BUILDING ENGINEERING AND TECHNOLOGY CAPACITY IN THE ARAB COUNTRIES

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ABSTRACT. This paper is an attempt to present the necessary measures to be taken by Arab countries to build their engineering and technology capacity. In this regard, the paper highlights the current status of research and science, scientific publications, higher education, access to knowledge and Internet, intellectual property and content generated in Arab countries. The paper pinpoints the failures in these areas and suggests possible solutions.

1. INTRODUCTION

Except for Western Europe, with its recent extensions through the European Union, United States, Canada, Russian Federation, Australia, New Zealand and Japan, the rest of the world, including all Arab countries, is classified by the United Nations as developing. About 70% of world's population belong to this class [1]. The quantitative basis for this classification is a human development index that measures not only per capita income but also social development through literacy, education, healthcare and life expectancy. By this compound measure, Arab oil rich countries are regarded as developing despite their oil wealth. Taiwan, Hong Kong, Singapore and South Korea are shedding the label and a few countries such as Brazil, China, India, Mexico, South Africa, Chile and Turkey are seeking an active transition. These countries combine areas of considerable development with aspects of neglect and decay.

There are big differences, however, within the class of developing countries. The needs in Saudi Arabia are different from those in Namibia, and China cannot be compared with Bahrain. To make further distinction, the phrase "least developed countries", or LDCs, is sometimes used for the poorest nations which cannot be regarded as developing by any measurable index; for example Haiti [1].

The relationship of developing countries to global development can be described as analogous to a highway, with three groups of developing countries acting as traffic on that highway according to their abilities:

a. Fast moving vehicles: India, China, Brazil.
b. Slower moving traffic: Mexico, Argentina and some countries in the Middle East and South East Asia.
c. Pedestrians: sub-Saharan Africa, small island states.

Poverty, disease and public health, environmental degradation, lack of primary education, food shortage and energy uncertainty problems, hamper development in many Arab and developing countries. Scientific research can contribute towards addressing these problems.

Arab countries must be enabled to approach their problems themselves, and therefore, need to establish their own, autonomous research potential. In fact, over the last few decades, the global approach to international development has shifted from developed countries effectively telling developing countries how to address their own problems, to developing countries identifying their problems and working with developed countries to achieve the assistance they need. Unfortunately, many Arab countries have limited capacity to identify where and how scientific research can help tackle their problems.

Capacity is not well defined, but can be understood as the ability of individuals, organizations or societies, to meet their needs. In the new approach to development, Arab countries would decide their own needs. However, without sufficient knowledge and skills in many areas including engineering, science and technology, Arab countries may find it difficult to do this effectively. Moreover, it is unclear whether Arab countries themselves see engineering, science and technology as a priority. Indeed, an existing lack of primary education in many Arab countries is often seen as a more pressing problem than building longer-term engineering, science and technology capacity.

2. ENGINEERING AND TECHNOLOGY CAPACITY BUILDING

In the global economy of the 21st century, engineers and technologists play a key role in overall economic development for countries and regions. In the well developed countries, the roles of the engineers and technologists are well understood, appreciated and utilized. In much of the Arab countries, however, the available pool of engineering talent is typically below critical mass – and economic development and even important basic societal needs that rely on engineering and technology – such as clean water supply and sanitation – lack the technical talent to address them. Moreover, the role of the technologist is totally misunderstood and not appreciated.

Economic development for Arab countries can be effectively stimulated by building the engineering and technology capacity of their workforce. A competent engineering and technology workforce base can then provide one or more of the following paths to economic development:

1. Attraction of technically oriented multinational companies, who can invest effectively in the Arab countries once there is a cadre of qualified local employees available.
2. Effective utilization of foreign aid funds, and providing a legacy of appropriate infrastructure projects and technically competent people to operate and maintain them.
3. Establishment of small business startups by technically competent entrepreneurs.

In this regard, countries of Central Europe can set an example. Thanks to their growing ranks of high-skilled workers, these countries are shaping up as the next outsourcing haven for engineering and software development, just behind China and India [2].

