

Integration of Sustainability in Engineering Education in Palestine

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Abstract— Supporting engineering education is considered as one of the main goals that lead to strong Palestinian economy due to the strong interactions and synergy effects between education and the economy. Engineering education is considered a mid-point that connects natural resources at one side to industrial products at the other side. To keep this connection in a sustainable manner that guarantees maintaining these resources for the longest time of life, engineering courses and programs are designed by integrating sustainability aspects into engineering education in order to increase productivity resource efficiency without damaging the environment. The focal point of this paper is the academic faculties of engineering where education and training courses are designed and delivered on one hand and innovation and research are fostered on the other hand. This paper demonstrates an overview of the potential contributions of academia in altering the attitude of industries toward more sustainable resource consumption and capacity building for implementing sustainable engineering. Bachelor and master engineering programs will be considered in the paper. Cooperation and partnership between higher educational institutions and industry will be addressed in the context of sustainability and taking into account national and international indicators for this partnership.

Index Terms— Engineering Education; Sustainability; Development; Partnership.

I INTRODUCTION

Palestine has a highly renewable human capital resource, 60.3% of the population in West bank and Gaza are under the age of twenty [1]. This resource has its impact on the incentive for more investment in the education and transfer of knowledge. According to the Palestinian Ministry of Education and Higher Education, there are 49 Palestinian Universities and colleges working in West bank and Gaza [2].

Education has been of great importance to the Palestinian people. Studies indicate that the ratio of university students to the total population is considerably higher for Palestinians than all other Arab nations and many advanced European nations [3]. Palestinian students have exceptionally high educational aspirations in spite of disruptive influence of the Israeli occupation and dire poverty. Students work hard in school and are supported by their parents. Palestinians of all social and economic origins and all political persuasions agree on the necessity of high-quality education for their youth. This is perhaps the highest priority of every Palestinian family [4].

The overall number of Palestinian graduates increased by 18.5% between the academic years 2003/2004 and 2011/2012 [5]. Engineering programs are the favorite choice of the Palestinian society, hence engineering program along with health science attract the best students. It is very common that, students with grades above 90% in high school diploma are enrolled in engineering programs. In 2010/2011

around 11.2% of the students accepted in the universities in the bachelor programs are accepted in engineering disciplines. On the graduation level 8.8% among bachelor degree university graduate are from engineering disciplines [3].

However, as in other countries in the region, an educated workforce is not correlated with economic productivity. Mismatch between the qualifications demand and supply is a major challenge for the educational institutions; [5]; [6]. Preparing students based on the real-time job market qualifications demand will increase the chances of getting and retaining a job that equip them in the best way for a rewarding career and with the most relevant skills for their chosen field. Employers will have the needed skilled individuals for enhancing their competitive advantage.

A Energy problems

Energy acts as a main indicator of industrial activity and improved standard of living. GNP is correlated easily with energy per capita consumption. For non-fossil fuel producing countries in the region such as Palestine energy supply can be a limiting factor of growth and prosperity. Maximizing the use of the available energy resources on one hand and utilizing renewable energy resources on the other hand will be the wise option for such countries. For Palestine electricity grid reaches 99% of population unlike other countries in the region. Even in the oil rich countries the electricity grid and supply is not 100%. Palestinians in the West

Bank do not generate their electrical power. The total power purchased is around 98%, the bulk is supplied by Israel, and Jordan provides around 6%. In Gaza Strip, Israel supply 50% and Egypt supply 7%. The rest is supposed to be generated by the Gaza 140-MW Power Station (GPS). Main problem in Palestine is the equality of electricity and its duration. Interruptions and break downs are very frequent in winter time. In Gaza Strip situation is much worse due to the unavailability of fuel for the GPS, such that it operates only a few hours a day. People depend for most of the time on diesel generators generating electricity at a high price and polluting the environment. Other constrains when it comes to energy is the price and the cost. Electricity prices in Palestine are very high because energy is imported from Israel at a relatively high cost and then taxed by the Palestinian Authority. The average selling price of electricity is 0.115 €/kWh. There are no subsidies; energy therefore takes a large part of the household income of Palestinians. The average annual income per capita in Palestine is € 1,030; the electricity bill amounts to about 10% of the family income [7].

