ROLE OF ENGINEERS IN THE NATIONAL ECONOMIC DEVELOPMENT PROSPERITY

By

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Abstract
Engineers are one of the important assets of a nation. Way back, at the time of industrial revolution, when the introduction of technologies, transportation and manufacturing were made which had a deep impact on the social, economic and cultural conditions of times. New Inventions were made by generous people of nation while engineers played a role in building and upholding a nation. Today's engineers have a collective responsibility to improve the lives of the people of their community. Our country is now becoming more crowded, more consuming, more polluting, more connected, and in many ways less diverse than ever before. One must ask that what should be done now and in the near future to ensure that the basic needs for water, sanitation, nutrition, health, safety, and meaningful work are fulfilled for the community. As we can foresee today that in very near future that there is going to be an unprecedented demands for energy, food, land, water, transportation, materials, waste disposal, earth moving, health care, environmental cleanup, telecommunication, and infrastructure. The role of engineers will be critical in fulfilling all these demands at various scales, ranging from remote small communities to large urban areas. In Pakistan there are 0.144 million engineers registered with PEC in 23 disciplines ranging from geological and mining to aeronautical engineering. This paper discusses all such roles to be performed by engineers in Pakistan for improving the status of community living standards and fulfilling basic needs of food fiber and shelter.

Keywords: engineers, development, sustainability, community and diversity, environment infrastructure

Introduction

Who is an engineer? According to Oxford advanced learners English dictionary, an Engineer is a person whose job involves designing and building engines, machines, roads, bridges, etc or a person who is trained to repair and control engines. An engineer can be Electrical, Mechanical, Civil, Materials, Electronic, Petroleum, Software, Chemical, etc. Engineers are also found in military barracks because they design and build military structures and equipments, so they can be soldiers as well. We also have Genetic Engineers in society now a days.

At the beginning of 2^{nd} half of 18^{th} century, when the industrial revolution sparked in United Kingdom by a small number of innovations such as discovery of concrete which has become the foundation of almost every building in the world. Another technological development was the improvement of steam engine, the British engineers had offered a better path with engineered road and railways. These constructions had directly reflected on the economy of United Kingdom by means of transporting goods throughout the nation, as well as providing workers to factories.

As engineering rose to a distinct profession after the industrial revolution, engineers see themselves as either independent professional practitioners or technical employees of large enterprise. Engineers today work in diverse and diffuse teams, often across time zones and national borders. At the same time, the problems engineers are being called upon to solve have become larger and more complex. The modern engineer must be able to synthesize a broad range of disciplinary knowledge while keeping the systemic nature of the problem within their view. As we take on the challenges facing us, it will be engineers and their creativity that design the world we want and turn ideas into reality.

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Engineers provide the bridge between science and society. In this role, engineers must actively promote and participate in multidisciplinary teams with other professionals, such as: ecologists, economists, medical doctors, and sociologists, to effectively address the issues and challenges of sustainable economic development because engineers working on a global scale will help promote public recognition of the engineers and understanding of the needs and opportunities in today's fast developing world in order to ensure the engineers' role in a sustainable economic development in it.

The role of engineers is becoming more critical in fulfilling the demands of community at various scales, ranging from remote small communities to large urban areas (mega cities), mostly in the developing world (United Nations, 1998). If engineers are not ready to fulfill such demands, who will? As George Bugliarello (1999) has stated, the emergence of large urban areas is likely to affect the future prosperity and stability of the entire world. Today, it is estimated that between 835 million and 2 billion people live in some type of city slum and that the urban share of the world's extreme poverty is about 25 percent (United Nations, 2001).

Considering the problems facing our planet today and the problems expected to arise in the first half of the twenty-first century, the engineering profession must revisit its mindset and adopt a new mission statement - to contribute to the building of a more sustainable, stable, and equitable world. As Maurice Strong, Secretary General of the 1992 United Nations Conference on Environment and Development, said, "Sustainable development will be impossible without the full input by the engineering profession." For that to occur, engineers must adopt a completely different attitude toward natural and cultural systems and reconsider interactions between engineering disciplines and non-technical fields.

