List of courses and their coordinators).
3. Import programs (List of program courses).
4. Manage accounts (Add/remove/update users).
5. Change or reset passwords or users.

Figure 8 illustrates the assign coordination function.

![Assign Coordination Function]

**4. Critical assessment**

Despite its value-added benefits, the adoption of the implemented generator 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 application is automating.

The web-based ABET syllabi generator offers the means necessary to create, modify and distribute syllabi in an efficient way. However one of the major points still to be made lies in the complete integration of the generator with the already existing University Management System (UMS). Having multiple distinct standalone applications to learn and to use distracts ordinary users from the intended goal of the application.

While the application generates the syllabi in Adobe pdf format which is a popular format, some users require them in Microsoft Excel, or Microsoft Word which is a limitation of the software application. Furthermore, in any engineering program, there are some courses that are offered by other schools within the university such as arts, sciences, education and humanities. Such courses are repeated across different engineering programs and insofar the application requires manual entry of such courses syllabi for each individual program. Automating this process will have big advantages in terms of limiting manual entries where they would be entered once and all programs would have access to them. Moreover, it will limit the amount of overhead in administrative work done by the faculty members.

The solution to the identified issues is not beyond realization. In fact, a simple, yet effective solution is currently being implemented. The new version will be integrated into the web-based UMS system to offer an embedded experience to both faculty and students.
5. Conclusion

University learning improvement is an on-going process that needs to be done in a continuous manner in order to secure sustainability. This is crucial to institute a process that will facilitate continuous improvement [8]. ICT (Information and Computer Technology) plays an important role in supporting such a process. This paper described the automation of course syllabus in the multi-campus Lebanese International University. The solution was an online software application which may be used at any university developing course syllabi according to best practices and in alignment with ABET approach. Although the application is simple, it provides a good basis to develop the courses syllabi for any program across multi-campuses. Enhancement and evolution of the online syllabus application is possible and there are already plans to integrate it with the existing university management system which will provide an embedded system where all needed applications may be accessed in a consolidated manner.

References

BUILDING A SUSTAINABLE PARTNERSHIP BETWEEN PRIVATE SECTOR AND ACADEMIC INSTITUTIONS IN PALESTINE

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Abstract

The paper presents the current situation of the post-secondary education in Palestine and in particular to the challenges facing a- building a sustainable partnership between private sector and academic institutions and b- implementing relevant experiential learning and sustainable curriculum development. The paper presents the process that is needed to build sustainable collaborative and effective partnership between the academic institution and the private sector/employer to help in meeting the economic challenges facing the Palestinian institutions, private sector and the young university graduate.

Keyword

Education, Curriculum development, Experiential Learning,

1. Introduction:

Recent studies indicated to the fact that many Palestinian academic institutions in need for updating existing academic and vocational training curriculum as well as be integral part of the social and economic drive to meet national priorities. In reality, many academic programs have not been reviewed for more than twenty years, as is the case of the pure and applied science, tourism and agriculture academic programs. In many situations, the curriculum changes are very slow due to the lack of systematic cyclic review. If changes happened, it is left to the efforts of the faculty initiative and energy to carry out the required changes.

The total number of licensed post-secondary institutions the Palestinian Ministry of Education & Higher Education (MOEHE) has reached forty-nine institutions. They are organized into three classifications and are registered as higher education service providers [1]. According to the Law of Higher Education, higher education institutions can be one of the following [2], [3]:

- Universities (Us) consisting of no fewer than three colleges or faculties and granting BA degrees or higher.
- University Colleges (UCs) offering academic, technical or professional programs and granting two- or three-year diplomas or the higher BA degree.
- Polytechnics granting diplomas or BA and higher degrees in professional and technical fields.
- Community Colleges (CCs) offering academic, professional or technical programs of no less than one year duration and leading to diplomas in the respective programs.

* Currently: coordinator of the tertiary education project in Palestine funded by the World Bank
As of 2014 the most active and sought after institutions for higher education in Palestine are Universities (Us) in which the majority of the programs offer BSc, BA, MSc degrees and occasionally Ph.Ds. The second are University Colleges (UCs) that offer BSc, BA, Diploma and Certificate degrees and thirdly Community Colleges (CCs) that offer one to three year diploma and training certificate degrees.

The nature of the academic programs, private sector engagement, employment opportunities as well as local cultural practices have a great influence on the academic program success and sustainability. Unlike other parts of the Middle East and North Africa, the percentage of Palestinian girls and young women has reached 50% of the primary school population and 54% of secondary school students. In 2013 statistics, the female presence in higher education reached 58% of the student population [4]. In many cases, due to the restriction of movements and the unsettled political situation, female choices for career are limited to what the local post-secondary institutions are offering, and this may play a role in low enrollment in several Palestinian institutions.

In the following sections, the authors will present brief look at the composition of the Palestinian private sector. It will be followed by the author’s recommendations to build strong foundation of creating sustainable collaborative partnership fostering the build of skills based on experiential learning and effective partnership between the stockholders in the educational process.

2. Brief look at the Palestinian Private Sector

Palestinian private sector are characterized by their small size. Economic growth potential in Palestine rely on the Palestinian private sector. Small-scale, single owners and family enterprises dominate businesses. Large enterprises are still very limited in number.

The most thriving business is in the IT sector, which is not considered as a driving force to the economy. There are many constraints facing new businesses in the various sectors. Tourism, fishery, agriculture, food, pharmaceutical, leather and stone cutting industries and more are all in need for revival. Major obstacles are due to the confiscation of fertile agricultural land due to construction of the Wall, the presence of over 600 checkpoints and barriers preventing the movement of people and goods within the West Bank and the ongoing siege of the Gaza Strip. All are a major contributor in reducing the prospects of the Palestinian economy overcoming its irregularities. Given these ground realities, the chances of the occupied territories fulfilling their considerably high economic potential are slim.

Palestine has very limited natural resources. At the same time, it has a renewable human capital resource. More than 65% of the population under the age of twenty-five means an increase in the labor force. This tendency has its impact on the availability of young labor force and an incentive for more investments in the economy. Therefore, education at the secondary and post-secondary levels is very essential to the welfare and existence of the Palestinian population and aspired national hood.