B Water problems

In general Palestine suffers from shortage of water. In particular it suffers from continuous increase of the water scarcity. Climate changes and environment issues are adding to already present political concerns over the water problem [9]. Palestinian water abstractions have declined over the last ten years, as the result of the combined effect of dropping water tables, Israeli restricted drilling, deepening and rehabilitation of wells. Water withdrawals per capita for Palestinians in the West Bank, are about one quarter of those of the Israelis, and are continously declining over the last decade. By regional standards, Palestinians have the lowest access to fresh water resources as shown in Table 1 below [10]. Domestic water supply in Palestine is variable and discontinuous. The nominal daily supply rates to a quarter of the connected population are less than 50 liter/capita per day. Some network services providing as little as 10-15 liter/capita per day, such rate is below the minimum international humanitarian disaster levels. Actual household use in the West Bank is estimated to average 50 liter/capita per day. In addition, about 50% of households claim quality problems in their drinking water supply [10].

C Material problems

Material management is an engineering technique concerned with planning, organizing and control of flow of materials from their initial purchase to destination. Material management aims at getting the right quality and quantity of supplies in the right time and place at the right cost. The objectives of material management refer to material planning, purchasing, procuring, storing and inventory control.

TABLE 1

Per capita availability of renewable water resources in Jordan basin (Sources: World Bank, 2007, PWA, [11]).

Country	m ³ per capita per annum
West Bank	75
Gaza	125
Jordan	200
Israel	240
Lebanon	1200
Syria	1500

On the other hand, material management helps in organizing supplies, distribution and quality assurance of materials. In general, the best procedure for material management flow is outlined in Figure 1 that represents a material management cycle [12].

Palestine suffers from shortage in different types of materials that are considered vital for development of this region. Therefore, it is even more important to use adequate management techniques to manage the most important material resources like petroleum and construction materials to sustain the resources for a longer period. Stone, marble and aggregate make up to 50% of materials used in construction. Managing the life cycle of this material will improve the efficiency of this resource and the regional economy as well [13]. The rest of materials used in construction are divided into metals and non-metals. The most widely used metal is steel followed by aluminium while the non-metals relate to rubber, plastic, and wood. Petroleum producing countries in MENA depend on oil and gas, responsible for 90% of their GDP [14].

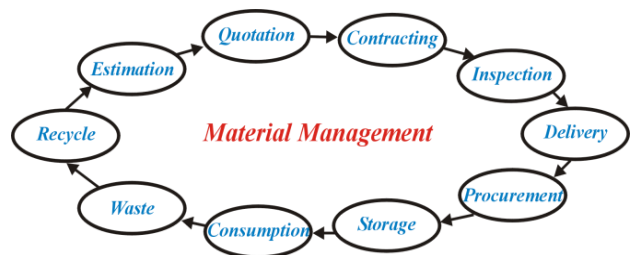


Figure 1: Material management flow diagram

I. ENGINEERING PROGRAMMES IN PALESTINE

Palestinian Education Sector Strategy 2011-2013 was built on the four core pillars: enrolment, quality of education, management, and linkage with the needs of the market and society.

A Existing programs

Engineering programs along with IT attract the best students in Palestine. In 2010/2011 11.2% of the 40000 students accepted in the universities in the bachelor programs are accepted in engineering disciplines. Among the 103000 university students 18.1% are in engineering bachelor programs. Figure 2 shows existing engineering programs at Palestinian universities [15].

Engineering programs are 5 year programs that include basic science, basic engineering science, specialized courses, labs and practical training in addition to cape stone or graduation project. Those programs are based on credit hour systems.

However because of difficulties imposed on importing lab equipment by Israeli occupation and adding to this the limited funding available for such equipment, some of labs and practical aspects are not covered properly in classes. Such situation assures the need for a stronger relationship between academic programs and industry in Palestine; this is to give student better opportunities to get hands-on experience in direct contact with the local industry [16].