Responsibility of Engineers:

Engineers have a collective responsibility to improve the lives of the people primarily of their own community and the world as a whole. The countries are now becoming more crowded, more consuming, more polluting, more connected, and in many ways less diverse than at any time in history. One can ask that what should be done now and in the near future to ensure that the basic needs for water, sanitation, nutrition, health, safety, and meaningful work are fulfilled for the community. In future this will further create unprecedented demands for energy, food, land, water, transportation, materials, waste disposal, earth moving, health care, environmental cleanup, telecommunication, and infrastructure. The role of engineers will be critical in fulfilling all these demands at various scales, ranging from remote small communities to large urban areas.

Like all other nations, our elected governments wish their citizens to be able to live with a reasonable level of economic prosperity, to enjoy educational, health and social services that enable them to live their lives in dignity and without hardship, and to do so in a manner that ensures that negative impacts of human activity on the environment are acceptable, and increasingly minimized. Many components of good-quality health, educational and social services, and clean technologies to protect the environment must be provided. To be able to afford reasonable standards of social and environmental services, nations therefore need to build their economic prosperity.

Since past two centuries, for instance, civil and environmental engineers have played a critical role in improving the condition of humankind on Earth by improving sanitation, developing water resources, and developing transportation systems. These successes have contributed to the extended and comfortable life. Most engineering achievements of the past were developed without consideration for their social, economic, and environmental impacts on natural systems. Not much attention was paid to minimizing the risk and scale of unplanned or undesirable perturbations in natural systems associated with engineering systems.

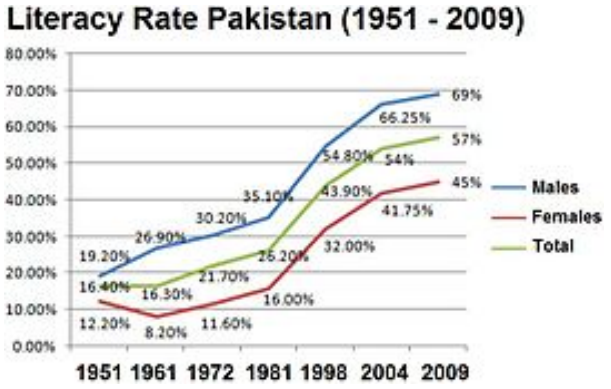
As we enter the twenty-first century, we must embark on a worldwide transition to a more holistic approach to engineering. This will require: (1) a major paradigm shift from control of nature to participation with nature; (2) an awareness of ecosystems, ecosystems services, and the preservation and restoration of natural capital; and (3) a new mindset of the mutual enhancement of nature and

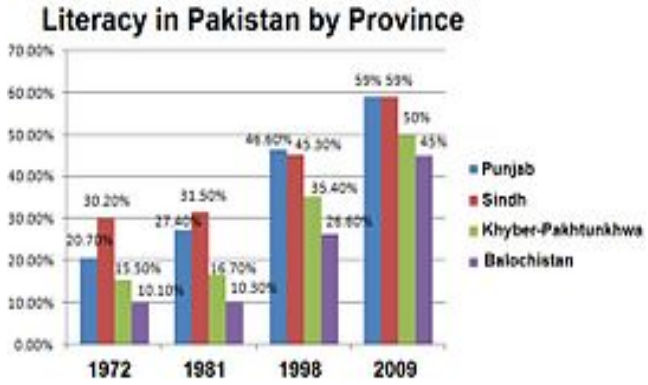
humans that embraces the principles of sustainable development, renewable resources management, appropriate technology, natural capitalism (Hawken et al., 1999), biomimicry (Benyus, 1997), biosoma (Bugliarello, 2000), and systems thinking (Meadows, 1997).