3. Building sustainable collaborative partnership in academia

Collaborative partnerships are shaped by many factors. Partnership exist when the collaborating parties agree on clear mutual benefits, defined objectives, roles and deliverables. Under severe economic limitations, as the situation in Palestine, short-term collaboration or per project partnership is deemed more effective than long-term alliances due to the dynamics of the political situation and restrictions of movement. Short-term partnership is shaped around mutual agreement to execute identified tasks. For the academic institutions, the goal would be to provide training space to the academic program students as well as to provide the professional know how transfer opportunities of the market needs and labor requirements to the faculty members. Meanwhile, for the private sector, the collaboration will provide large pool of academics who can provide practical solutions to the business operational glitches. Moreover, the private sector receive trained individuals to meet the market needs at no financial cost.

Strong partnership start by building strong academic program advisory committee that allows the faculty at the academic institutions to interact directly with the private sector decision maker. The creation of advisory committee does not requires resources rather the strong well of collaboration.

To encourage sustainability in building the academic program, collaboration between the program academic leaders and the private sector is essential. Both parties, under the ministerial auspices, need to identify needed; economic sector priorities and sector occupational skills as the first building block of the academic program. Market labour need and private sector capacity to absorb graduate must also be considered at the early stages of building or upgrading the academic program. Creating collaborative networks among post-secondary institutions serving the same disciplinary education stream and the private sector will increase the effectiveness of steering the academic programs to meet national goals and economic priorities and open the door for more internships and employment for graduating students associated with the networked academic institutions.

3a. Building sustainable curriculum

The process of program review is not systematic and dependent on the program leader to initiate the process. Moreover, in many institutions the private sector played minimal role in the buildup of the curriculum. Despite well-written intended learning outcome, the process for developing curriculum lack coherence and causes many inconsistency resulting in heavily criticized program graduate. A study conducted on 16 institutions over the past 12 months, indicated to the fact that neither the design of a course academic unit nor the evaluation methodology relate directly to the specified ILO. This is an indication that proper program design and mapping procedures are not being used. It is relevant to transfer some of the international practices in developing curriculum and to show the importance of completing a program map that interfaces ILOs with the planned program activities.

Currently, the role of the private sector in the formulating of the academic program is completely absent or at best is limited. Figure 1 displays a basic flow chart showing the entrenching
involvement of the private sector and businesses in the curriculum design. The first step for building sustainable and effective educational programs is to start at recognising the national strategic plans that the country is targeting. For example, if the country rich in oil, then one of the strategic directions is to build strong institutions dealing with petro-chemical industries. Each academic institution need to identify its strategic mission, which could be based on several, factors among them the served surrounding industries, communities and resources.

A program advisory committee consisting of several representation from the private sector/employer, current program students, academic institution administration and the program faculty members is essential tool to sustain the well-being of the program. Periodic development of academic programs is considered an important first step towards bridging the gap between the labor market and the offered academic career choices.

It is important to engage the private sector in a systemic and periodical way for reviewing the programs and to advise on any occupational changes and update information on market demand and trainee required skills.

Once the program design/modification is approved, a detailed program map that cross checks planned program courses with the intended learning outcome for the planned courses need to be drafted and approved to ensure coherence of the building blocks leading to skilled graduate.

Each academic program therefore must be designed to fulfill national occupational need to support the surroundings and national industries and businesses. Here the private sector and employers must be engaged with the build-up of the academic programs to assist in building the intended learning outcome and training requirements to result in skilled graduate. The creation of a program advisory committee from the surroundings employers and private sector can be a key source of feedback on the quality of the program deliverables. Continuous and periodic program review process must also be outline to maintain fine turning of the program deliverables.

Figure (1) Basic flow chart highlighting the involvement of the private sector in educational institutions.
Such proposed program build is completely absent in Palestine. It is noticeable from the presented flow chart the degree to the private sector involvement in building the curriculum. The private sectors are involved with the institution at a very early stage, and are an integral part in the program advisory committee and curriculum development to ensure students acquire the right occupational skills for the market.

3b. Building sustainable experiential learning process

Experiential learning is the process of learning through experience. Many academic programs include elements of internship or field training to introduce program students to real life work environment. In industrialized countries, experiential learning is regulated to ensure high academic integrity in implementing the process. Internship engage the program student within the academic term or year in short and limited period of weekly engagement with the employer. The student is not disconnected from the academic institutions during the internship. However, in the cooperative model, the student dis-engage himself completely from the academic institution while working. There are various co-op models depending on the hosting institution offered programs. It could be a mandatory for graduation or be optional, all depends on the program certification and professional association requirements.

A "co-op placement" is a required work period within a program of study related to an essential element of the program where the total of all placements does not exceed 50 percent of the time spent in institutional study. The co-op placement must be approved as a suitable learning situation and work must be performed for and evaluated under the supervision of a person qualified in the appropriate field and monitored for progress and performance.

The inclusion of either an internship or co-operative education foundations in many academic programs provide a unique opportunity for employers and educators to share the responsibility of preparing students for these rapidly changing working conditions. The employer becomes a co-educator helping to develop today's students to become graduates ready to navigate their career and place in society.

Running an internship or a co-op program involve collaboration of three parties, the academic institution, the learner and the employer. Below are brief listing of the benefits and responsibilities of each party.

Academic Institutional benefits include:
- increased enrollment as internship and co-op programs attract top quality, superior, well-motivated students
- well-qualified graduates who are prepared to assume a productive role in society
- enhanced visibility and reputation of co-op through interactions with the community
- feedback from employers on the quality and relevance of program curriculum
- information on current research and development in employer sectors, with opportunities for collaborative projects

Internship or Co-op students gain:
- a well-rounded education, enriched by practical application of classroom learning to gain relevant employment skills and realistic expectations of the workforce before graduation
- opportunities to test and gain a broader understanding of career options, often in a variety of employment settings with financial remuneration to help to defray educational costs
- documented practical experience, a résumé, job search skills and a network of contacts upon graduation
- maturity and self-esteem as productive members of the workforce as well as confidence and skills developed through working with others

Employer benefits:
- employers can select from a group of applicants who have already met high entrance requirements and have completed some post-secondary training as well as some preparation for operating effectively in the workplace
- employers enjoy access to a pool of screened, motivated, temporary employees for special projects, peak periods, vacation relief, or maternity leave coverage without costly advertising and dozens of unsuitable resumes to wade through
- employers can evaluate potential career employees without obligation or commitment to permanent employment

4. Conclusion

For sustainable collaborative partnership between the academic institutions and the private sector/employer, academic institutions must engage the private sector in developing and periodically reviewing the academic program. Parties should work together to identify national occupational skills and focus on building healthy economic environment to meet the country needed occupational skills and strategic priorities.

