

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 for both its production and its application.² The national systems of higher education and 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 organised and supported by suitable institutions and policies. Thus, an apparent knowledge gap between countries may arise because of a variety of reasons, such as:

- A shortage of human capital
- Limited access to recorded knowledge
- An absence or weakness of the organisations necessary to enable human capital to function
- An absence of the vital economic and science policies by which to enable the acquisition, accumulation and application of a particular knowledge,
- An absence of the organisations and/or supporting institutions that provide the necessary legal and financial services.

This conference is concerned with Arab countries. Thus, our first task is to pin-point 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.

My paper is organised in two parts:

The first part presents data and analysis through which the nature and extent of the Arab knowledge gap can be pin-pointed.

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² The term human capital is used to refer to an “educated person.” Another term in common use today for university graduates is: Highly Skilled Personnel (HSP). Several decades ago, before gender issues became important, the term in use was High Level Manpower.

The second part 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 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 curtails this influence. Yet this situation can be readily reversed.

Part I: The Nature of the Arab Knowledge Gap

Knowledge is a complex entity. The indicators that specify the relative standing of countries include: human capital; funding of R&D; the yearly number of publications in refereed journals; the population of scientific and engineering workers; the educational system; the number of patents registered annually; the export of products of advanced technologies; and the rate of change of these indicators. In this paper, I will examine 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 under-development 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 Organisation of Islamic Countries (OIC) published a volume on scientific activities in all Islamic countries which account for roughly 25% of the world population. The OIC reports that their share of the world’s research output during the past decade was roughly 2.5% of world output.³ The UNESCO Science Report 2005 has an account of science in the Arab world.⁴ Additional sources of information will be cited in this paper to enable us to compare and contrast the performance of Arab countries.

³ S.T.K Naim and Atta-ur-Rahman (editors), Status of Scientific Research in OIC Member States, COMSTECH, Pakistan, (in press, 2006). The volume includes a chapter on each member country which covers basic information on: population, changes in literacy during past decade, information on the top ten scientific disciplines, areas of scientific research during past five and 10 years, productive universities, names of leading authors by university, number and trends in scientific publication during the past decade, exports and GDP,

⁴ UNESCO, UNESCO Science Report 2005, UNESCO 2005.

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 educational systems dramatically, investing heavily in infrastructure and study abroad. When I was a university student in 1949, there were only 10 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 inhabitant was higher than that of either China or India (year 2000).

Research and graduate work in Arab universities, however, are still on a limited scale. Teaching loads are at a high level and research funding (as I will show later) 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 (Table 1). Clearly, then, there are far more Arabs undertaking foreign study than either Chinese and Indians. About 82% of these Arab students are pursuing post-graduate education in OECD countries. European universities are the major destination of Arab students.

On the basis of incomplete UNESCO statistical information, I estimate that 12,000 Arabs earn PhDs abroad annually and that 85%, or more, of these brain drain. This is a loss to the Arab world of around 10,000 PhD graduates annually. There are 60,000 to 70,000 Arab PhDs working in the Arab world, compared with an estimated 150,000 abroad.

Of the scientific human capital holding a PhD in the Arab world, only about 10,000 publish one or more scientific paper 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 countries. As we note 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.

Table 1: Study Abroad for Arab and Selected Countries

			Population	Study Abroad	Study at home	
Country	1999	1999 Corrected	(1997, m.)	Per million		Per million
ARAB	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 statistics and others. The second column contains UNESCO data. The third column was obtained by correcting the UNESCO data with EU statistics.

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

Table 2 -Number of HSP in OECD Countries, 1999

Country	Expatriates	HSP %	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: Table II.A2.6, SOPEMI 2004, Trends in International Migration Annual Report, OECD, 2004.