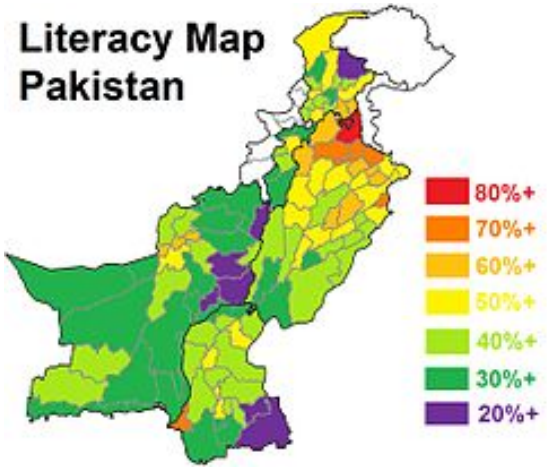
In addition, engineering educators must take a closer look at how engineering students are being prepared to enter the "real world." Current graduates will be called upon to make decisions in a socio-geo-political environment quite different from that of today. In their lifetimes, engineering students now attending universities and colleges can expect to see an increase in world population, major global warming phenomena, and major losses in biological and cultural diversity on Earth. Whether colleges and universities are doing enough proactively to teach students what they need to know to operate in a future environment is an open question (Orr, 1998). Clearly, engineers must complement their technical and analytical capabilities with a broad understanding of so-called "soft" issues that are non-technical. Experience has shown that social, environmental, economic, cultural, and ethical aspects of a project are often more important than the technical aspects.

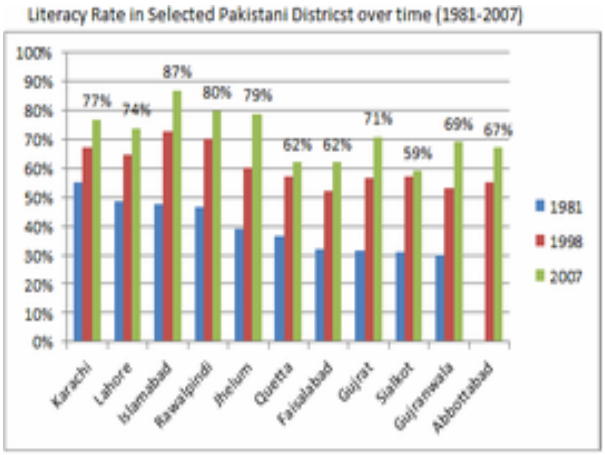
Education Base and Engineering in Pakistan

Let us have a look at the level of education and particularly engineering curriculum being taught in Pakistan. Figure below show the literacy rate during various years since 1950s and onward. It indicates that education level is steadily increasing from 15% in early years and has attained 45%. Its position is better in Punjab and Sindh and in their cities rather than rural areas. Balochistan has lowest literacy rate among all the provinces. Highest literacy level is in Islamabad and Karachi where it has touched 80%. Various regions are also separately indicated in the figures.









An issue of equal importance is the education of engineers interested in addressing problems specific to developing communities. These include provision of safe water and its purification, sanitation, power

production, shelter, site planning, infrastructure, food production and distribution, and communication, among many others. Such problems are not usually addressed in our engineering curricula. Thus, our engineers are not educated to address the needs of the most destitute people in our country. This is unfortunate, because an estimated 50 percent of the Pakistan's population lacks clean water, 60 percent lacks adequate sanitation, and 40 percent lacks adequate housing.

Shown below is curriculum of Civil Engineering & Computer Engineering being offered and approved by HEC (HEC 2009).