5. References

AN EARTHQUAKE ENGINEERING PROGRAM ADEQUATE TO LEBANON NEEDS

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ABSTRACT

Even though earthquakes of great magnitude haven’t occurred in the last century along the Mediterranean East shore, Lebanon is considered to be a high to moderate seismic risk region. Therefore it is essential to prepare the country to face this threat. One of the crucial steps to be considered is to prepare future engineers right from the start, through an adequate educational program to meet this challenging task.

Seismic engineering science is progressing with an accelerated rhythm, thus it is necessary to endow the future generation of engineers with appropriate competence and knowledge. An adequate University curriculum becomes a necessity: this curriculum is required to be multidisciplinary, since seismic engineering is a multidisciplinary science; multilingual and multicultural, given that globalization has transformed the world into a small town.

The article presents the multidisciplinary and innovative Earthquake Engineering Master’s Program proposed for the first time in Lebanon, aiming to prepare engineers to a wider insertion in the local, regional and international market.

Key Words: Earthquake Engineering Program, Multidisciplinary, Globalization.

1. Introduction

The world has become flat [1]; the global interconnection is growing, and the barriers between disciplines are open therefore a more adequate education of engineers should be proposed in order to accommodate all these changes.

Globalization is defined as the cultural, economically and politically integration on a global level. It is the result of communication and interconnection between people and businesses worldwide. Therefore the challenges of globalization will only be solved by multilingual, multidisciplinary and multicultural efforts.

Globalization has transformed the world into a more dynamic and competitive global town, as noted in [2]: «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.

Therefore, the engineering universities are invited to introduce multidisciplinary, multilingual and multicultural programs, in order to account for the globalization in higher education, as reported in [3] and [4]. Moreover the research work is encouraged to focus on intellectual growth and teamwork between different disciplines and cultures, rather than staying focused only on individual growth [2].

Globalization and the opening of global geographical and cultural barriers encourage the modernization of the curriculum for the education of engineers in general and the one for the education of earthquake engineers in particular. Many engineering schools and research centers have already took the challenge of introducing interdisciplinary programs [5,6,7], some has introduced multilingual programs [8]. Moreover earthquake engineering, already a multidisciplinary science is moving a step further; it is becoming global in its vision and its objectives, [9].

From our side, in order to follow the evolution and take the challenge we have prepared the first earthquake engineering Master’s program in Lebanon targeting a multidisciplinary and innovative educational approach, capable of integrating future engineers into the new globalized world. This work is the first step which should be followed by all other engineering specializations; many recommendations to achieve this goal were offered in [2].

The earthquake engineering program designed for Lebanon aims helping engineers’ enrollment in the Lebanese, regional and international market. Indeed Lebanese engineers are oriented toward several job markets: local market, but especially regional (the Middle East, the Arab Peninsula and Africa), and finally international since a considerable percentage of graduated engineers are oriented toward international renowned engineering universities.

In the following paragraph 2 introduces the Lebanese earthquake engineering program, and paragraph 3 concludes.

2. The Earthquake Engineering Program

For the first time a Masters Earthquake engineering curriculum, inspired from the most innovative programs in the field, is proposed in Lebanon at the University of Balamand. This Masters is still linked to the civil engineering department. It is designed for the Lebanese environment and adapts the requirements of the Order of Engineers, and civil engineering’s job market, etc ....
Therefore we have prepared an earthquake engineering program, considering three main targets: first multidisciplinary knowledge which considers the globalization in education, second the needs of Lebanon and the region, and third an excellent international level.

**Target 1: a multidisciplinary and global program**

As demonstrated in [2], proposing a multidisciplinary program is essential. Inspired by the most innovative programs in earthquake engineering (as the one offered by the University States of New York at Buffalo or the one offered at Rose School in Pavia among others), we have proposed our program by ameliorating and adding what we have considered as shortages or as more suitable for Lebanon engineers. Therefore we have introduced different engineering disciplines (structure, geotechnical), seismology in addition to social sciences through decision analysis and risk management.

Indeed earthquake engineers should be endowed with very solid knowledge. Therefore we have kept the fundamental courses in earthquake engineering, and strengthen them by some required courses as «Theory of structures II», «Steel structures», and «Soil structure interaction», and elective courses as «Finite element». Moreover we have introduced multidisciplinary courses as «Introduction to earthquake engineering and seismology», as well as «Earthquake loss estimations», which considers social sciences of management and recovery plan.

As we are in a period of transition, introducing a great variety of elective courses seems a little shy. Once all elective courses are offered we might open officially several sub-specialties in the program such as: seismology, structural earthquake engineering, geotechnical earthquake engineering, earthquake loss estimations and resilient cities.

**Target 2: the needs of the Lebanese, regional and international markets**

The opportunities for Lebanese engineers are the Lebanese, regional and international markets.

**The Lebanese market:**

Lebanon was through history always a meeting point of civilizations, and his people are excellent travelers. Therefore Lebanese engineers find opportunities in the Middle East region, the Arabian Peninsula, and in Africa. This status should be enforced and made more international in order to face the increasing competition due to the globalization which opens the market barriers. Similarly those engineers are moving towards international universities in order to pursue postgraduate studies.

The biggest challenge of this program is to prepare students to face this international «challenge». The greatest difficulty which may be encountered while preparing a program to meet international level and requirements is the multilingual competence. In Lebanon, this skill is not an obstacle for students, it is rather an asset acquired from infancy as most of the educational institutions (primary and secondary schools) in Lebanon are trilingual (Arabic, French and English). This asset facilitates the mobility of engineers from one
side, and the multiculturalism through direct access to references in the original language from the other.

What remains is adapting the program to the needs of the Lebanese society, the labor market and the profession of engineers in Lebanon.

The Lebanese society despite living in a high seismic risk area is still not very aware of the need to consider this fundamental aspect in the choice of their habitation, thus future engineers should acquire a solid knowledge on the seismicity of their region, the nature of the soil, the effects of earthquakes and the consequences on society.

To exercise the engineering profession in Lebanon requires unavoidably the admission to «the Boarder of Engineers and Architects of Lebanon». As earthquake engineering is still a very new science in Lebanon and as it is only recognized by the Order as a sub-specialty, therefore the newly qualified seismic engineers cannot be a member in this order unless they follow the sufficient number of suitable courses in their specialty in addition to civil engineering core courses.

As most seismic engineering methodologies are recent and codes continue to undergo changes, a continuous learning through adequate trainings is necessary for Lebanese engineers as well as for many engineering professors enrolled in the academic environment. Indeed Lebanese companies use, until now, the elementary linear methods in the analysis of structures against seismic loads. Thus it is necessary for new graduates to apply innovative methods in engineering offices and to start initiating a radical change in calculation methods.