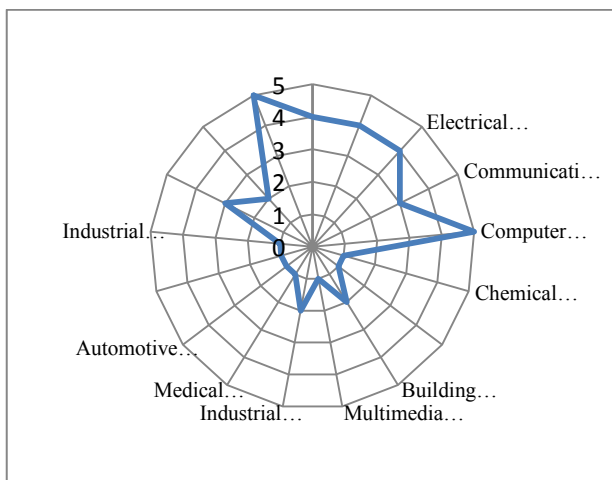


Figure 2: Engineering programs at Palestinian universities.

B Proposed model for engineering education

A new model for engineering education is developed based on the Integrated Definition Function (IDEF) Modelling technique. The engineering education model shown in Figure 3 is based on considering “Engineering Education” as the main function to be modelled. This function is supported mainly by six variables: inputs, outputs, controls, mechanisms, information and Dynamics. These variables are connected as follows:

Outputs: The main outputs of the engineering education process are:

- Knowledge - Knowledge is the most important output on which most of other outputs depend.

- Graduates - Graduate engineers from all disciplines should obtain the necessary level of education that fits to the needs of the local society.
- Opportunities - Having good education process leads to opening new opportunities, jobs, and business.
- Development - This educational technique helps in the development of local industry and society leading to improving the life level of people.

Inputs, Information, Controls & Mechanisms: The main inputs to the engineering education process are:

- Curriculum – Preparing curriculum for engineering program requires taking inputs from existing literature. To support traditional educational techniques, Cooperative education should be applied to assure sustainability.
- Students – Students are the centre of education process. Besides to theoretical information, students need to be aware of technological issues related to their disciplines.
- Assessment is used to control and evaluate the level and adequateness of these students. Students need to attend Lifelong Learning courses during and after their study period to stay up to date with all recent advances.

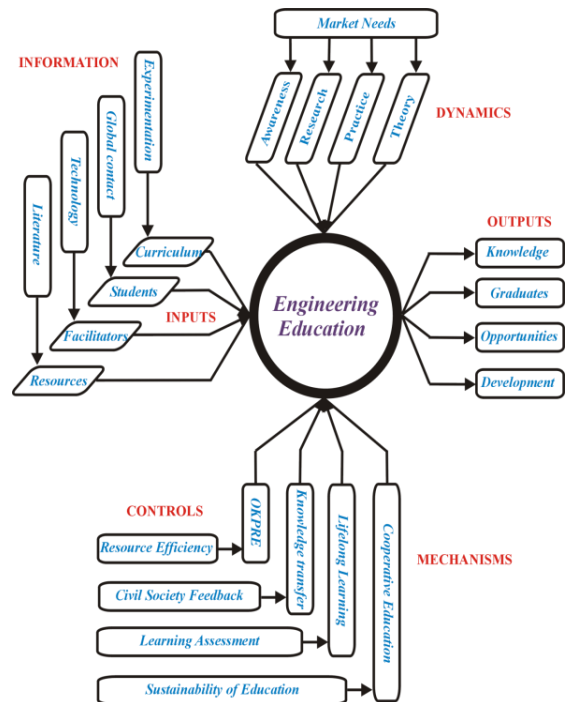


Figure 3: Developed model for Engineering Education

- Facilitators – In modern educational theories, teachers are called facilitators because their main job is facilitating ways for students rather than lecturing. Facilitators get their experience from global contacts with higher educational institutions and industrial

partners. They transfer knowledge obtained through these contacts to the education process. The level and appropriateness of this knowledge is measured and controlled by taking feedback from local society.

- Resources – All previous items require resources to be accomplished. These resources are decided referring to the experimentation requirements and should be related directly to the existing resources of the local society. Resource efficiency methods should be followed her including the preparation for an Open Knowledge Platform for Resource Efficiency (OKPRE). This platform plays the role of intermediate between universities and society. It can be either in personal form or just an Electronic Platform with public access.
- Dynamics - The dynamics deteriorating Engineering Education process take their input from Market needs. The variables affecting these dynamics are: Theory, Research and Practice used to vary Awareness of students. The output of these dynamics is the Knowledge given to students. In order to obtain a balanced knowledge level, all previous variables must be balanced.