Engineering and technology capacity building can be described as follows: It is a dedication to the strengthening of economies, governments, institutions and individuals through education, training, mentoring, and the infusion of resources. Engineering and technology capacity building aims at developing secure, stable, and sustainable structures, systems and organizations, with a particular emphasis on using motivation and inspiration for people to improve their lives. Engineering and technology capacity building efforts, therefore, aim at developing a sufficient pool of well educated and certified engineering and technology graduates in Arab countries to affect three desirable outcomes:

1. To engage effectively in the global economy; direct foreign investment, international trade, mobility of engineers and technologists, and the flow of work to countries with cost-effective talent will result.
2. To insure that international aid funds are utilized effectively and efficiently – for initial project implementation, for long-term operation and maintenance, and for the development of capacity to do future projects. And a sufficient pool of engineers and technicians can enable a developing country to address the poverty reduction, safe water and sanitation, etc.
3. To stimulate job formation, a technical workforce pool is needed, made up of people who are specifically educated and prepared to engage in entrepreneurial startup efforts that meet local needs.

3. PRINCIPLES FOR ENGINEERING AND TECHNOLOGY CAPACITY BUILDING

Engineering and technology capacity building in Arab countries, as a lever for economic and social development, is currently recognized as an important priority in the global engineering community. The phrases "technology transfer" and "engineering and technology capacity building" are two of the many used to describe scientific partnership between developed and Arab countries [3]. However, building engineering and technology capacity is much more than just technology transfer. Technical aspects are, of course, fundamental, but it is a mistake to regard the process as mere transfer of equipment and training in laboratory skills.

Engineering and technology capacity building should be refocused on the network model, operating according to the following principles [4]:

1. Responsiveness: ensuring that capacity building activities are driven by demands from Arab countries, rather than seeking to impose capacity building where such demand is not apparent.
2. Coordination: establishing consortia of funding bodies rather than individual agencies working separately.
3. Longevity: aiming for long-term initiatives with partners who are prepared for failures along the way and prepared to wait for tangible results.
4. Networks for innovation: placing more emphasis on building capacity in institutions, and within networks of researchers, policy-makers and civil society groups (both between developed and Arab countries and between Arab countries themselves).
5. Flexibility: ensuring that capacity building activities suit the specific circumstances of particular regions and countries, recognizing that some Arab countries may already have pockets of excellence in science and technology.

A necessary pre-requisite to addressing these issues is their recognition by Arab countries, and consequent putting in place policies that result in a better environment as well as commitment of national resources. A corresponding co-requisite is that the world community works with the Arab countries to produce a measure of equity in all these issues. This will ensure that the efforts of the scientific community to contribute to the ultimate goals of human development, as well as world understanding and peace, will succeed. The following sections will summarize the current situation in Arab countries, and will provide outlines of the measures that can be taken to build engineering and technology capacity in Arab countries.

4. RESEARCH AND SCIENCE IN ARAB COUNTRIES

The situation of research and science in Arab countries is alarming. While in the developed countries there are approximately 3000 scientists and technicians per million inhabitants, this ratio in the Arab countries is less than 200 per million [4],[5]. Similar ratios apply to expenditures for scientific research and development in terms of Grand National Product (GNP). The Arab countries largely depend on results from research done in developed countries. There is a dire shortage of - predominantly native – researchers and scientists who could find autonomous, less short-lived, solutions adapted to local conditions. A common idea in Arab countries is that scientific research is a sort of a luxury which a poor nation cannot afford. Most citizens think that research and science, which need enough funds and human resources, are only challenges for developed countries, where a tradition of scientific research already exists. This prejudice is particularly striking among some entrepreneurs or private investors, for whom scientific research in Arab countries is nothing but a fiction which could at most provide a suitable pretext for obtaining some tax reductions after some donations.

On the other hand, the governments of most Arabic countries, facing dramatically urgent basic needs of the population, tend to postpone scientific research and training for more prosperous days. Following the standards of new global economic policies, a number of them have been implementing a diminution in the influence of the State, giving more opportunities to private investors and opening their countries to transnational commerce and economical activity. This gives raise to a huge import of sophisticated technology. As a result, small countries begin to be invaded by imported science and technology, without any real possibility of fully understanding the essential theory underlying each new equipment.

There are, of course, numerous barriers and challenges to conducting scientific research in Arab countries, ranging from limited material and financial resources to poor physical and communication infrastructures; for example inadequate laboratory equipment, a lack of up-to-date books and journals, and long periods of isolation from mainstream scientific activities. In most Arab countries the social status of scientists is rather low. Especially in low-income Arab countries, research is a luxury owing to economic constraints, wages are insufficient; people frequently need to hold two jobs and many scientists hold several other jobs. The lack of scientific careers, scientific tradition, institutional support and collaboration with the local scientific community aggravates the problem. Moreover, in many occasions some of the most intractable challenges are cultural and political issues, exacerbated by the scarcity of resources.