Similarly, Lebanese engineering students are not yet aware of the need for this specialization, they are moving more easily toward following restrictively the basic and traditional engineering sciences curriculum instead of moving toward innovative curriculum. Their main argument is: first the difficulty of being accepted by engineering companies in case they use innovative methodologies, second the difficulty to conduct a construction site where workers have no proper training (manpower in the construction field which is rather not Lebanese, learned by doing through on–the–job experience and not through specialized schools), and third the difficulty of convincing the architects to consider seismic design standards and limit irregularities in structures when they have no structural justification.

Hence the need to address two important issues: making the manpower more professional through their enrollment in adequate educational programs and also initiating architects in universities into basic rules and requirements for seismic design. These proposed solutions also justify the interdisciplinary aspect of our program.

The regional and international market:

The attractiveness of the Lebanese engineers profile in the region is due to three factors: 1-The well-known reputation of Lebanese Universities that have already established their reputation in the region very long ago, 2- common language spoken in the Arab world and multilingual skills that facilitate their transfer and dislocation for work purpose, 3- the Lebanese companies already established in these regions and some extended even in Africa, where a large Lebanese diaspora helps the integration process.
An innovative curriculum, offered for the first time in the region, will provide those engineers with a superior asset that differentiates them from others and therefore facilitates their integration into the regional market where the earthquake risk is considerable.

Freshly graduated Lebanese engineers are attracted to the international markets in Europe, Canada or United States to pursue graduate studies. Our innovative proposed program endowed with multidisciplinary, multicultural skills offers an international level facilitating their insertion in the sought markets and academic institutions.

**Target 3: Program with international level**

The program with international level considers innovative teaching methodologies which includes the latest scientific and technological discoveries and encourages research.

Earthquake engineering is a relatively recent science with a very dynamic rhythm if compared to the basic engineering sciences. It undergoes changes in codes and methodologies on a continuous basis, which creates a huge challenge to include those methodologies in the program.

The Lebanese Universities until recently were teaching oriented, and investing in research is relatively recent, thus a continuing education program for teachers should be considered. Similarly recruitment of experts in the field of seismology is necessary to offer some advanced courses. But the instability of the region does not always help to attract qualified foreign professors and researchers, hence the need for a transitional period to establish the innovative program that will not be perfect unless all the essential requirements are achieved. For this, we kept some traditional methodologies and courses waiting to recruit new experts in some of the very advanced fields.

Moreover, what is even interesting about this program is its orientation towards research. Given most of the courses are innovative, and given that Lebanon is a virgin region in this area, students might work through research projects on practical cases for Lebanon and the surrounding regions.

This academic curriculum appears to be strengthened through the development of many research axes: Axis 1 «Earthquake loss estimation and resilient cities» Axis 2 «Assessment and strengthening of historical buildings: preservation of cultural heritage» and « Performance-based seismic engineering methodology», Axis 3 «Seismic Design: direct displacement based method», Axis 4 «Multi-criteria decision analysis and risk management». Students can participate to those research axes by following the adequate courses which include practical projects and through their Master’s final project.

Research in the preceding noted fields has been already initiated and concrete results were achieved in the following two areas: the axis of «Earthquake loss estimation and resilient cities»; where we evaluated the seismic losses mainly of Byblos city, amongst other Lebanese villages and towns, the axis of «assessment and strengthening of historic buildings: preservation of cultural heritage»; where students participated to the field mission, the results were published in [10] in the «2nd European Conference on Earthquake and Seismology Engineering».
3. Conclusion

The world is becoming more «flat», dynamic and competitive. It is therefore increasingly
difficult for engineering universities, which prepare engineers and leaders of the future, to keep
pace with the extremely rapid and globalized evolution. Future generations of engineers which
will be facing global problems, are required to be capable to solve complex, multidisciplinary
and multicultural issues. Many international institutions have already included multilingual and
multidisciplinary educational programs. Inspired by this interesting experience, we already took
the challenge and developed our first innovative program of earthquake engineering in Lebanon,
which takes into account the society and the local and international work market. Our second
objective is to establish a seismic center, at international scale integrating the three pillars:
academic, experimental and research.

ACKNOWLEDGMENT

I thank Pr. Abdul Menhem Alameddine who always encourages me to write in the field of
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Identification and Assessment of Potential Environmental Impacts of Cesspits on Selected Groundwater Wells in Tulkarem District using Groundwater Modeling

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Abstract— Groundwater is the major source of water to the Palestinians. The quality of groundwater may be deteriorated over time due to the cumulative effects of several years of practices. The work of this thesis focused on the identification and assessment of potential impacts of cesspits on groundwater wells in Tulkarm District. A particle-tracking model was developed using MODPATH and different scenarios were worked out in order to delineate the contributing areas of contamination to each well of interest. Results confirm that the cesspits considered as one of the main sources of pollution for many groundwater wells in the study area. A wellhead protection zone was delineated for selected groundwater wells in the study area in order to arrive at effective management plan to minimize the risk of groundwater contamination. Overall, the recommendations call all relevant authorities to assume their responsibilities and to take immediate actions to control and if possible to prevent the groundwater contamination.

Keywords— Groundwater; Cesspits; Particle-tracking; MODPATH; Contributing Areas; Contamination; Protection zone.

I. INTRODUCTION

Groundwater is considered the main fresh water resource in the West Bank and definitely the only reliable source for water supply for Palestinians (Alfred, 2007). Because of that, protecting groundwater from pollution is a priority and a major concern as well.

Pollutants originating from landfills, cesspits, overuse of fertilizers and pesticides can pollute groundwater. If groundwater becomes polluted, it will no longer be safe to drink unless treated (Nas and Berktay, 2006).

Cesspits are considered as concentrated point sources of pollution that are widely used in the majority of the communities in the West Bank. The percentages of household that using cesspits in the West Bank by type of locality and region are 59.7% in urban areas, 93.4% in rural areas and 29.1% in refugee camps (PCBS, 2007).

In high density residential areas with no sewer networks, cesspits produce significant amounts of contaminants such as nitrates, bacteria, and organic matter. This form of pollution is a concern to rural homeowners who use groundwater wells for domestic use (Almasri, 2007).

When such contaminants reach the sources of water persistently, contaminant concentrations increase. High concentration of contaminants in drinking water can cause serious diseases when this impaired water is consumed by human beings.

The flow path lines provide an important representation of the flow direction and the path that the contaminant would potentially follow from a specific location until it reaches a groundwater well given that the hydrogeological conditions permit (Pollock, 1994).

