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Higher Education, R&D, Economic Development, Regional and Global Interface

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Introduction

Knowledge and science are universal activities. Every society, however, has its own problems and its own challenges. An essential feature of knowledge is that it requires human capital (educated persons) for both its production and its application.

The national systems of higher education and research and development (R&D) are the quintessential tools for the creation and application of knowledge. Although knowledge can be stored indefinitely on paper or discs, it is of little value unless appropriately educated and skilled persons can access and transform this knowledge.

Even then, knowledge is ineffective unless the persons seeking to use it are appropriately organized and supported by suitable institutions and policies. Thus, an apparent knowledge gap between countries may arise because of a variety of reasons, such as:

- *Shortage* of human capital.
- *Limited* access to recorded knowledge.
- *Absence* or weakness of the organizations necessary to enable human capital to function.
- *Absence* of the vital economic and science policies by which to enable the acquisition, accumulation and application of particular knowledge.
- *Absence* of the organizations and/or supporting institutions which provide the necessary legal and financial services.

This Seminar is concerned with Arab States. Thus, our first task is to pinpoint the causes of the prevailing knowledge gap and consequent crises in development in the Arab countries and to figure out how to bridge this gap.

The author has organized this paper in two parts:

Part I presents data and analysis through which the nature and extent of the Arab knowledge gap can be pinpointed.

Part II discusses measures that, if adopted, would enable the Arab countries, singly and collectively, to work towards overcoming their developmental crises through an effective use of their human capital and resources. The central problem in the interface between higher education and R&D on the one hand and the application of knowledge, on the other, is that the former has no direct influence on the latter. The influence that systems of higher education exert on society and the economy is through the research that they produce and through the employment of their graduates. The limited amount of research and the high level of brain drain curtail this influence. Yet this situation can be readily reversed.

Part I. Nature of the Arab knowledge gap

Knowledge is a complex entity. The indicators that specify the relative standing of countries include: (i) human capital; (ii) funding of R&D; (iii) yearly number of publications in refereed journals; (iv) population of scientific and engineering workers; (v) quality of the education system; (vi) number of patents registered annually; (vii) export of products of advanced technologies; and (viii) rate of change of these indicators. In this paper, the author examines only the first four of these indicators.

It is difficult to define the magnitude of those indicators which are associated with specific levels of development. However, there is universal acceptance that certain countries have attained take-off in terms of economic growth. It is, for example, accepted that China and India are in such a state of 'take-off'. International discourse today is no longer concerned with the underdevelopment of China and India, but rather with when they may be expected to join the club of industrial nations. Thus these two countries provide a useful yardstick with which to compare other countries.

The Organization of Islamic Countries (OIC) published a volume (Naim and Atta-ur-Rahman, eds., 2006) on scientific activities in all Islamic countries which accounts for roughly 25 per cent of the world population. This volume includes a chapter on each Member Country which

covers basic information on: (i) population, (ii) changes in literacy during past decade; (iii) information on the top ten scientific disciplines, (iv) areas of scientific research during past five and ten years, (v) productive universities, (vii) names of leading authors by university, (viii) number and trends in scientific publication during the past decade, (ix) exports and GDP). The OIC reports that their share of the world's research output during the past decade was roughly 2.5 per cent of world output. The UNESCO Science Report (UNESCO, 2005) gives an account of science in the Arab World. Additional sources of information will be cited in this paper to enable us to compare and to make a contrast of the performance of Arab countries.

1. Comparative status of Arab human capital

Arab countries emerged from their colonial period with very low levels of human capital. After independence, all Arab States expanded their education systems dramatically, investing heavily in infrastructure and study abroad. In 1949, there were only ten universities in the Arab World and some 30,000 university graduates. Since then, over 300 universities have been established and they have graduated an estimated 15 million students. *Table 1* shows that enrolment in national universities in the Arab World per million inhabitants was higher than that of either China or India (year 2000).