C Proposed model for industry-academia partnership

Figure 4 depicts a proposed model for industry-academia partnership represented in integrated definition function schematic diagram. This figure shows that academia requires at least four inputs to fulfill the learning process from one side and the partnership with industry from the other side. Curriculum is considered the main input, courses and teaching plans should be prepared carefully to qualify graduates to be able to compete in the local market and worldwide. Moreover, the curriculum must take into account needs of the local market to contribute in its development. The second input is the students; these students are considered the core of the academic process where modern learning methods are student based learning techniques. Other resources are required to support the academic institutes in their partnership with industry. Laboratories, ICT and technical facilities are considered significant part of these resources besides the necessity of libraries, books and search engines.

In order to establish a serious partnership between academic university and industry, the university must study carefully the needs of the market and feed it into its curriculum and learning techniques. These information help in building awareness of the necessity for a real cooperation that leads to social and economic development of the local society. Industry-academia partnership can take the forms of activities as shown in figure 4:

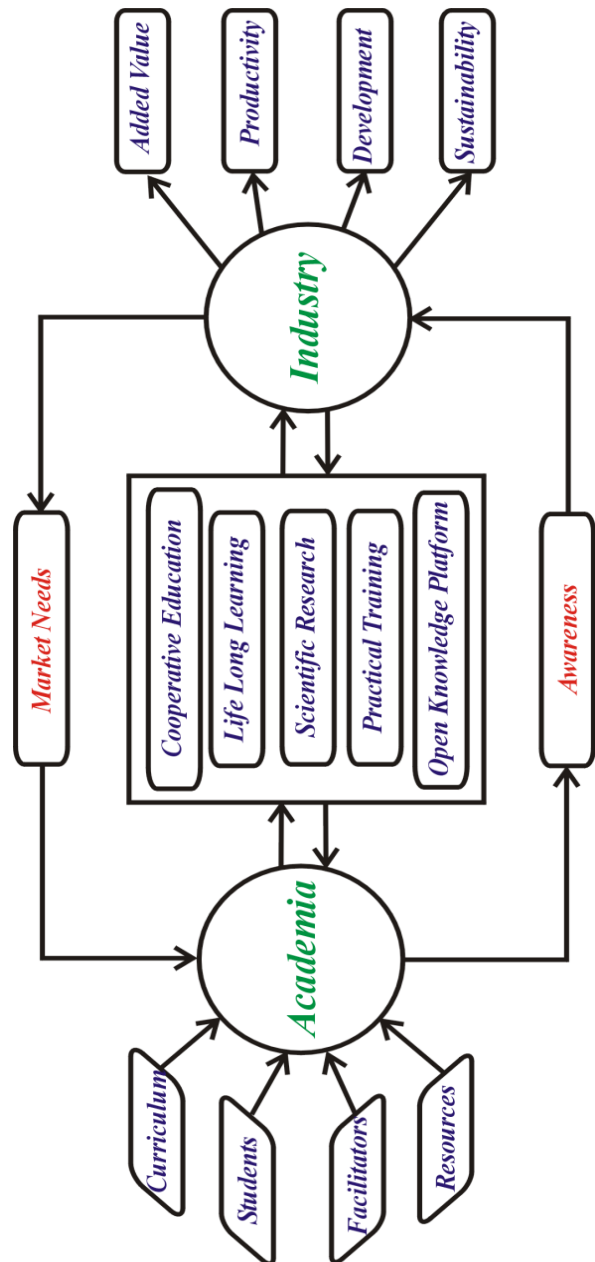


Figure 4: Integrated definition model for industry-academia partnership

In order to establish a real partnership between academic university and industry, the university must understand the needs of the market and incorporate them into its courses and learning techniques. These information help in building awareness of the necessity for a real cooperation that leads to social and economic development of the local society. Industry-academia partnership can take the following forms of activities:

- 1- Cooperative education: Cooperative (CO-OP) education is considered one of the most important learning methods for Engineering, Information Technology and Business educational disciplines. CO-OP can be divided into two main techniques: In-class cooperative learning and

in-market cooperative learning. It helps students to share ideas and opinions, ask for reasoning, work in teams, encourage everyone to participate and energize groups. On the personal level, it leads students to learn monitoring, observing, intervening and processing. In-market CO-OP learning aims at developing partnership with local market and industry and opening new opportunities for students and graduates in their future career and business. On the other hand, it helps in bridging the gap between theory and practice and qualifying students to be ready for work challenges from the first working day. It improves the level of education in Palestine and encourages students to continue their higher education in the region avoiding brain drain and leading to better development of their countries.