Contributing areas of wells and springs when intersect contamination sources like cesspits can stimulate and provoke the mobilization of contaminants toward them. This very idea is the cornerstone of this research.
II. APPROACH

A. Research overall Methodology

The methodology of the research starts by a description of the problem followed by an identification of the location of the contaminated wells in the study area (Tulkarem Governorate). That was carried out by comparing concentrations against the Palestinian Standards of Drinking Water (PSI, 2005).

Data collection was carried out for the selected study area. After that the methodology proceeded by the development of a groundwater model for particle tracking using MODPATH for the specific case study. The MODPATH was linked to the available MODFLOW model for the Western Aquifer Basin which was developed by Abusaada (2011), different scenarios were worked out in order to delineate the contributing areas of contamination to each well of interest.

The outcomes from the MODPATH model were analyzed especially the capture zones for the groundwater wells and the flow path lines that provide an important representation of the flow direction and the expected path that the contaminant will follow from a specific originating location such as cesspits until it reaches the groundwater well.

The MODPATH results were assessed and a wellhead protection zone was delineated for selected groundwater wells in the study area in order to arrive at effective management plan to minimize the risk of groundwater contamination. A variety of figures and charts were also developed using MS Excel based on MODPATH outcomes.

B. Tulkarem Governorate. The Research Case Study

Tulkarem Governorate is located at the northwestern part of West Bank with a total surface area of nearly 268 square kilometers. It is bounded by the Jenin and Nablus district in the north, west and south and by the 1948 cease-fire line in the east. There are approximately 40 grouped communities within the study area. Approximately 169 thousand Palestinians live in Tulkarem Governorate (PCBS, 2011).

Tulkarm Governorate area is part of the WAB. Renewable groundwater resources are considered the main potential water resources available in the study area. Groundwater in the area is exploited by several public and private groundwater wells. The total number of functional wells in the governorate reaches about 66 wells. Depth of these wells is ranging between 60 and 400 meters. Domestic water is mainly taken from 17 municipal wells, the rest of wells mainly used for agricultural purposes.

Wastewater collection in Tulkarem Governorate is still underdeveloped. Most of the communities are using cesspits to dispose of their wastewater. However, Tulkarem City and two other towns have partial wastewater collection networks (ARIJ, 1996). Cesspits are frequently evacuated by private tankers that dispose of in nearby wadis or by the sides of the roads. Many of the cesspits seep into the streets especially at the center of the villages where houses are dense. It causes social, health and environmental problems at these locations. Such method of disposal increases the chance of sewage infiltration into the groundwater, along with contacts of pollutions, such bacteria and viruses resulting in deterioration of water quality.

C. Domestic Water Quality in Groundwater Wells in the Research Study Area (Tulkarem Governorate)

All groundwater wells in the study area are potentially affected by contamination sources which are summarized as follow:

- The unserved communities which dispose of their wastewater in cesspits and later in nearby wadis or by the sides of the roads.
- Wastewater wadis in Al-Zumer catchment area where the communities and industrial sector disposed their wastewater.
- Uncontrolled and illegal dumping sites of solid wastes.
- Fertilizer application in agricultural fields.
- The Israeli settlements in the study area. These settlements are usually intended for intensive industrial or agricultural activities.

The figure below (Figure 1) depicts the GIS map for the contaminated wells in Tulkarem District during the period from 1996 to 2006.

From chemical and biological analyses, most wells in Tulkarem District have shown high concentrations of nitrate and organic pollutants in areas with cesspits.
III. THE MODELING APPROACH

A. Model Outline

A steady-state numerical model of the Western aquifer basin was developed using MODFLOW groundwater model by Abusaada (2011). The boundary of the study area was extracted from the model domain. It contains Tulkarem District and part of Jenin District. The boundary is set to include all the communities where their cesspits may affect the groundwater wells. There are 17 municipal groundwater wells and 49 communities in the study area (Figure 2).

B. Development of the MODPATH Model for the Study Area

Simulation of groundwater flow pathways was modeled for the study area using the steady-state groundwater flow model for the Western aquifer basin.

Different scenarios were worked out in order to see the influence of the contamination from cesspits on the groundwater wells. This was performed by developing a MODPATH model for the study area, which uses the flow field as computed by MODFLOW.

The first scenario analyzes the capture zones for the groundwater wells using MODPATH backward tracking command. A set of particles were designated in the cells that represent the location of the groundwater wells in the model domain. In this way it was possible to see which contributing areas of the wells intersect the contamination sources.

The second scenario analyzes the flow path lines of the contamination from cesspits. This was performed by forward tracking where the starting location of the particles was considered at the
location of the communities in the study area. In this way the flow path lines of the contaminant provide an important representation of the flow direction and the path that the contaminant will follow a specific originating until it reaches groundwater wells.

IV. RESULT AND ANALYSIS
A number of different simulations were tested in order to show the influence of wastewater generated from cesspits on the groundwater wells. The purpose of the simulation for these scenarios was to determine the expected general wastewater flow pathways from communities and to delineate the capture zone for the groundwater wells in the study area.

Scenario Analysis Results from MODPATH model can be summarized as follows:

- The results from MODPATH backward tracking analysis shown different shapes of the capture zones for groundwater wells in the study area. These shapes are affected by the hydraulic conductivity and the current pumping rates of the wells. When the area of the capture zone of a well increases this leads to the inclusion of more of contamination sources (see Figure 3).

![Fig. 3: The Capture zone for Attil Cooperative Society well](image)

- The contributing areas for the majority of the contaminated groundwater wells intersect with cesspits. On the other hand, the study area described above has outcropping formations which largely dictate the direct recharge of wastewater from cesspits to these groundwater wells. That means that the groundwater wells in the study area are highly vulnerable to pollution from cesspits.
- The water quality of the groundwater wells in the study area (see Figure 1) emphasizes and supports the results from the scenarios of MODPATH model. The majority of the wells in Tulkarem District that were contaminated with coliform bacteria and NO3 intersect the contributing area of contamination.
- The path lines of contaminants in the study area are affected by the regional groundwater flow direction which was generally towards the west direction.

V. A PROPOSED MANAGEMENT PLAN
Economic development in addition to human activities on land may create stresses on water resources in terms of both quality and quantity in the West Bank and elsewhere (Khalaf and Hithnawi, 2007). On the other hand, population growth and accelerated urbanization place extra stress on the available water resources. Thus, the importance of taking a comprehensive approach to groundwater pollution protection and integrated management plan has been well established in the literature.