Research and graduate work in Arab universities, however, are still carried out on a limited scale. Teaching loads are at a high level and research funding (as shown further on) is almost non-existent. As a result, Arabs have continued to depend on study abroad for their post-graduate education. According to UNESCO's latest (1999) statistics, the total number of Arab students enrolled in universities outside the Arab World was 120,602, compared with 106,036 Chinese and 52,932 Indians (see *Table 1*). Clearly, then, there are far more Arabs undertaking foreign study than either Chinese or Indians. About 82 per cent of these Arab students are pursuing post-graduate education in OECD Member Countries. European universities are the major destination of Arab students.

Table 1. Study abroad for Arab States and selected countries

Country (1)	1999 (2)	1999 (3) (Corrected)	Population per million 1997 (4)	Study abroad per million (5)	Study at home per million (6)	Study at home per million (7)
Arab World	111,854	120,602	253.4	476	3,168,445	12,474
China	95,899	106,036	1,227.0	86	7,364,000	6,002
India	48,348	52,932	962.0	55	9,834,000	10,223

Source: Compiled from UNESCO (2005) statistics amongst others.
Second column shows UNESCO data.
Third column shows corrected UNESCO Data with EU statistics.

On the basis of incomplete UNESCO statistical information, the author estimates that 12,000 Arabs are awarded Ph.Ds. abroad annually and that 85 per cent, or more, of these brain drain. This is a loss to the Arab World of around 10,000 Ph.D. graduates annually. Consequently, there are 60,000-70,000 Arabs having Ph.Ds. working in the Arab World compared with an estimated 150,000 abroad.

Of the scientific human capital holding a Ph.D. in the Arab World, only about 10,000 publish one or more scientific papers in a refereed international periodical per annum. Most of the remainder have no opportunity to become research active because of poor working conditions and a lack of R&D funding.

China and India are currently considered the champions of rapidly developing countries. They have taken the place of Korea and Taiwan who have now joined the ranks of OECD Member Countries. As can be noted from *Table 1*, Arab countries have invested more in education, at home and abroad, than either China or India. Obviously, it is not the amount of human capital that is making China and India the champions of development and the Arab countries slow developers. As we shall note later, in greater detail, it is rather the national science and economic policies adopted by Arab States that deprives them of the benefits of their substantial human capital.

The total number of Arabs who brain-drained to OECD Member Countries by 1999 was 967,548, which is roughly 300,000 *more* than Indians, and only slightly lower than Chinese (see *Table 2*).

Table 2. Number of Highly Skilled Personnel (HSP) in OECD Member Countries, 1999

Country	Expatriates	HSP Percentages	HSP Number
Arab World	4,462,391	22	967,548
China	1,928,199	51.9	1,000,735
India	1,649,711	39.6	653,286

Source: SOPEMI. 2004. *Trends in International Migration Annual Report*, OECD, 2004. Table II.A2.6,

NB: The term now in common use for university graduates is Highly Skilled Personnel (HSP). Before the importance of gender issues the term in use was High Level Manpower (HLM).

On a *per capita* basis, the Arab brain drain is four times greater than that of China; and five times that of India. Overall emigration from China and India is 3.6 million compared to 4.5 million from the Arab World. Thus, China and the Arab World export an equal number of Highly Skilled Personnel (HSP). But in terms of total emigration (skilled and semi-skilled, and dependents) the Arab World exceeds China and India combined.

Arab professionals perform very effectively in OECD Member Countries; this is attested to by the continuing brain drain as well as by the prominent positions held by Arab professionals. No comparative surveys of the performance by national groups are available; although there are major differences between different groups; one cannot say that any one group has out-performed another.

Deriving economic growth from human capital depends on the methods utilized during the execution of economic activity. Investments made through turnkey contracts that make little provision for technology transfer to national and regional organizations do not generate local employment. They result in a low multiplier factor. If we examine the behaviour of China,

India, Korea and others we find that these countries pursue specific policies which use every activity as a mechanism to acquire and accumulate technology. They thus learned to: (i) maintain; (ii) operate; (iii) innovate; (iv) upgrade; and (v) duplicate all their investments.