Scientific research in general, and development in particular, are therefore, inadequately appreciated in Arab countries. Owing to this, as well as to economic difficulties and frequent political unrest, there is no consistent research and science policy. Accordingly, researchers, scientists and scientific staff are faced with very uncertain career options. Scientists and researchers are often out of touch with their own population and their problems. Therefore, the public image of research and science is as low as the scientist's motivation to do scientific research which might benefit the development of their own country. Moreover, due to the impossibility of regular contacts with competent colleagues, Arab scientists are isolated. Such isolation has a devastating effect, particularly on those researchers and scientists who were educated in an industrialized country. It often leads to "Brain-Drain" and emigration of qualified researchers and scientists. The International Organization for Migration states that the brain drain of highly skilled professionals is making economic growth and poverty alleviation impossible across the Arab countries [6].

Although the preceding statements are of general validity, there are vast differences between Arab countries. Some Arab countries have few pockets of very efficient and respectable scientific research centers. Unfortunately, in most of these research centers, scientists and researchers are isolated from their own population and their problems and are mostly involved in solving problems related to research in developed countries.

The Arab countries must be willing, and enabled, to approach their problems autonomously and independently. National research capacities will need to be generated to deal with technological transfer and change as well as with their consequences. The traditional concepts of technological transfer from developed to Arab countries were superseded and new ways of collaboration in scientific research and technology must be found. Historically, collaborations between Arab and developed countries for building research capacity have generally taken four forms [4]:

1. Donor country research: researchers from developed countries carry out research about Arab countries, occasionally involving local researchers. Clearly, 'parachute science', in which investigators from developed countries merely collect samples, return home and publish papers, is of no real use to scientists and citizens in Arab countries.
2. Fellowships: people from Arab countries attend courses and gain qualifications in developed countries.
3. In-country training: developed countries train and teach people within Arab countries institutions.
4. Financial support: Arab countries universities and research programs are funded directly by donors.

Of these, the second has been (and remains) the most common, but is seen as being the least effective for enabling participation, learning and uptake by Arab countries researchers and research users. This model of capacity development that is still used by some development partners failed for one simple reason: by taking our best brains and sending them out to the best international institutions, we simply gave them away in the majority of cases. Many Arab researchers who go to industrialized countries for further training become involved in research that is currently running in those countries. This research, however, is normally intended to solve the problems of that particular country. They became absorbed and integrated in those institutions, conducting research in environments that could not be reproduced in Arab countries. Many of these researchers, upon return to their homelands, if they do, continue to spend funding and time on the same topic for which they received training. In other words, much of the research conducted in Arab countries is a continuation of research already underway in developed countries and which indeed benefits these developed countries.

To tackle this problem, a new capacity building model must be used. A possible example is by linking PhD students and their supervisors in Arab countries to universities and co-supervisors based in developed countries. The programs are run on sandwich basis, with exchange visits between supervisors and short attachments for students at developed countries universities. The problem to be addressed must be defined by the Arab country, and be relevant to its development needs. This model develops supervision capacity for the Arab country academics, and enhances research expertise for both Arab countries faculty and students without transplanting and luring away the student from the Arab countries. The linkage may also help in establishing laboratories whose costs may be out of the current financial reach of many Arab countries universities.

Whereas international collaborations are eagerly sought, local inter-institutional or even intra-institutional partnerships are notoriously difficult to establish, in part because of scarcity of resources as well as politics. Research groups often operate in isolation, limiting the scope and success of their work, and develop collaborative projects only when encouraged.

5. SCIENTIFIC PUBLICATIONS IN ARAB COUNTRIES

Because of intellectual property issues, current scientific literature tends to be very costly, beyond the cost that can be sustained by academic and research institutions in most of the Arab countries, especially considering the overall volume of international scientific output. The negotiating power of any single Arab institution, in terms of getting lower cost access, is very limited, and there is a need to work in larger groups not only to establish such access, but to unbundled it with respect to specific databases. A closely related challenge, again resulting from the sheer volume of literature on the internet, a lot of which is not vetted, is the limited expertise in identifying, evaluating, and exploiting internet based sources (internet literacy). While there are a number of international organizations trying to support capacity building in the research sector in Arab and developing countries, through strengthening the production and dissemination of, and access to, information and knowledge; for example International Network for the Availability of Scientific Publications (INASP) [7], still there is a room for a collective work to be done by the Arab countries in this area.