Table: 1 Summary of civil engineering course approved by HEC and being taught in Pakistan

Domain	Knowledge Area	Total Courses	Total Credit Hours	% overall
Non Engineering	Humanities	7	12	31
	Management Sciences	3	9	
	Natural Sciences	8	21	
Engineering	Computing	3	9	69
	Engineering Foundation	8	28	
	Major Based Core (Breadth)	6	20	
	Major Based Core (Depth)	7	24	
	Interdisciplinary Engineering Breadth	2	7	
	Civil Engineering Project	1	6	
	Sub Total	27	94	
	Total	45	136	

Domain	Knowledge Area	Total Courses	Total Credits	% Overall Cr Hr based
Non-Engineering	Humanities	7	19	32.8%
	Management Sciences	2	6	
	Natural Sciences	6	19	
	Sub Total	15	44	
Engineering	Computing	3	9	67.2%
	Engineering Foundation	8	30	
	Computer Engg. Core (Breadth)	5	19	
	Computer Engg. Depth Electives	5	20	
	Inter-Disciplinary Engineering Breadth (Electives)	2	6	
	Senior Design Project	2	6	
	Sub Total	25	90	
Grand Total		40	134	100%

(source: www.hec.gov.pk)

3. The nature of economic development: One major goal of the country must be to raise foreign exchange, for the purpose of paying for its imports. Another is to ensure that the needs for imports are minimised by ensuring that local suppliers can compete effectively where they have the competence to do so.

The most frequently used indicator of prosperity internationally is the gross domestic product (GDP) / capita. GDP / capita is made up as the product of labour productivity (GDP / hour worked) and labour utilization (hours worked/person). Labour productivity is the product of value created per hour worked, and overall economic efficiency of the economy. Hence we have:

Prosperity (GDP / capita) = (Value created/hour worked) x (economic efficiency) x (labour utilization)

Sustainable economic development for our nation relies on environmentally responsible development of energy, manufacturing and other exportable items to minimise imports, exploiting forest, mineral or energy resources in a responsible manner. Therefore safe and reliable infrastructure is vital – industry and businesses need reliable electricity supply, broadband, safe public transport, a water supply that can be consumed without concern, safe food handling and so on to withstand all the worst climatic events.

At a second level, there is a need for environmental protection – agriculture and industry can achieve the greatest possible returns if there is good environmental management. Particularly critical in this respect is the means applied to treat liquid waste and manage sold waste. Aquifer contamination of seepage into lagoon areas is preventable and unacceptable. Flood mitigation is also very important.

At a third level, the amenity value of transport facilities is critical – common community and businesses use the rail, roads, airports, buses and taxis etc.

Fourthly, the amenity of building residences, offices and other structures is important. Institutions, hospitals, hotels that are safe and in which all facilities function reliably are more important to maximise returns. Local community, industry and businesses need suitable premises with all time uninterrupted supply of gas, water, sewage and electricity.

Lastly, if manufacturing is to exist, then competitive edge through using high technology to make products is the best way to obtain high returns per hour worked.

Engineers Education in Pakistan:
Engineers are virtually builders of the country and they should play their role in overcoming the prevalent crisis and pave way for a strong, stable and prosperous Pakistan. They should also dispel negative propaganda while serving within the country or abroad and convince the Investors to make their wise investment in setting up joint ventures and new industry in Pakistan. Pakistan Engineering Council registers in the following disciplines:

Sr. No.	Engg. Discipline	Registered Engineers
1.	Aeronautical	1,469
2.	Agricultural	3,509
3.	Architecture	217
4.	Automotive	68
5.	Biomedical	694

6.	Chemical	10,118
7.	Civil	32,184
8.	Computer	9,133
9.	Electrical	34,590
10.	Electronics	16,486
11.	Engineering Sci.	67
12.	Environment	158
13.	Geology	77
14.	Industrial	1,801
15.	Mechanical	24,677
16.	Mechatronics	986
17.	Metallurgy	2,878
18.	Mining	1,329
19.	Nuclear	05
20.	Petro-Gas	1,366
21.	Tele Com	4,023
22.	Textile	1,431
23.	Transport	72