This is the main reason for the rapid growth registered by China and India. Their adoption of the requisite science and economic policies has promoted the utilization and development of national organizations to acquire, accumulate, apply, and adapt technology. Arab countries have not adopted similar policies and practices (Zahlan, 1999).

Planners expect to recover the cost of educating human capital from the contributions made by graduates to the national economy. Thus, the ability to employ graduates productively is of central economic importance. The brain-drain phenomenon has shown that a country may educate its youth, but without employing this youth productively, it cannot derive the desired economic benefits from its investment in education.

National policies regarding the processes of production, innovation and investment determine the extent to which economic growth may be derived from human capital. Investments made through turnkey contracts that make little provision for the employment of national organizations and labour result in a low multiplier factor.

Furthermore, the Arab World is a vast market for technological investments. The oil and gas sector, the construction industry, transport, manufacturing industries, ICT and many others have led to massive investments of over US$3,000 billion between 1980 and 2000. Yet there has not been a corresponding increase in *per capita* income. Once again, a more efficient use of human capital would produce better results. Clearly, the problem facing the Arab countries is not one of a shortage of capital, human capital or even R&D. A solution to this problem undoubtedly lies in a better utilization of human capital (Zahlan, 1999).

R&D Funding

The only way to retain research quality personnel (Ph.D. level) and keep them fit is by enabling them to conduct research; this means that R&D funding is a critical factor.

In *Table 3*, the author summarizes some of the comparative data presented in the UNESCO Report, and finds that the Arab countries, along with the least-developed countries (LDCs) (which happen to be the poorest in the world) allocate the lowest proportion of their GNP to R&D. The Gulf Cooperation Council (GCC) countries [Bahrain, Kuwait, Qatar, Saudi Arabia, the Sultanate of Oman and the United Arab Emirates (UAE)] are amongst the lowest supporters of R&D in the Arab World in terms of the percentage of their gross domestic product (GDP) devoted to R&D. The major area where the Arab countries are in deficit in comparison with China and India is in research funding. The Chinese and Indian governments devote far more towards R&D than any Arab government (see *Table 3*). This is, of course, an important reason why the Arab brain drain is much higher, on a *per capita* basis, than that of China or India. China spends ten times more than the Arab countries on R&D per inhabitant; India spends three times more.

Table 3. Comparative support for R&D (2002) in Gross Expenditure on R&D (GERD)

Country	GERD US$ billion	GERD percentage of GDP	GERD per inhabitant US$	Researchers per million inhabitants
World	829.9	1.7	134.4	894.0
Developed countries	645.8	2.3	540.4	3.272.7
Developing countries	183.6	1.0	42.8	374.3
Less-developed countries	0.5	0.1	0.7	4.5
Arab States Africa	**1.2**	**0.2**	**6.5**	**159.4**
Arab States Asia	**0.6**	**0.1**	**6.2**	**93.5**
All Arab States	**1.9**	**0.2**	**6.4**	**136.0**
Brazil	13.1	1.0	75.0	314.9
China	72.0	1.2	56.2	633.0
India	20.8	0.7	19.8	112.1
Israel	6.1	4.9	922.4	1 395.2

Source: UNESCO. (2005), Table 1, p. 4.

2. Comparative research output

A useful gauge for assessing scientific activity is to compare the number of research publications in refereed international journals per country and per million populations. From such comparisons, it can be seen that Arab output increased from eleven publications per million populations in 1981 to 33.2 in 2003. The Republic of Korea output was only six per million in 1981 it equalized with the Arab World in 1985 and was thirteen times larger in 2003. India's output appears to have remained constant at seventeen to nineteen publications per million over the period 1981-2003; while that of China increased from a low of one to 36.1 in 2003. China equalized with the Arab World in 2003. Since 2003 both China and India

have dramatically increased their R&D appropriations and deepened their science policies to accelerate the rate of economic development (see *Table 4*).