Arabs scientists and researchers have something to take to the market if they could be enabled to get there. Arab universities and research institutes should consider joining forces to publish one specialized journal in each discipline. For example, rather than having a large number of unknown journals published by individual universities and institutions throughout the Arab world, a better approach is publishing one journal in each discipline, for example Arab Journal of Electrical and Computer Engineering, Arab Journal of Mechanical and Aerospace Engineering, Arab Journal of Chemical and Petroleum Engineering and Arab Journal of Civil and Architectural Engineering. Such journals with strong support from the Arab universities and institutions would establish themselves in the scientific world. One hope for Arab countries in accessing scientific information, and disseminating their knowledge, is through the open source copyright forum, a movement that needs to grow in terms of scope (scholarly articles to software to genetic resources) and coverage (researchers and universities worldwide). Arab scientists and publishers should also consider the utilization of the potential of disseminating their knowledge through the establishment of On-Line Arab Journals.

6. HIGHER EDUCATION IN ARAB COUNTRIES

In a detailed study of the results of foreign aid to developing countries over the past several decades, Easterly concludes [8]:

1. Previous efforts have tried to use foreign aid, investment in machines, fostering education at the primary and secondary levels, controlling population growth, and giving loans and debts relief, conditional on reforms, to stimulate the economic growth that would allow these countries to move toward self sufficiency
2. All of these efforts over the past few decades have failed to lead to the desired economic growth.
3. These massive and expensive efforts have failed because they did not hit the fundamental human behavioral chord that "people respond to incentives".

Having concluded that past efforts at stimulating economic growth in developing countries have failed, Easterly [8] outlines what he thinks would work. He argues that there are two areas that can likely lead to the desired economic growth in developing countries, and can lead them toward economic self sufficiency:

1. Utilization of advanced technologies and
2. Education that leads to high skills in technological areas.

The education systems in Arab countries are not geared towards churning out innovators and entrepreneurs. There is a strong emphasis on theory and little attention given to problem-solving and working in a team. Few Arab graduates have the practical and language skills needed to work in the type of competitive multinational environment in which innovation tends to flourish.

Arab countries have over 300 higher education institutions with a variety of experiences and priorities. The primary objectives of these institutions are to produce white-collar workers, teachers, and work force for mining, textiles, and agricultural industries. The state of higher education and scientific research in Arab countries suggests structural changes in higher education system, institutional linkages between developed and Arab countries, mobilization of the Arab Diaspora and funding. While emphasis on health and basic relief needs must continue, there is also a critical need to break the cycles of poverty through development of strong competitive economies that can relate to world markets. The building of adequate pools of people with quality educations in science, technology, and engineering can help lead to economic growth and healthy economies.

Engineering education in Arab countries should include significant coverage of entrepreneurship – how to start, operate, and grow a small business. Note that US companies such as Hewlett-Packard, Microsoft and Yahoo all were started in garages by enterprising young people with a technical bent. Engineering graduates should be equipped to take a path of generating jobs rather than seeking one if they wish to do so.

One needs only a look at examples from India, South Korea and China to see the effect of concerned efforts to enhance the education of engineering and technology graduates on the economies of these two countries [9]. In 1970 South Korea had about 6,000 engineering graduates. In 1980 these were increased to 14,000. By 1990, the figure jumped to about 80,000. When plotted against South Korea's per capita GNP growth, the number of engineering graduates almost directly parallels the growth of the South Korean economy, offset by a few years. This data appears to show a direct cause and effect – investment in building a well qualified and sufficiently large pool of engineers leads to sustainable economic development [9].

In the case of India there has been a long-term effort to increase the numbers of engineering graduates and quality of their education. Whereas in the past, many of these graduates sought employment outside the country, now many are returning and newer graduates are staying to work in India in the software and design industries, often to high tech cities where well-paying careers and extensive numbers of colleagues await them. The growing number of technically proficient and well-educated specialists also has enabled India to become a prime location for outsourcing technical support by the world's leading technology firms [9].

In China, already a major economic power, the proportion of first science and engineering degrees to all bachelors-equivalent degrees was 59%, as compared to about 33% in the US in 2001. Excellence in (science and engineering) higher education helps a country to be technologically innovative and economically competitive [9].