The groundwater wells in the study area are highly vulnerable to pollution from cesspits, dumping sites, wastewater discharged without any type of treatment, industrial and agricultural activities (SUSMAQ, 2002).

The wellhead protection zone was delineated for selected groundwater wells in the study area using the outcomes from MODPATH backward tracking analysis. The data was processed and analyzed by GIS tools for better visualization (Figure 4).
V. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

The following are the main conclusions:

- In light of the analysis carried out in this research, the contributing areas for the majority of contaminated groundwater wells in Tulkarem District intersect with contamination source (cesspits). This confirms that the cesspits considered as one of the main sources of pollution for most groundwater wells in the study area.

- Delineation of protection zones for groundwater wells in the study area is an effective management plan to minimize the risk of groundwater contamination. The best integrated management plan approach for wellhead protection zones can be implemented through discussions between regulators and stakeholders taking into account public participation and awareness.

- The results and observations from this thesis call on all the decision makers and individuals to take immediate actions to prevent contamination of groundwater resources.

B. Recommendations

The recommendations listed herein support the future studies and address the following issues regarding the management of groundwater from contamination:

- Construction of sewerage networks and wastewater treatment plants that cover all communities that use cesspits as well as rehabilitation and sustainable maintenance of the existing wastewater distribution networks.

- Identification of areas with heavy contamination loading in the West Bank and the implementation of protection plans to minimize the risk of groundwater contamination under the current and future challenges.

- There is a strong need to establish a regular groundwater quality monitoring system for all domestic sources.

- Set up management policies and regulations of land use activities for wellhead protection zones especially the critical zones around the groundwater sources. Developing preventive guidelines and operational controls necessary to ensure better management for groundwater resources which can be part of the Palestinian Water Authorities regulations.

- It is important to carry out an economic analysis to assess the potential impacts of the proposed management plan options on the local economy.

References


Online Professional Green Engineering Education

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Abstract

The American University of Beirut (AUB) with its partners the Lebanese American University, and The American University of Cairo introduced a joint professional online diploma in green technologies. This paper aims to shed light on the market need for online professional education in areas related to energy, buildings and water in the Middle East and to address methods of quality assurance of the online degree and how learning can be improved.

Keywords: Online professional education; green technologies; interdisciplinary engineering programs

1. Introduction

Rapid urbanization, population growth and change in consumption patterns have built up considerable stress on the environment and, on energy and water demand in the region. Water and land use strategies cannot be separated from energy issues. Existing technical and managerial capacity of governments must adopt highly complex energy resource planning processes in order to evaluate the water and energy requirements of accelerated socio-economic development. Energy and water are placed high in the political agenda, and private sector involvement in these issues is becoming crucial.

The private sector and universities are responding to new urgency of preparing skilled green labor for the green energy market, buildings, and products. There is a growing demand for trained personnel in green technologies with a deep understanding of integrated approaches to building design from concept to actual construction, to alternative energy generation methods and to techniques for safe water production and re-use.

In response to market demand, the American University of Beirut (AUB) has recently started a new online post-graduate diploma program in green technology jointly with the Lebanese American University (LAU) and The American University in Cairo (AUC) [1]. The curriculum is first to be piloted at universities in Lebanon and Egypt, with the ultimate goal to have the diploma offered in numerous countries and universities across the region [2].

According to an AUB market study targeting candidates of architecture, engineering and science backgrounds, over 65 % responded that they are interested to obtain a professional diploma in green technologies (see Figure 1) [3]. Moreover, distance education has evolved in recent years to also include an increasing number of adult-learners who may be within reasonable proximity to a residential campus, but because of work and personal responsibilities are unable to regularly attend a physical campus (see Figure 2). Additionally, these adult-learners consider themselves to be self-starters and more independent students who thrive in an environment which provides a balance between flexibility and structure [4].
This paper describes the requirements of the recently introduced professional diploma in green technology in three areas of concentration; energy, building, and water. It also addresses the quality assurance methods for the online aspect of the offered diploma and elements of its success.
2. Professional Diploma Program in Green Technologies

The goal of the professional Diploma in Green Technologies is to foster problem-solving competencies among professionals pursuing careers in green industries, develop lifelong learning skills among professionals from different disciplines, assist professionals in acquiring the diverse and critical skills needed to advance in their green technology careers, and finally develop expertise in green technologies related to applications in energy, water, and buildings.

The diploma is offered in three specializations; energy, water and buildings. The joint diploma aims to provide a unique and focused program that caters to the engineering and architecture professionals and students with a Bachelor of Science aspiring to enhance or complement their technical and decision-making skills in green technologies or progress in green businesses. Eighteen credits are required to complete the diploma structured as follows:

• 6 credits of core courses
• 6 credits in the area of specialization (Energy, Building, or water)
• 4 credits elective courses
• 2 credits project in the area of specialization

The required two core courses of the program (Green Economy: Policies and Law and Green Technologies System Approach to Sustainability and Management) provide solid foundation in both technical and economic aspects of green technologies in Energy, Buildings, and Water. The specialization courses consist of more in depth development of expertise in the selected major through a number of specialization courses such as Solar Energy, Wind Energy, Biofuels and Energy Storage Technology courses for students specializing in Energy. Other students specializing in Building can develop their expertise by taking courses related to Sustainable Building Materials, Construction and Demolition Management and Sustainable Restoration of Existing Building. Last but not least, students specializing in Water can learn more about Smart Irrigation, Water Treatment Water Networks Design and Wastewater Treatment. In addition to that, students will have to enroll in elective courses, and a final graduation project. The student survey shows that students are interested in this diploma mainly due to the specialization courses being offered and how relevant and mechanical they can be in their workplace instead of having theoretical courses that cannot be applied.

This diploma program is designed to address the trend towards healthier and socially responsible communities by training professional on effective ways to develop and advance sustainable energy and water efficiency in production, utilization, storage, and re-use. The program builds on and fosters effective e-learning and e-collaboration among faculty in institutions in Lebanon and Egypt with expertise in energy, buildings, and water through co-teaching and co-supervision of projects in these fields. This program targets professionals who are mainly interested in advancing their careers without having to be regular master students. Pro-Green is tailored to grow the educational mission of the universities to expand its outreach to professional communities.

In its first semester in February 2015, 24 students were enrolled from six countries in the region. According to the term evaluations, 90% of students have never participated in online learning before. Students are spending 5-7 hours per week on each course. Registered students
reside in the Middle East and Europe and come from varied nationalities such as Lebanese, Canadian, American, and Australian [5].