Table 4. Publications per million populations (1981-2003)

Country	1981	1985	1990	1991	1992	1993	1994	1995	2003
Arab World	11	15	21	21	21	21	24	26	33.2
Brazil	16	19	25	27	31	31	34	42	74.8
China	1	3	7	7	8	8	9	11	36.1
France	496	593	628	627	686	721	768	840	826
India	17	15	16	17	17	17	18	19	19.4
Korea (Republic of)	6	15	42	48	58	74	97	144	433
Netherlands	567	768	932	920	1 009	1 098	1 166	1 252	1 209
Switzerland	1 202	1 406	1 352	1 361	1 525	1 622	1 780	1 878	2 005

Source: Institute of Scientific Information (ISI), Philadelphia, US.
(Compiled by the author).

The Arab countries in 2007 are roughly at the same level as 2003 of India and China in R&D output and human capital. China, like Korea before it, is moving very briskly ahead. It is very likely that China has already moved far ahead of the Arab World during the past four years.

3. International cooperation amongst Arab researchers

The enormous scale and complexity of knowledge makes it imperative for knowledge workers to cooperate. In order for cooperation to take place, enabling social and political conditions are required to facilitate these processes. (See *Table 5*)

Table 5. Regional and international cooperation of researchers in the Arab World, 1995.

Country	Total Number	N°. Joint Papers	N°. Main Partner	N°. OECD	N°. Arab	N°. Multinational
		%	%	%	%	%
Algeria	328	227 (69)	France 151(65)	187 (81)	3 (1)	
Bahrain	106	29 (27)	UK 7 (24)	11 (38)	3 (10)	6 (21)
Egypt	1 999	585 (29)	USA 154 (26)	367 (63)	123 (21)	49 (8)
Iraq	114	34 (30)	USA 5 (15)	20 (59)	12 (35)	0
Jordan	266	95 (36)	USA 23 (24)	58 (61)	18 (19)	12 (13)
Kuwait	290	117 (40)	USA 25 (21)	56 (48)	26 (22)	17 (15)
Lebanon	73	32 (44)	USA 14 (44)	27 (84)	1 (3)	4 (13)
Libya	58	35 (60)	UK 9 (26)	16 (46)	7 (20)	4 (11)
Mauritania	7					
Morocco	536	395 (74)	France 214 (61)	314 (80)	2 (0.5)	61 (15)
Oman	84	37 (45)				
Palestine	16					
Qatar	59	36 (54)	Egypt 23 (64)	9 (25)	24 (67)	2 (6)
Saudi Arabia	1 240	294 (24)	USA 72 (25)	161 (55)	79 (27)	26 (9)
Somalia	6					
Sudan	112	74 (66)	USA 10 (14)	45 (61)	11 (15)	13 (18)
Syria	134	81 (60)*	France/UK 16 ea	44 (86)	0	2=ICARDA
Tunisia	342	147 (46)	France 87 (59)	122 (83)	3 (2)	17 (12)
UAE	137	55 (40)	Egypt 11 (20)	26 (47)	22 (40)	6 (11)
Yemen	30	28 (83)	Egypt/UK 6 ea	15 (54)	8 (29)	4 (14)
Total	**5937**	**2 301 (39)**	**849 (33)**	**1,478 (64)**	**342 (15)**	**223 (10)**

Source: Zahlan, 1999.

NB: Including twenty-nine publications by scientists at the International Centre for Agricultural Research in Dry Areas (ICARDA).

The extent of cooperation between researchers is reflected in the conduct of scientific research resulting in co-authored publications. *Table 5* above shows that researchers in all Arab countries were involved in international cooperation in 1995. There are major differences between Arab countries in the level and patterns of cooperation.

Cooperation in science and technology are of vital importance to the quality and success of the scientific enterprise. The reason is that scientific progress depends on high quality expertise that is a scarce commodity. Hence the importance of cooperation between the relatively small number of scientists working in each specific field. The trend towards the increasing dominance of teams in the production of knowledge in all fields is supported by extensive recent studies (Wuchty, Jones and Uzzi, 2007). Increasingly these teams have a multi-organizational complexion.