On a per capita basis, the Arab brain drain is 4 times greater than that of China; and 5 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 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 countries; this is attested to by the continuing brain drain as well as by the prominent positions held by Arab professionals in OECD countries. 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 utilised during the execution of economic activity. Investments made through turnkey contracts that make little provision for technology transfer to national and regional organisations do not generate local employment. They result in a low multiplier factor. If we examine the behaviour of India, China, 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 maintain, operate, innovate, upgrade and 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 utilisation and development of national organisations to acquire, accumulate, apply, and adapt technology. Arab countries have not yet adopted similar policies and practices.⁵

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 organisations 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 \$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 utilisation of human capital.⁶

R&D Funding

In Table 3, I summarise some of the comparative data presented in the UNESCO Report. We find that the Arab countries, along with the less developed countries (who happen to be the poorest in the world) allocate the lowest proportion of their GNP to R&D. The GCC countries are amongst the lowest supporters of R&D in the Arab world. 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 (see table 3) far more towards R&D than any Arab government. 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 10 times more than the Arab countries on R&D per inhabitant; India spends 3 times more.

⁵ A, B. Zahlan, Science and Technology in the Arab World: Progress without Change, Centre for Arab Unity Studies, Beirut, 1999 (in Arabic) Henceforth, Zahlan (1999)..

⁶ A, B. Zahlan, ibid.)

Comparative Research Output

A useful gauge for assessing scientific activity is to compare research publications in refereed international journals per country and per million population (Table 4). From such comparisons, it can be seen that Arab output increased from 11 publications per million population in 1981 to 33.2 in 2003. The Republic of Korea output was only 6 per million in 1981, it equalised with the Arab world in 1985 and was 13 times larger in 2003. India's output appears to have remained constant at 17 to 19 publications per million over the period 1981-2003; while that of China increased from a low of 1 to 36.1 in 2003. China equalised 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.

The Arab countries are in 2007 at roughly the same level as 2003 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 4 years.

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.

The extent of cooperation between researchers is reflected in the conduct of scientific research resulting in co-authored publications. Table 4 show 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.

Table 3: Regional and International Cooperation of Researchers in the Arab world, 1995.

Country	Total Number	Joint papers	Main Partner	OECD	Arab	Multinational
		No. & (%)	No & (%)	No & (%)	No & (%)	No & (%)
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	123 (21)	49 (8)
Iraq	114	34 (30)	USA 5 (15)	20 (59)	12 (35)	0 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)	754 (33)	1,478 (64)	342 (15)	223 (10)

- including 29 publications by scientists at ICARDA.

Source: A. B. Zahlan Science and Technology in the Arab World: Progress without Change Centre for Arab Unity Studies Beirut 1999 (in Arabic)

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. The trend towards the increasing dominance of teams in the production of knowledge in all fields is supported by extensive recent studies.⁷ Increasingly these teams have a multi-organisational complexion.

International co-operation between scientists and technologists takes many forms. One of the most basic forms of cooperation are 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 of Arab scientists with the international community is at a low level.

Another level of co-operation consists of research collaboration between scientists in two or more countries. I undertook a detailed analysis of Arab scientific output and discovered that co-operation between Arab scientists is almost non-existent despite the presence of a number of Arab regional organisations whose objective is to promote such co-

⁷ Stefan Wuchty, Benjamin F. Jones and Brian Uzzi, "The Increasing Dominance of Teams in Production of Knowledge," *Science* **316**, no. 5827, pp.1036-1039, 18 May 2007

operation. Neither national nor regional Arab organisations devote serious resources to promote co-operation.

The Arab countries 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 in the application of codes and standards and many others.

Scientists in GCC universities published 1,722 papers in 1990 and 2,716 in 1995. Of these one quarter were co-authored with scientists

Table 4: Comparative Support for R&D (2002) in Gross Expenditure on R&D (GERD)

Country	GERD \$billion	GERD % of GDP	GERD per inhabitant \$	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 op.cit. Table1 p.4.