2- Lifelong Learning: Lifelong learning (LLL) is a very wide concept and has been defined by different people at different definitions depending on the national context. It can hold the following definitions:

- Adult learning.
- Non-traditional students in a formal and informal environment.
- Supplementary (non-degree) study programmes.

The activities carried out under LLL can vary from part-time, distance, adult, mixed-mode, electronic and open learning.

Lifelong learning can be monitored either by HEIs or by topic providing private sector associations. Nevertheless, it is required from the governments to lay out rules and measures for the implementation of Lifelong learning in the frame of cooperation between higher education and industry. In Palestine LLL contributes in educating and updating knowledge of engineers and technicians working in the local industry. This aims at providing these people with the state of the art about modern developments and innovations arise all over the world. In order to enhance LLL process it is necessary to make student, staff and technician mobility between Palestine and European countries. This mobility aims at transferring knowledge and know-how about recent developments.

3- Scientific research: research is considered as one of the main building blocks used in the development of societies. This research requires a serious study of the requirements of local industry tackling practical problems in this industry to be solved. University professors must work together with their students on solving technical problems specified by the industry. Working on these problems requires deep knowledge of scientific theories and experimental processes to attach theory to practice.

4- Practical training: In scientific and practical faculties every students needs to make a practical training after the fourth year of his study to fulfil the graduation requirements. Trainees are supervised by senior engineer working in the training company and followed up by a university professor from his faculty. A daily report should be written by the trainee, signed by the supervising engineer and submitted to the promoting university professor.

This training qualifies the student for conducting the practical skills and tightens relations and cooperation between the university and industry.

5- Open knowledge platforms: Platforms for disseminating knowledge should be established and formed by people from universities and others from the industry. Each platform will handle the open distribution of knowledge in a specific topic. Forums, websites and social media can be used to build these platforms. The existence of these platforms contributes in increasing sustainability and improving resources efficiency in Palestine.

Partnership between industry and academia contributes in increasing the added value for the participating industrial sectors improving the contribution value of these sectors in the local economy. Productivity of the partner companies will be significantly improved due to the influence of the scientific research conducted by the partner university to solve the different problems of the production lines. On the societal scale, this cooperation leads to developing the social and economic situation of the Palestinian society. Regardless of the hard political situation in Palestine that deteriorates the development and continuity of the industrial sector, this industry-academia partnership increases the sustainability of this sector and helps in saving resources and products.

III. SUSTAINABILITY EDUCATION IN PALESTINE

A Bachelor programs related to sustainability

A working definition for sustainable engineering will include the topics of energy, water, natural resources, solid waste, quality, management and relevant issues. Sustainable engineering program does not exist on the Palestinian universities neither as BS nor MS level. However table 2 presents some of the related programs or those which include some elements of sustainable engineering.

Two Bachelor programs in environment engineering exist in Palestine, one in West Bank and another one in Gaza Strip. One program is recently introduced in An-Najah University. While water related graduate programs exist in 3 universities in West Bank and one in Gaza Strip. Only one graduate program for sustainable development exists at Al-Quds University.

Most B.S engineering programs have courses related to energy, water, solid waste and environment. Table 3 presents an example of such courses in some of Palestinian universities.

TABLE 2

Sustainable engineering related programs in Palestinian universities

Program	level	university
Environment engineering Technology	B.S	Palestine Polytechnic University
Environment engineering	B.S.	Islamic University of Gaza
Energy and Environmental Engineering	B.S.	An –Najah University
Water Resources Engineering	MS	Islamic University of Gaza
Water and Environmental Sciences	MS	Al-Azhar University
Water and Environmental Engineering	M.S	Birzeit University
Water and Environmental Sciences	M.S	Birzeit University
Water and Environmental Engineering	M.S.	An –Najah University
Clean Energy and Energy Conservation Engineering	M.S	An-Najah University
Rural sustainable development	M.S	Al-Quds University

TABLE 3

Sustainable engineering related courses in some B.S. engineering programs.