What is needed? First and foremost, a large enough pool of high quality, accredited engineering graduates is needed in Arab countries so that the good results listed above can be realized. It must be recognized that there will be some leakage of these graduates to jobs in developed countries, but many will choose to stay where family ties and native country culture provide a comfortable environment. Thus, the basic need is the availability of good jobs in the Arab countries. This is a chicken-and-egg issue. Increased demand for engineers will result only when there is a sufficient pool of well qualified graduates to attract direct foreign investment, multinational corporation operations, offshore outsourcing from developed countries, and entrepreneurial startups. Arab countries planners and government officials must pursue effective economic development and job generation strategies, in parallel with making the needed investments to enhance the quality and quantity of engineering graduates.

As technology based economies grow in Arab countries, one important source of top talent – in addition to new engineering graduates – is the return of previous emigrants from the Diaspora. Several countries that are developing well have benefited from the return of former citizens who see new opportunities in their home countries, and bring back foreign experience and network contacts to the benefit of their home countries. For example, recently India established the Hindustan Semiconductor Manufacturing Company (HSMC) to build ten semiconductor fabrication units. HMSC is governed by expatriates of Indian origin who are already involved in the semiconductor industry in California Silicon-Valley [10].

In addition to increasing the number and quality of engineering graduates, and pursuing strategies to have good local jobs available, Arab countries need mechanisms to apply research and development results from local universities and companies for economic gain. Such mechanisms as incubators and small business development financing are needed. While small, private companies have emerged as the main engines for innovation in the developed countries, Arab's political and financial systems provide little support to private entrepreneurs. Ambitious private entrepreneurs are often dependent on family members for start-up capital. This greatly limits the scale of their projects. With few incentives for independent innovation, Arab students educated in foreign universities have tended either to stay abroad or to return home as employees of foreign-owned multinationals.

7. THE INTERNET AND ACCESS TO KNOWLEDGE IN ARAB COUNTRIES

Fortunately, and unfortunately, access to knowledge generates synergy. Greater access leads to more rapid advancement, and if properly managed, greater human development, for those with access. The unfortunate part of it is that those who are ahead consequently advance faster, so that those who are behind are left further back. The knowledge and development gap therefore expands [11].

In most of the Arab countries, there is a continuing failure by both governments, academic and research institutions to allocate significant resources (human and financial) to address these issues. Without understanding the benefits of joining the knowledge society, efforts from outside will be dissipated because they are neither owned nor sustainable by the beneficiaries. Sustainable means, firstly, that the supported efforts should endure, and, secondly, that these shall enjoy long-term support from the population they serve. Real awareness can only be measured through internal financial commitment. Without attacking the need for military and sports expenditure by some Arab countries, let us imagine what would be the national economic and development impact, in any Arab country, if the limited national resources were allocated to Information and Communication Technologies (ICTs)

and knowledge access, with the same desperation they are allocated to military and sports spending. In developed countries, there is a clear belief that access to knowledge is of paramount importance for progress and development. The governments of many Arab countries, on the other hand, believe that joining the knowledge society is futile; an unnecessary activity that not only wastes time but also wastes scarce government funds.

Arab scientists and researchers are increasingly awakening to the use of the Internet as a powerful search and delivery medium, enabling efficient two way access to world wide information sources, without which scientific research becomes a permanent state of "follow my leader". However, in many Arab countries, Internet access is very limited and the access to the global information infrastructure is very costly. Calculations show that the cost on internet access in some Arab and developing countries may be more than one hundred times its cost in the developed countries [11]. Limited and disproportionately expensive bandwidth for linking into the global highway, very low rates of basic literacy and numeracy, very limited penetration, and in many cases total absence of Information and Communication Technology structures are the major problems that need to be seriously addressed before Arab countries can gain access to knowledge society. Until this is addressed, access to online materials in large volumes will remain a very expensive venture and a barrier to access to the knowledge society.

8. INTELLECTUAL PROPERTY AND CONTENT GENERATED IN ARAB COUNTRIES

The current largely one-way traffic in the knowledge market, resulting from the domination of intellectual property by the more developed countries, is one of the biggest challenges facing Arab countries. In fact, approaching closure of the gap based only on closing the infrastructure divide inevitably compounds the situation: the one way traffic will simply flow more efficiently. Arab countries cannot survive in the market place if all they ever do is buy: they must produce content, something to take to the market place. Simply transferring knowledge, equipment and instrumentation is not enough to help Arab countries build their own engineering and technology capacity. Ownership of initiatives by the Arab countries is a critical prerequisite to the success of any prescription.