Presently, there are over 1,44,568 registered engineers in the above mentioned disciplines in the country (PEC 2013). These professionals are distributed throughout the country in all economic sectors, from natural resources through manufacturing to a wide series of services of all kind. They practice their discipline in a very wide array of fields ranging from underground exploitation of minerals to satellite communications, embracing all areas of science and reaching into economics, management, and social science. Importantly, engineers are the bridge between science and technology. Without engineers, technology has little meaning. This precious asset must be continually upgraded to serve the immediate needs of the country's production system, both in terms of human resources and modern technology. Therefore, engineering institutions must be hotbeds of technology creation and the place where new principles of production and technology management are explored and systematically investigated.

Engineers Training and Utilization:

Globally large number of engineers are graduating but a major portion is not been able to find suitable and relevant job to their qualification. A 2005 study conducted by the Pratt School of Engineering found that the margin of engineer graduates is higher than expected. According to this report only in the U.S. engineering graduates were 140,000, India has produced 120,000 and in China graduating engineers 517,225 in 2004. Where these engineers are employed is elaborated in another study by Chaturvedi &

Sachitanand, 2013 which states that somewhere between a fifth to a third of the million students graduating out of India's engineering colleges run the risk of being unemployed. Others will take jobs well below their technical qualifications in a market where there are few jobs for India's overflowing technical talent pool. Beset by a flood of institutes (offering a varying degree of education) and a shrinking market for their skills, India's engineers are struggling to subsist in an extremely challenging market.

Although we have been offering training to the engineers for the well being of country since its creation but it has not delivered desired results. Engineering institutions therefore must now put in more emphasis on a problem solving approach, introducing new dynamics in the solution of problems affecting community well-being and economic growth. Rather than putting emphasis on the usual disciplinary divisions (viz. civil, mechanical, electrical, etc.), the focus must now be on the main problem areas falling within the purview of the engineer: such as infrastructures, environment, processes and systems. Each one has a particular set of parameters, including materials of various types, energy in various forms, etc. Mentalities must be transformed, attitudes changed. Engineering education must place greater emphasis on problem definition and formulation. Outreach approaches toward other disciplines must now be entertained. It is high time now that old conventional engineering designs must be rediscovered and given a central role in training engineers. Interdisciplinary projects should be encouraged to young graduates and special courses to that effect be introduced accordingly.

Even though very encouraging initiative have been stressed by PEC and HEC since 2001 onward and through this action spectacular progress has been observed in bridging the gap between universities and industry, but these efforts are still too limited and too sporadic. It is for the benefit of both, engineering institutions that they must learn how to deal better with small or medium-sized technological firms and train their students to meet the needs of industry. Courses on technological innovation and entrepreneurship should be regular parts of the curriculum. Interdisciplinary projects undertaken jointly with small firms should be given special attention.

There is a need to study the effectiveness of our engineering education system of our country and tailor according to needs of the industry. In this way engineers can contribute positively to the prosperity and progress of our nation.

Conclusions and Recommendations:

1. In Pakistan there are 0.144 million registered engineers in 23 disciplines. The curriculum have been revised and updated after the creation of HEC which includes 30 – 35 % non engineering courses and 65-70 % engineering courses.

2. This precious asset must be continually upgraded to serve the immediate needs of the country's production system, both in terms of human resources and modern facilities. Therefore, engineering schools must be hotbeds of generic technology creation and the place where new principles of production and technology management are explored and systematically investigated.

3. Even though spectacular progress has been achieved in recent years in bridging the gap between universities and industry, the efforts are still too limited and too sporadic. In particular, engineering institutions must learn how to deal better with small or medium-sized technological firms and train their students to meet the needs of this important sector of our economy.

4. Courses on technological innovation and entrepreneurship should be regular parts of the curriculum. Interdisciplinary projects undertaken jointly with small firms should be given special attention.

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