Uni- versity	Program	Energy	Water	Solid waste	Environ- ment
Birzeit Uni- versity	Electrical Engineering	1			
	Mechanical Engineering	2			1
	Civil Engineering		6	1	1
	Architectural Engineering	1			
An- Najah Uni- versity	Electrical Engineering	1			
	Mechanical Engineering	2			
	Civil Engineering		4		7
	Architectural Engineering	1			2
	Chemical Engineering		1	1	4
	Industrial Engineering	1			

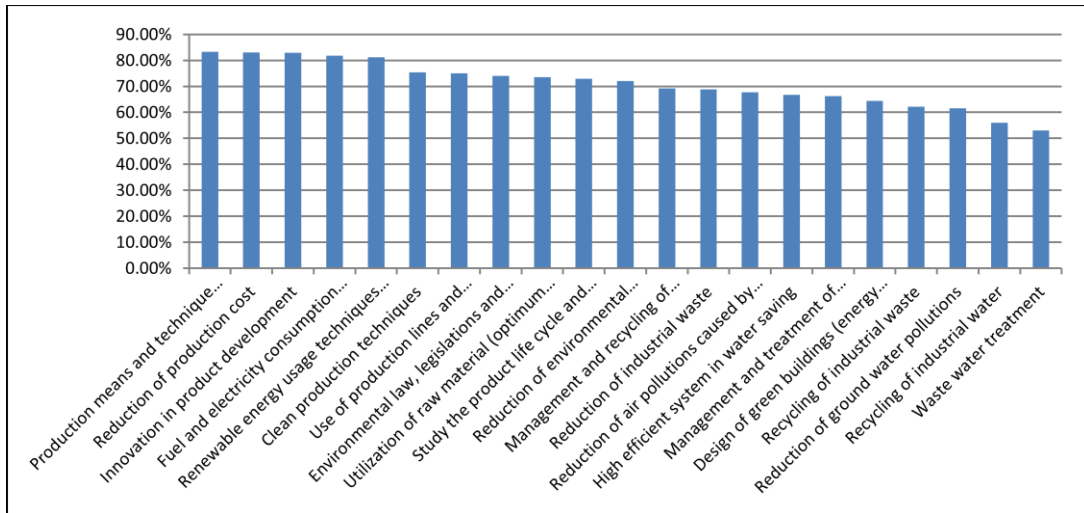


Figure 5: Industry need for sustainable courses based on market survey [17].

B MS Sustainable Engineering at Birzeit University

The Middle Eastern Partnership in Sustainable Engineering (ME-Eng) TEMPUS project comes to address the sustainability challenges discussed above. The Master program in Sustainable Engineering will be established in the faculty of Engineering at Birzeit University with joint resources from An-Najah National University.

This program will teach graduate courses related directly to the needs of the local industry and sustainable engineering. Market study and survey of industries showed their interest in sustainable engineering courses as given in Figure 5.

Sustainable engineering program at Birzeit University aims at meeting the economic development needs in Palestine by raising the national production level and providing environmental needs, it is based on the market survey results as depicted in figure 5. This is consistent with the international trends for conserving the natural resources and utilizing the renewable energy resources taking into account water conservation, pollution reduction and implementing Remanufacture, Reuse and Recycle processes. Therefore, the program conforms to the principles of sustainability in manufacturing, production and building processes in all industrial sectors in Palestine and abroad. The program aspires to implement the sustainability principle as a foundation for building and development to maintain human life on this globe without causing harm to future generations.

The main objective of the program is to build Palestinian human resources in sustainable engineering. Graduates of this program will have a comprehensive overview in sustainable production. They can integrate sustainability through efficient utilizing of materials, water and energy while decreasing their influence on environment. They will gain analytical tools for the evaluation and assessment of the effect of sustainability on the product life cycle.

The program aims to achieve the following specific objectives:

- Qualifying local human resources to manage and operate the local industrial establishments.
- Development of production processes and quality control in national industry.
- Providing engineers with analytical tools in the fields of sustainability and cleaner production.
- Increasing competitive capabilities of the local products.
- Enhancing skills required for the best resource efficiency and utilization of local resources.
- Preserving environment and avoiding pollution of air, water and soil.
- Establishing scientific research in sustainable production and its applications.
- Spreading awareness of quality and sustainability.
- Exploring technical and engineering aspects in sustainable development.

Table 4 presents some of the courses to be delivered in this program and their type.