To put something in the market place, knowledge, suitably protected, must be globally exploited. The dearth of patents held by Arab academic and research institutions and individuals is not simply because there is no scientific output; it is because, in many cases, the value of such output is not recognized or the mechanisms for protecting it internationally are not available, or, where available, not known and appreciated by researchers. In the last two decades, China emerged as a manufacturing powerhouse, drawing on a vast supply of cheap labor, to undercut western manufacturers in everything from T-shirts to DVDs. Now China wants to move from "Made in China" to "Invented in China". Although China is now exporting vast quantities of commodities, a dependence on knowledge and expertise "rented" from other countries is restricting profitability. On the sale of a DVD player, the Chinese exporter will typically receive less than 5% of the price, compared to nearly 60% for the foreign patent owners. The Chinese government has made it a top priority to enhance the country's innovation capability, allocating over 10 billion US$, in 2006 to investment in science and technology, an increase of nearly 20% on 2005. A similar year-on-year increase is planned for the next five years [12].

9. CONCLUSION

Research, science and development are inseparable. Where research, science and development go, innovation and growth follow. The Arab countries must address the reality of this and related challenges. Engineers and technologists play a vital role in the development of any country. Arab governments, universities and other institutions must focus less on meaningless headline goals and more on practicalities. They must start fighting to build their engineering and technology capacity. The main emphasis must be research and science, access to knowledge and higher education. The main focus must be on Arab countries to put something in the market by generating and exploiting scientific intellectual property. In order to achieve these goals the following is recommended:

1. Engage scientists from Arab countries in collaborative research with scientists from developed countries. However, a prerequisite in this approach is to stress that success will not be achieved through simple external prescription, but through home grown solutions assisted by the international experience and participation of partners from developed countries. We need ownership of initiatives by Arab countries as a critical pre-condition to the success of any prescription.
2. Many development problems are rooted in complex, multi-faceted issues, related to both scientific and non-scientific factors. The traditional single-discipline focus in engineering and technology research and education may therefore not be appropriate for addressing development problems. Thus, engineering and technology needs to be more fully integrated across academic disciplines and oriented more towards problem-solving than traditional resource exploitation. In fact the higher education systems in Arab countries need a fundamental restructuring. New higher education systems must be adopted. These systems must graduate doers, extremely fast learners and graduates who have the can-do spirit rather than the theoreticians who are currently graduated from our universities and higher technical institutions.
3. Arab countries must discard the widely used model for building research capacity in engineering and technology with people from Arab countries attending courses and gaining qualifications in developed countries. In the new model, developed countries will train and teach Arabs scientists within Arab countries institutions. Scientists from Arab countries will point out problems they face and the sort of help they need to find solutions.
4. With funds from Arab League, relatively oil rich Arab countries must establish a project for collecting scientific books, equipment and instruments and make arrangements for their shipment to university libraries in relatively poor Arab countries. Arab scientists in Diaspora can contribute to the project by establishing similar arrangements in their regions.
5. With funds from the Arab League, Arab universities and research institutes must join forces to publish journals in each engineering and technology discipline. These would replace the large number of unknown journals currently published by individual universities and research institutes. Publishing On-Line technical journals should be considered as an alternative medium, possibly relatively cheap, for publishing research output of Arab scientists. This would increase the visibility of Arab researchers and scientists and would probably attract research funding.
6. The most important research topic each Arab country or group of countries must conduct, regardless of its size or wealth, is research to determine its research priorities. Especially for Arab oil rich countries, it is essential to develop plans for the

eventuality that oil reserves will be depleted, when they will have to rely on other technical products and services to continue to flourish in the globally competitive economy [13]. Such plans will require the collaboration of governments, universities and research institutions in each country or group of countries.

7. Arab countries must plan to put something in the market. This can be achieved by encouraging the ownership of initiatives. Arab countries must plan to the era of "Invented in Arab countries" rather than "Made in Arab countries".
8. With help from the Arab League, Arab countries should establish a consortium for negotiating subscriptions in electronic scientific databases. The negotiating power of such consortia would be much more than that of any individual country. This would facilitate access to these databases for poor Arab countries.

While it is not difficult to simultaneously implement all the above mentioned recommendations, the author believes that restructuring the higher engineering and technology education may represent the first priority. This would enable Arab countries to build a pool of engineers and technologists with quality education that can help lead to economic growth and healthy economies.

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