International cooperation between scientists and technologists takes many forms. One of the most basic forms of cooperation is the exchanges that take place at scientific meetings: in 1995 for example about 18,000 scientific meetings, whose proceedings were published, took place around the world. These meetings provided opportunities for scientists to meet and exchange information.

Scientists based in Arab countries do not have a satisfactory rate of participation in such meetings. They contributed only a total of 200 papers to the 18,000 meetings that were held worldwide in 1995. In other words the connectivity link-up of Arab scientists with the international community is at a low level.

Another level of cooperation consists of research collaboration between scientists in two or more countries. The author undertook a detailed analysis of Arab scientific output and discovered that cooperation between Arab scientists is almost non-existent despite the presence of a number of Arab regional organizations whose objective is to promote such cooperation. Neither national nor regional Arab organizations devote serious resources to promote cooperation.

The Arab States share a wide range of common scientific and technical problems. Thus there should be considerable incentives for co-operation. Most of the Arab World is in a dry zone

where water is scarce; this dictates certain research issues in water use in agriculture and in water management. Likewise several Arab countries are oil and gas producers; this provides common technological challenges and opportunities for sharing experiences. Moreover they all share a number of problems in health, and in the application of codes and standards as well as in many other fields.

Scientists in GCC universities published 1,722 papers in 1990 and 2,716 in 1995. Of this one quarter were co-authored with scientists in non-Arab institutions. In 1990 collaboration within the GCC was only 2.7 per cent of all co-authored papers; this increased to 6 per cent in 1995. See Zahlan (1999) for detailed information on R&D regional and international collaboration.

Scientists in the Maghreb countries (which generally apply to Algeria, Morocco and Tunisia) exhibit a high level of international collaboration but a very low level of regional collaboration. The level of international collaboration in four Maghreb countries underwent some changes between 1990 and 1995: Algerian collaboration fell from 80 per cent of all publications to 69 per cent; Libya increased from 31 per cent to 60 per cent Morocco from 64 per cent to 74 per cent and Tunisia from 29 per cent to 64 per cent. The average rate of international collaboration for the Maghreb countries increased from 54 per cent to 64 per cent during this period. Scientists in Algeria, Morocco and Tunisia published a total of 1,264 papers in 1995; of these some 804 were co-authored with scientists outside their own countries. Very surprisingly only eleven of the 804 publications involved scientists from two Maghreb countries. Of these eleven only *one* paper was conducted fully by Maghreb scientists. Regional collaboration is thus exceedingly meagre.

The rate of international co-authorship in the Mashreq countries (Egypt, Jordan, Lebanon, Syria and Palestine) is close to the world-wide average of 25 per cent. Cooperation within the Mashreq is also very limited.

4. Arab science and technology systems

The crisis in Arab development arises from the fact that Arab countries are not receiving the returns normally expected from their investments in human resources, R&D and Gross Fixed

Capital Formation (GFCF). This is largely due to the underdeveloped condition of national science and technology systems (S&T-System).

The S&T-System consists of a complex knowledge-intensive system of organizations and institutions. An important function of the S&T-System is to enable the production, accumulation, acquisition, diffusion and conversion of knowledge into useful and desired outputs.

The quality and efficiency of the connectivity that links up the various components of the S&T-System with each other as well as are as critical as the components themselves. In other words the components are of little benefit without the associated connections. These issues are discussed at length in Zahlan, (1983, 1990, and 1999).

A factor impeding the formation of connectivity is the prevailing national economic and science policies combined with the weaknesses (and often non-existence) of Arab professional societies and scientific associations and the lack of funding to support the travel of Arab scientists to participate in national, regional and international scientific conferences and activities.

The extent of articulation of the skills, education and management of labour force with the S&T-System determines labour productivity and the ability to acquire and accumulate new technologies. A concern with labour productivity and performance is central to the international competitiveness of a nation's economy.