The PROGREEN project has a well-recognized advisory board, including private sector industry leaders, government affiliates, and International Non-Governmental Organizations, such as Dar Al Handasah (Shair and Partners), the Lebanese Order of Engineers and Architects, the United Nations Develop Program (UNDP), Lebanese and Egyptian municipal leaders from Beirut, Tripoli and Giza, and many more high profile leaders in the green energy sector [6].

3. Quality Assurance in the online diploma

The online program quality assurance and sustainability should have the following elements:

• **Program inclusiveness within the University**: Commitment of a Group of faculty responsible for the offerings and program quality.

• **Training for Instructors**: Committed Trainers; Faculty Effort; Incentives

• **Resources: Learning Management System** (LMS) platform; IT skills; network support; software availability (storyline); admissions, registrar and finance team; automation all processes.

• **Support**: e-learning team: setting accounts and authentications; supporting faculty and students; counseling, advising, instructional material; archiving.

• **Quality assurance**: Evaluation of learning outcomes; evidence of learning; modality of examinations; class size policy (minimum 6 students; maximum 20 but could be reduced to 15 students per class)

• **Program Promotion**: Network of learners

Having three major universities pouring their determination and knowledge into this diploma gives it more credibility and sustainability. A lot of barriers might occur when dealing with institutions from different countries; such as country instability, country infrastructure and internet availability. It is always best practice when working in a consortium to standardize procedures, train staff periodically and have all processes centralized.

Mid- and end- of semester evaluations of learning outcome by survey to both faculty and students were performed for the first semester and continue to be implemented in the following semester. Sixty three students were asked about what aspect(s) of the course(s) they find most useful and interesting and the qualitative replies of 44 responses revolved around learning from Group discussions and the activities; the reading of the class responses; lectures and colleagues presentations; the balanced evaluation of various green building rating systems; learning about green building assessment and sustainable design; class Assignments, posts, and Discussions; the general overview on the sustainability issues; the on line group work discussion was very productive and interesting; exposure to new information and ideas; and presentations and case studies.

When students were asked about the most challenging aspect(s) of the course/s, their answers varied depending on their professional background and familiarity with the technical terms but many found that downloading material was a challenge due to internet speed in Lebanon and wanted more flexibility in deadlines of assignments for working professionals and less reading load in some courses. Students reported that online delivery is convenient for them but recommended that more interaction with instructor via videoconferencing or skype be scheduled.
once every month. Other students commented that the online delivery with strict deadlines has improved their time management skills. One student found that the best thing about the program was “the practical things that I learn and apply them next day in my work.”

Students were asked about the number of hours per week they spend on a course including time spent working online, doing readings, reviewing discussions, writing papers, and any other course-related work. The answers of the students are presented in Table 1 and the majority has spent 6 hours. Note that most of the offered courses were 1- or-2-credit modules except for the core course.

Table 1: No. of hours spent by students online course per week.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Count</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>0 -- 3 hours (1)</td>
<td>3</td>
<td>7.14%</td>
</tr>
<tr>
<td>3 -- 6 hours (2)</td>
<td>19</td>
<td>45.24%</td>
</tr>
<tr>
<td>6 -- 9 hours (3)</td>
<td>15</td>
<td>35.71%</td>
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<tr>
<td>More than 9 hours (4)</td>
<td>5</td>
<td>11.90%</td>
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<tr>
<td>No answer</td>
<td>0</td>
<td>0.00%</td>
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</table>

Students were asked to indicate how often they contact the instructor through email, course communication forum, phone or Skype. Their answers are summarized in table 2. Only 28.5% of the surveyed student indicated that they needed to communicate frequently with instructors.

Table 2: Student form of communication with instructors

<table>
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<tr>
<th>Answer</th>
<th>Count</th>
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<tr>
<td>Very Frequently (1)</td>
<td>4</td>
<td>9.52%</td>
</tr>
<tr>
<td>Frequently (2)</td>
<td>8</td>
<td>19.05%</td>
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<tr>
<td>Occasionally (3)</td>
<td>14</td>
<td>33.33%</td>
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<tr>
<td>Rarely (4)</td>
<td>9</td>
<td>21.43%</td>
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<td>Very Rarely (5)</td>
<td>4</td>
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<td>Never (6)</td>
<td>3</td>
<td>7.14%</td>
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<tr>
<td>No answer</td>
<td>0</td>
<td>0.00%</td>
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In general, the assessment of learning outcomes and quality assurance of the program is an ongoing process and is being monitored closely to improve the offerings with time and the quality of learning.

4. Conclusions

The green technologies diploma is shown to offer flexibility by accommodating candidates’ working schedule. Candidates can engage in their course activities at their convenience, weather
watching on-line lectures, performing assignments, interacting in on-line forums, whenever their time permits within flexible deadlines. In addition, the certificate is strictly online thus allowing eligible professionals interested in green technologies in the region to apply to the diploma.

“Through comprehensive lectures, flexible study hours, and amiable learning environment, the Pro-Green diploma is both an enjoyable and enriching learning experience. Offered through a user-friendly online platform, the diploma allows for the understanding and direct application of the recent practices in ecofriendly building. Moreover, the interdisciplinary backgrounds of the professors and colleagues make this program a real-life simulation of a professional integrated project team working towards Sustainability!” This is a statement by an architect enrolled in the diploma program.

Acknowledgment

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[4] The Distance Education Accrediting Commission (DEAC), USA. http://www.deac.org/