Table 5: Publications per Million Population

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
India	17	15	16	17	17	17	18	19	19.4
Republic of Korea	6	15	42	48	58	74	97	144	433
France	496	593	628	627	686	721	768	840	826
Netherlands	567	768	932	920	1009	1098	1166	1252	1 209
Switzerland	1 202	1 406	1 352	1 361	1 525	1 622	1 780	1 878	2 005

Source: Compiled by the author from information at the Institute of Scientific Information Philadelphia USA.

in non-Arab institutions. In 1990 collaboration within the GCC was only 2.7% of all co-authored papers; this increased to 6% in 1995.⁸

Scientists in the Maghreb exhibit a high level of international collaboration but only 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% of all publications to 69%; Libya increased from 31% to 60% Morocco from 64% to 74% and Tunisia from 29% to 64%. The average rate of international collaboration for the Maghreb increased from 54% to 64% 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 11 of the 804 publications involved scientists from two Maghreb countries. Of these 11 only one paper was conducted by Maghreb scientists. Regional collaboration is thus exceedingly meagre.

The rate of international co-authorship in the Mashreq countries is close to the world-wide average of 25%. Co-operation within the Mashreq is very limited.

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 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 organisations and institutions. An important function of the S&T-System is to produce, accumulate, acquire, diffuse and convert knowledge into useful and desired outputs.

⁸ Detailed information on R&D regional and international collaboration is provided in Zahlan (1999).

The quality and efficiency of the connectivities that link the various components of the S&T-System are as critical as the components themselves. In other words the components are of little benefit without the associated connections.⁹

A factor impeding the formation of connectivities 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 \$2,000 billion in GFCF by 2000 and after a massive expansion in educational systems at all levels.¹⁰ It is estimated that at the moment Arab countries are investing between \$2,000 and \$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 the lack of integration between the educational system, the economy and the labour market.

Very briefly the main barriers to development:

- 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;
- The vertical integration of major national industrial firms and their heavy dependence on international Industry Related Services

⁹ These issues are discussed at length in: A. B. Zahlan, The Arab Construction Industry, Croom Helm, London, 1983; also published in Arabic by the Centre for Arab Unity Studies, Beirut, 1983; A. B. Zahlan, Acquiring Technological Capacity: A Study of Arab Consulting and Contracting Firms, Macmillan, London, 1990; also published in Arabic by Centre for Arab Unity Studies (CAUS), Beirut, 1990; and Zahlan (1999).

¹⁰ A. B. Zahlan, "Labour Productivity and Competition," Al-Mustaqbal al-Arabi, no 2, pp 98-112, 1994;

suppliers thereby giving little attention to national and regional organisations;

- The limited adoption of out-sourcing and sub-contracting by parastatals and private firms;
- The weaknesses of national and regional professional and scientific societies;
- The limited efforts to un-package technology and undertake reverse engineering;
- The very limited number of science policy studies undertaken in the region;
- The limited number of science and technology parks around universities and technical schools to promote technology transfer to small and medium enterprises;
- The poor quality of statistical and technical information services;¹¹
- The low level of incentives to encourage innovation;
- The low level of mechanisms to promote the diffusion of best practice;
- The limited attention paid to the promotion of competition;
- The low level of concern for labour productivity and quality control.¹²

Part II: 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 massive amount of research specially 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 high demand; and to increase

¹¹ There are of course some exceptions to this.

¹² There has been some effort in several Arab countries to improve standards and quality control.

their mobility through their endowment with certificates that reflect their levels of skills.

Consulting and contracting organisations 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, establish an efficient legal system, labour training and certification accurate and efficient statistical and information services. These measures would transform the strengthen the weak linkages between contracting and consulting firms professional organisations universities and Arab human resources.¹³ This measure should yield considerable socio-economic benefits and profits.

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 would enable scientists to network more effectively.

Information Communication Technology (ICT)

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.

¹³ *Imad Mustafa*, "Organizational Context of Knowledge Acquisition, Transfer, Management and Localization of Technology," background paper prepared for AHDR 2003, 2002. (np)