In 1970 the Arab States were close to European and Japanese levels of labour productivity. It is interesting to note that the decline took place after the first oil boom in 1974 after 'an investment' of US$2,000 billion in GFCF by 2000 and after a massive expansion in education systems at all levels (Zahlan, 1994). It is estimated that at the moment Arab countries are investing between US$2,000 and US$3,000 billion in new projects almost exclusively through the technology free turn-key approach.

The declining performance of Arab labour is a unique phenomenon. It is related to the increasing dependence on turnkey and client-in-hand forms of contracting which have grown

alongside the increasing numbers of professionals and financial resources! This is the consequence of the lack of integration between the education systems, the economy and the labour market.

Very briefly, the main barriers to development are, the:

(1) *Public sector policies* of pursuing technology-free turnkey contracts with international Consulting Engineering Design Organisations (CEDOs) with limited attention paid to the acquisition of knowledge.

(2) *Vertical integration* of major national industrial firms and their heavy dependence on international Industry Related Services suppliers thereby giving little attention to national and regional organisations.

(3) *Limited adoption* of out-sourcing and sub-contracting by parastatals and private firms.

(4) *Weaknesses* of national and regional professional and scientific societies.

(5) Limited efforts to un-package technology and undertake reverse engineering.

(6) *Very limited* number of science policy studies undertaken in the region.

(7) *Limited* number of science and technology parks around universities and technical schools to promote technology transfer to small- and medium-enterprises.

(8 *Poor quality* of statistical and technical information services; there are of course some exceptions to this.

(9) *Low level of incentives* to encourage innovation.

(10) *Low level of mechanisms* to promote the diffusion of best practice.

(11) *Limited attention* paid to the promotion of competition.

(12) *Low level of concern* for labour productivity and quality control; although some efforts have been made in several Arab countries to improve standards and quality control.

Part II. Conclusions: Measures to overcome current difficulties

It has been noted in *Part I* above that Arab human capital, R&D capabilities, financial and natural resources are equal to or higher than those of China or India on a *per capita* basis. Yet the performance of the Arab countries is far inferior to them. The reform of existing policies cannot take place without a thorough understanding of the causes for the poor comparative performance of Arab countries.

Understanding current difficulties in all their complexity requires a massive amount of research especially in the economic, management and science policy spheres. Only then will it be possible to define the wide variety of problems that confront us and to define operational methods for overcoming them.

There are well-known methods for rapid and low cost methods to diffuse expertise and to promote research in these practical areas, on a step-by-step basis. The adoption of these methods is facilitated by the rich abundance of Arab human capital and the large number of universities.

An essential measure to increasing employment and reducing cost consists in the training and certification of the labour force. The objectives of this measure would be to increase labour skills and productivity in technologies which are in big demand; and to increase their mobility through their endowment with certificates that reflect their levels of skills.

Consulting and contracting organizations are basic instruments for converting investments in education and R&D into economic benefits. Thus measures to enable Arab consulting and contracting industry to increase market share should have high priority. This would entail increasing the ability to compete with international contractors in the home markets. The measures include improving financial services, establishing an efficient legal system, labour training and certification, accurate and efficient statistical and information services. These measures would transform and strengthen the weak linkages between contracting and consulting firms, professional organizations, universities and Arab human resources (Imad, 2002). This measure should yield considerable socio-economic benefits and profits.

1. Funding scientific meetings

The paucity of scientific cooperation and collaboration between scientists in the Arab World is a major obstacle to benefiting from available human capital. Scientific meetings provide a low-cost mechanism to effect exchanges between professionals. An increase in the funding of scientific conferences in the Arab World would enable scientists to network more effectively.

2. Information and Communication Technologies (ICTs)

Arab countries lag behind other nations in developing their ICT sectors. Yet they are purchasing a wide range of ICT services, hardware for military telecommunication, TV and radio services, industries, government departments, airports and airlines, banks, etc. A concerted effort to un-package the ICT components of large contracts would promote local participation in technology transfer and innovation in this vital domain.

Bridging the knowledge gap should be straightforward and low in cost and would contribute immensely to national well-being, self-reliance and prosperity.

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