## Organizing Committee

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<td>Dean, Faculty of Architecture, Art &amp; Design Directory</td>
<td>NDU</td>
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<tr>
<td>Yehia Temsah</td>
<td>Professor, Assistant Dean, Faculty of Engineering</td>
<td>BAU</td>
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<tr>
<td>Elie Haddad, Ph. D.</td>
<td>dean of the School of Architecture and Design</td>
<td>LAU</td>
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<tr>
<td>Maroun El-Daccache, Ph. D.</td>
<td>chair of the Department of Architecture</td>
<td>LAU</td>
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<tr>
<td>Carla Nasr, B.L.</td>
<td>Chief of Cabinet, Order of Engineers and Architects – Beirut - Lebanon</td>
<td>OEA</td>
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<tr>
<td>Issa Dahboul, BSME</td>
<td>Director, Training Center</td>
<td>OEA</td>
</tr>
<tr>
<td>Zahi Daou, BSCE</td>
<td>Assistant director, Training Center</td>
<td>OEA</td>
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**Scientific Committee**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adnan Harb, Ph. D.</td>
<td>Associate Professor and Associate Chair at the Department of Electrical and Electronics Engineering</td>
<td>LIU</td>
</tr>
<tr>
<td>Ali Assi, Ph.D.</td>
<td>Department of Electrical &amp; Electronics Engineering</td>
<td>LIU</td>
</tr>
<tr>
<td>Amin A. Haj-Ali, Ph.D.</td>
<td>Dean - School of Engineering</td>
<td>LIU</td>
</tr>
<tr>
<td>Barbar Akle, Ph.D.</td>
<td>Assistant Dean, School of Engineering</td>
<td>LAU</td>
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<tr>
<td>Bassam Hussein, Ph.D.</td>
<td>Chair - Department of Industrial Engineering</td>
<td>LIU</td>
</tr>
<tr>
<td>Chadi Abou Jaoude, Ph. D.</td>
<td>Faculty of engineering in computer science, multimedia, system and telecommunication.</td>
<td>UA</td>
</tr>
<tr>
<td>Charbel Bou Mosleh, Ph. D.</td>
<td>Assistant Professor Mechanical Engineering</td>
<td>NDU</td>
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<tr>
<td>Charles Yaacoub, Ph. D.</td>
<td>Associate Professor, Chair, Department of Telecommunications Engineering</td>
<td>USEK</td>
</tr>
<tr>
<td>Elie Karam, Ph. D.</td>
<td>Assistant Dean, Faculty of Engineering, Chairman, Electrical Engineering department</td>
<td>UOB</td>
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<tr>
<td>George E. Nasr, Ph.D.</td>
<td>Dean, School of Engineering</td>
<td>LAU</td>
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<tr>
<td>Ibtihal El- Bastawissi, Ph. D.</td>
<td>Dean, Architecture, planning and urban design</td>
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<tr>
<td>Karim Nasr, Ph. D.</td>
<td>Professor of Mechanical Engineering</td>
<td>UOB</td>
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<tr>
<td>Lama Hamandi, Ph. D.</td>
<td>Senior Lecturer, Electrical and Computer Department</td>
<td>AUB</td>
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<tr>
<td>Maged B. Najjar, Ph. D.</td>
<td>Chairman, computer Engineering department</td>
<td>UOB</td>
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<tr>
<td>Michel Khoury, Ph. D.</td>
<td>Associate Professor/Chairperson/Industrial &amp; Mechanical Engineering and Petroleum Engineering</td>
<td>LAU</td>
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<tr>
<td>Michel Nahas, Ph. D.</td>
<td>Assistant Professor Department of Computer and Communications Engineering</td>
<td>LIU</td>
</tr>
<tr>
<td>Prof. Tarek Farghaly</td>
<td>Professor, Architecture and Environmental studies</td>
<td>BAU</td>
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<tr>
<td>Rached Zantout, Ph.D.</td>
<td>Associate Professor and Chairman, Electrical and Computer Engineering Department</td>
<td>RHU</td>
</tr>
<tr>
<td>Name</td>
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<td>Institution</td>
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<tr>
<td>Raymond Ghajar, Ph. D.</td>
<td>Professor and Associate Dean School of Engineering</td>
<td>LAU</td>
</tr>
<tr>
<td>Rida Y. Nuwayhid, Ph.D.</td>
<td>Dean, College of Engineering</td>
<td>RHU</td>
</tr>
<tr>
<td>Talal Salem, Ph. D.</td>
<td>Assistant Professor, civil engineer</td>
<td>NDU</td>
</tr>
<tr>
<td>Talal Salem, Ph. D.</td>
<td>Assistant professor, Department of civil and environmental engineering</td>
<td>NDU</td>
</tr>
<tr>
<td>Zahi Nakad, Ph.D.</td>
<td>Associate Professor and Chairman, Department of Electrical and Computer Engineering</td>
<td>LAU</td>
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**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AUB</td>
<td>American University of Beirut</td>
</tr>
<tr>
<td>BAU</td>
<td>Beirut Arab University</td>
</tr>
<tr>
<td>CEIE</td>
<td>Committee of Education in Engineering</td>
</tr>
<tr>
<td>CET</td>
<td>Committee of Education and Training</td>
</tr>
<tr>
<td>ESIB</td>
<td>University Saint Joseph</td>
</tr>
<tr>
<td>FAE</td>
<td>Federation of Arab Engineers</td>
</tr>
<tr>
<td>FLE</td>
<td>Federation of Lebanese Engineers</td>
</tr>
<tr>
<td>IUL</td>
<td>Islamic University of Lebanon</td>
</tr>
<tr>
<td>LAU</td>
<td>Lebanese American University</td>
</tr>
<tr>
<td>LIU</td>
<td>Lebanese International University</td>
</tr>
<tr>
<td>MUT</td>
<td>Manar University of Tripoli</td>
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<tr>
<td>NDU</td>
<td>Notre Dame University</td>
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<tr>
<td>OEA</td>
<td>Order of Engineers and Architects</td>
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<tr>
<td>RHU</td>
<td>Rafic Hariri University</td>
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<tr>
<td>UA</td>
<td>Antonine University</td>
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<td>UL</td>
<td>Lebanese University</td>
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<td>UOB</td>
<td>University of Balamand</td>
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<tr>
<td>USEK</td>
<td>Holy Spirit University</td>
</tr>
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<td>USJ</td>
<td>University Saint Joseph</td>
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<tr>
<td>WFEO</td>
<td>World federation of Engineering organizations</td>
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</table>
Message from Khaled Chehab
President of the Federation of Lebanese Engineers

It is a great honor to welcome engineers from all countries to the 10th World Congress on Engineering Education (WCEE 2013) "Engineering Education for sustainable Development" in Beirut, Lebanon. The theme of this Congress is versatile and it will be a great opportunity for authors and educators from all over the world to discuss the different visions related to the engineer’s education. I wish a full success to this gathering and to the future of Engineering Education.

The World Federation of Engineering Organizations

WFEO serves society and is renowned as a respectable and valuable source of advice and guidance on the policies, interests and concerns that relate to engineering and technology. The role and responsibility of engineers in addressing the challenges facing society is more recognized and acknowledged worldwide. The World Federation of Engineering Organizations (WFEO) is the sole body representing the engineering profession of all kind and disciplines.

Committee on Education In Engineering

The aim of the Education in Engineering Standing Technical Committee (CEIE) is to work for the development of the profession and to work toward the mobility of Engineers around the world. Its aim is to become one of the accreditation agencies for the engineering programs, working together with other international agencies.