TABLE 4
Courses in Sustainable Engineering program.

	Course title	Type
1	Sustainable engineering	obligatory
2	Energy efficiency and renewable energy	obligatory
3	Life cycle analysis	elective
4	Clean production	elective
5	Water Efficiency and Water & wastewater Treatment Technologies in industry	elective
6	Special topics in sustainable engineering	elective
7	Thesis/ Seminar	obligatory

IV. ROLE OF EDUCATION IN SUSTAINABLE DEVELOPMENT

Sustainable development is mostly defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [18]. Sustainability involves the integration of: economic, environmental, and social dimensions. Economic aspect defines the framework for making decisions. Environmental aspects recognize the diversity and interdependence within living systems, the goods and services produced by the world's ecosystems, and the impacts of human on the ecosystem. Social aspect refers to interactions between institutions and people, human values, aspirations and well-being, ethical issues, and decision making process.

The three main elements of the sustainability paradigm are usually thought of as equally important, and within which trade-offs are possible. Strong sustainability implies that trade-offs among natural, human, and social capital are not allowed or are very restricted, while weak sustainability implies that trade-offs are unrestricted or have few limits.

Three important findings were reported by Millennium Ecosystem Assessment MEA [19]. Firstly, approximately 60% of the ecosystem services examined are being degraded or used unsustainably. Secondly, there is established but incomplete evidence that human caused changes are increasing the likelihood of nonlinear changes in ecosystems such as disease emergence, abrupt alterations in water quality, the creation of dead zones in coastal waters, the collapse of fisheries, and shifts in regional climate. Thirdly, the harmful effects of the degradation of ecosystem services are being borne disproportionately by the poor, are contributing to growing inequities and disparities across groups of people, and are sometimes the principal factor causing poverty and

social conflict.

Water, air, and food are the most important natural resources to people. Humans can live only a few minutes without air, about a week without water, and about a month without food. Water also is essential for our oxygen and food supply. Plants, which require water to survive, provide oxygen through photosynthesis and form the base of our food supply chain. Conservation of water, efficient water devices, water recycling, waste water treatment are some aspects to be considered for implementing sustainable engineering.

Sustainable engineering principles are to be implemented for the success of any sustainable development. Such principles will include efficient use of natural resources among which is water, soil, rock, metals and non-metals resources. It also will involve efficiency in the use of energy and use of efficient equipment as well as use of renewable energy resources. Sustainable engineering requires the life cycle analysis of products and use of efficient management tools. In addition common sustainability metrics need to be studied, such sustainability metrics are generally based within certain disciplines such as ecology, economics, and physics, and how they may reflect on other disciplines [20].

On other hand there are dozens of environment performance indicators, EPIs that can be used to evaluate sustainability. Examples of multi-component methods that allow comparisons at a national level, which is necessary for promoting many types of systemic changes, include ESI, and EMPI. Environmental sustainability index (ESI), the ESI uses 76 variables to create 21 indicators of sustainability. The EMERGY (The term, EMERGY, is a contraction of Embodied enERGY) performance index (EMPI) differs in omitting the social variables, and instead creates a single unit that can be used to describe the production and use of any natural or anthropogenic resource

V. CONCLUSIONS AND RECOMMENDATIONS

The foregoing discussion in this paper talked about the existing engineering programs in the Palestinian Universities. The diversity of these programs fulfills most of the needs of the Palestinian people, but the absence of concentrated specializations makes it difficult to reach the objectives of the world in terms of sustainability. The main problems faced in Palestine are related to energy, water and materials. The high shortage in these resources declares the necessity to include sustainable engineering in most of engineering educational programs. The second part of the paper talks about the existing engineering programs according to the statistics of the Palestinian Ministry of Higher Education. On the other hand, there are two new developed models for education. The first model for engineering education emphasizing on the inputs, outputs, dynamics and mechanisms of this system. The second proposed model is developed for connecting engineering education to industry. This makes an aca-

demia-industry partnership. This partnership is considered one of the main machines capable of holding the process of development in industry and economy. The third part of the paper handles the integration of sustainability in engineering education showing some mechanisms and results. The fourth section explores the impact of this integration with some indicators. It is recommended to distribute the results of this study on higher education institutions and production companies in Palestine for more discussions and to get their feedback for further improvements.

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